# Annual Bluegrass Control in Greens Height Creeping Bentgrass

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## Introduction

This study was conducted on a mature stand of 'Penncross' creeping bentgrass (*Agrostis stolonifera*) and annual bluegrass (*Poa annua*) at the Valentine Turfgrass Research Center, Penn State University, University Park, PA. The objective of the study was to determine if selected materials could reduce the annual bluegrass population under simulated golf course putting green conditions.

## Methods and Materials

This study was a randomized complete block design with three replications. Treatments were applied on April 7 (APR), May 2 (4 WAT), May 17 (6 WAT), May 31 (8 WAT), June 15 (10 WAT), July 1 (12 WAT), July 15 (14 WAT), August 1 (16 WAT), August 15 (18 WAT), September 1 (20 WAT), September 15 (22 WAT), October 3 (24 WAT), October 17 (26 WAT), November 3 (28 WAT), and November 17, 2011 (30 WAT) using a three foot $CO_2$ powered boom sprayer (Figure 1) calibrated to deliver 87.12gpa using one, flat fan, TP9508EVS nozzle at 40 psi. The test area was maintained at 0.125 inch using a Toro triplex reel mower. Additionally, turfgrass was irrigated on an as needed basis to prevent moisture stress. The test area received maintenance fungicide applications to control disease.

The test site consisted of approximately 20 percent creeping bentgrass and 80 percent annual bluegrass at the initiation of the study. The annual bluegrass population was visually evaluated on April 7, 2011, again on November 1, 2011, and finally on April 12, 2012 on a plot by plot basis, to determine the baseline population and percent change of the population in each plot.

## Results and Discussion

Annual bluegrass phytotoxicity was rated ten times during the study (Table 1). All treated annual bluegrass revealed some level of phytotoxicity. This would be expected as the objective of the study was to eliminate the weed.

Creeping bentgrass phytotoxicity was rated twice during the study (Table 2 - also reference Figure 2). There was no phytotoxicity observed on April 25, 2011. On May 12, 2011 unacceptable phytotoxicity was observed on creeping bentgrass following some applications of MRC on April 7 and May 2, 2011. It should be mentioned that from April 7 (the first application date) to the May 2 (the second application date) 16.98 inches of precipitation was recorded (Table 7). Furthermore the test site consisted of a modified soil growing medium (Table 6). Both of these factors may have influenced the downward movement of MRC in the soil profile and the uptake of MRC by creeping bentgrass. This movement of MRC is postulated, but not documented.

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Turfgrass color was rated on July 6, 2011 (Table 3). There was no unacceptable color found on this rating date.

Turfgrass quality was rated on July 6, 2011 (Table 4). The quality rating included the following factors; turfgrass color, turfgrass density, turfgrass uniformity, and weed populations. Turfgrass quality was found to be acceptable on for all treated and non treated turfgrass.

In order to gain some insight into the annual bluegrass population, a November 2011 control rating was taken (Table 5). As would be expected, control was variable. At no time were any voids in the turfgrass canopy recorded. It seems that the annual bluegrass dissipated at a slow rate and the creeping bentgrass filled in any potential voids. On April 12, 2012, all treated turfgrass reduced the annual bluegrass populations by at least 75% and in some cases by 98%. It appears, that the April and September (spring and fall) timings are effective at reducing annual bluegrass populations.

MRC continues to show promise in the annual bluegrass control arena. There is more research needed to formulate the correct rate and timing to incorporate MRC into a turfgrass management scheme. Finally, the soil texture and amount of precipitation in this study needs to be further evaluated. If this one incidence is typical, it may be possible to reduce the rates or application frequency and increase post application irrigation. At this time this is speculation but warrants more investigation.

**Table 1.** Annual bluegrass phytotoxicity on a scale of 0-10, where 0 = dead turf, 7 = acceptable, and 10 = no phytotoxicity in a mixed greens height sward of 'Penncross' creeping bentgrass and annual bluegrass in 2011.

| Treatment | Form | Rate | Timing | (----------Poa Phytotoxicity---------- | | | | ) |
|---|---|---|---|---|---|---|---|---|
| | | oz/A | | 4/25 | 5/12 | 6/15 | 7/15 | 8/1 |
| MRC | EC | 55 | APR/4/8 WAT | 6.7 | 4.5 | 2.0 | 9.2 | 9.0 |
| MRC | EC | 55 | 4/8/12 WAT | 10.0 | 6.7 | 7.0 | 9.0 | 9.0 |
| MRC | EC | 82 | APR/4/12 WAT | 6.7 | 4.8 | 2.3 | 9.3 | 9.0 |
| MRC | EC | 27.4 | 4/6/8/10/12/14 WAT | 10.0 | 7.0 | 7.3 | 7.0 | 6.8 |
| MRC | EC | 55 | APR/8 WAT | 6.8 | 5.3 | 2.0 | 9.3 | 9.0 |
| MRC | EC | 82 | 4 WAT | | | | | |
| CHECK | | | | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| MRC | EC | 82 | APR/4 WAT | 6.8 | 4.5 | 2.0 | 9.0 | 9.0 |
| MRC | EC | 55 | 8 WAT | | | | | |
| MRC | EC | 55 | APR | 6.8 | 4.8 | 2.0 | 9.3 | 9.0 |
| MRC | EC | 110 | 4 WAT | | | | | |
| MRC | EC | 82 | 8 WAT | | | | | |
| MRC | EC | 27.4 | 8/10/12/14/16/18 WAT | 10.0 | 6.8 | 7.5 | 7.0 | 6.7 |
| MRC | EC | 27.4 | 12/14/16/18/20/22 WAT | 10.0 | 6.5 | 10.0 | 7.0 | 6.7 |
| MRC | EC | 27.4 | 16/18/20/22/24/26 WAT | 10.0 | 6.8 | 10.0 | 9.5 | 9.0 |
| MRC | EC | 27.4 | 20/22/24/26/28/30 WAT | 10.0 | 6.8 | 10.0 | 9.5 | 9.0 |

**Table 1 (cont).** Annual bluegrass phytotoxicity on a scale of 0-10, where 0 = dead turf, 7 = acceptable, and 10 = no phytotoxicity in a mixed greens height sward of 'Penncross' creeping bentgrass and annual bluegrass in 2011.

| Treatment | Form | Rate | Timing | (----------Poa Phytotoxicity---------- | | | | ) |
|---|---|---|---|---|---|---|---|---|
| | | oz/A | | 8/15 | 9/1 | 9/15 | 10/1 | 10/15 |
| MRC | EC | 55 | APR/4/8 WAT | 9.0 | 9.5 | 9.5 | 10.0 | 10.0 |
| MRC | EC | 55 | 4/8/12 WAT | 9.0 | 9.5 | 9.5 | 10.0 | 10.0 |
| MRC | EC | 82 | APR/4/12 WAT | 9.0 | 9.5 | 9.5 | 10.0 | 10.0 |
| MRC | EC | 27.4 | 4/6/8/10/12/14 WAT | 9.0 | 9.5 | 9.5 | 10.0 | 10.0 |
| MRC | EC | 55 | APR/8 WAT | 9.0 | 9.5 | 9.5 | 10.0 | 10.0 |
| MRC | EC | 82 | 4 WAT | | | | | |
| CHECK | | | | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| MRC | EC | 82 | APR/4 WAT | 9.0 | 9.5 | 9.5 | 10.0 | 10.0 |
| MRC | EC | 55 | 8 WAT | | | | | |
| MRC | EC | 55 | APR | 9.0 | 9.5 | 9.5 | 10.0 | 10.0 |
| MRC | EC | 110 | 4 WAT | | | | | |
| MRC | EC | 82 | 8 WAT | | | | | |
| MRC | EC | 27.4 | 8/10/12/14/16/18 WAT | 6.8 | 7.0 | 9.5 | 10.0 | 10.0 |
| MRC | EC | 27.4 | 12/14/16/18/20/22 WAT | 7.0 | 6.8 | 7.0 | 7.0 | 10.0 |
| MRC | EC | 27.4 | 16/18/20/22/24/26 WAT | 6.7 | 6.7 | 7.0 | 7.0 | 7.0 |
| MRC | EC | 27.4 | 20/22/24/26/28/30 WAT | 9.0 | 9.5 | 7.0 | 7.0 | 7.0 |

**Table 2.** Creeping bentgrass phytotoxicity on a scale of 0-10, where 0 = dead turf, 7 = acceptable, and 10 = no phytotoxicity in a mixed greens height sward of 'Penncross' creeping bentgrass and annual bluegrass in 2011.

| Treatment | Form | Rate | Timing | (---Bent phyto---) | |
|---|---|---|---|---|---|
| | | oz/A | | 4/25 | 5/12 |
| MRC | EC | 55 | APR/4/8 WAT | 10.0 | 6.0 |
| MRC | EC | 55 | 4/8/12 WAT | 10.0 | 7.2 |
| MRC | EC | 82 | APR/4/12 WAT | 10.0 | 6.0 |
| MRC | EC | 27.4 | 4/6/8/10/12/14 WAT | 10.0 | 7.3 |
| MRC | EC | 55 | APR/8 WAT | 10.0 | 6.3 |
| MRC | EC | 82 | 4 WAT | | |
| CHECK | | | | 10.0 | 10.0 |
| MRC | EC | 82 | APR/4 WAT | 10.0 | 6.2 |
| MRC | EC | 55 | 8 WAT | | |
| MRC | EC | 55 | APR | 10.0 | 6.0 |
| MRC | EC | 110 | 4 WAT | | |
| MRC | EC | 82 | 8 WAT | | |
| MRC | EC | 27.4 | 8/10/12/14/16/18 WAT | 10.0 | 7.0 |
| MRC | EC | 27.4 | 12/14/16/18/20/22 WAT | 10.0 | 7.2 |
| MRC | EC | 27.4 | 16/18/20/22/24/26 WAT | 10.0 | 7.0 |
| MRC | EC | 27.4 | 20/22/24/26/28/30 WAT | 10.0 | 7.2 |

**Table 3.** Evaluations of turfgrass color where 0 = brown turf, 7 = acceptable, and 10 = dark green turf in a mixed greens height sward with 'Penncross' creeping bentgrass and annual bluegrass in 2011.

| Treatment | Form | Rate | Timing | (---Color---) |
|---|---|---|---|---|
| | | oz/A | | 7/6 |
| MRC | EC | 55 | APR/4/8 WAT | 8.8 |
| MRC | EC | 55 | 4/8/12 WAT | 8.7 |
| MRC | EC | 82 | APR/4/12 WAT | 9.0 |
| MRC | EC | 27.4 | 4/6/8/10/12/14 WAT | 8.8 |
| MRC | EC | 55 | APR/8 WAT | 9.0 |
| MRC | EC | 82 | 4 WAT | |
| CHECK | | | | 8.2 |
| MRC | EC | 82 | APR/4 WAT | 9.0 |
| MRC | EC | 55 | 8 WAT | |
| MRC | EC | 55 | APR | 9.0 |
| MRC | EC | 110 | 4 WAT | |
| MRC | EC | 82 | 8 WAT | |
| MRC | EC | 27.4 | 8/10/12/14/16/18 WAT | 8.3 |
| MRC | EC | 27.4 | 12/14/16/18/20/22 WAT | 8.0 |
| MRC | EC | 27.4 | 16/18/20/22/24/26 WAT | 8.0 |
| MRC | EC | 27.4 | 20/22/24/26/28/30 WAT | 8.0 |

**Table 4**. Turfgrass quality of a mixed sward of 'Penncross' creeping bentgrass and annual bluegrass taken in 2011, where 0 = worst quality, 7 = acceptable quality, and 10 = best quality.

| Treatment | Form | Rate oz/A | Timing | (--Quality--) 7/6 |
|---|---|---|---|---|
| MRC | EC | 55 | APR/4/8 WAT | 8.2 |
| MRC | EC | 55 | 4/8/12 WAT | 8.2 |
| MRC | EC | 82 | APR/4/12 WAT | 8.5 |
| MRC | EC | 27.4 | 4/6/8/10/12/14 WAT | 8.2 |
| MRC | EC | 55 | APR/8 WAT | 8.5 |
| MRC | EC | 82 | 4 WAT | |
| CHECK | | | | 8.0 |
| MRC | EC | 82 | APR/4 WAT | 8.0 |
| MRC | EC | 55 | 8 WAT | |
| MRC | EC | 55 | APR | 8.5 |
| MRC | EC | 110 | 4 WAT | |
| MRC | EC | 82 | 8 WAT | |
| MRC | EC | 27.4 | 8/10/12/14/16/18 WAT | 8.0 |
| MRC | EC | 27.4 | 12/14/16/18/20/22 WAT | 8.0 |
| MRC | EC | 27.4 | 16/18/20/22/24/26 WAT | 8.0 |
| MRC | EC | 27.4 | 20/22/24/26/28/30 WAT | 8.0 |

**Table 5.** Percent control of annual bluegrass in a mixed greens height sward with 'Penncross' creeping bentgrass in 2011 and 2012.

| Treatment | Form | Rate oz/A | Timing | (--------% Control[1]--------) 11/1/11 | 4/12/12 |
|---|---|---|---|---|---|
| MRC | EC | 55 | APR/4/8 WAT | 91.8ab | 98.8a |
| MRC | EC | 55 | 4/8/12 WAT | 91.8ab | 83.4c |
| MRC | EC | 82 | APR/4/12 WAT | 90.0abc | 98.8a |
| MRC | EC | 27.4 | 4/6/8/10/12/14 WAT | 93.7a | 75.3d |
| MRC | EC | 55 | APR/8 WAT | 86.0cd | 97.2a |
| MRC | EC | 82 | 4 WAT | | |
| CHECK | | | | 0.0e | 0.0e |
| MRC | EC | 82 | APR/4 WAT | 94.0a | 95.5a |
| MRC | EC | 55 | 8 WAT | | |
| MRC | EC | 55 | APR | 85.8c | 97.2a |
| MRC | EC | 110 | 4 WAT | | |
| MRC | EC | 82 | 8 WAT | | |
| MRC | EC | 27.4 | 8/10/12/14/16/18 WAT | 88.2bcd | 88.2b |
| MRC | EC | 27.4 | 12/14/16/18/20/22 WAT | 87.9bcd | 97.3a |
| MRC | EC | 27.4 | 16/18/20/22/24/26 WAT | 88.4bcd | 98.8a |
| MRC | EC | 27.4 | 20/22/24/26/28/30 WAT | 83.9d | 82.0c |

1 - Means followed by same letter do not significantly differ (P=0.05, Duncan's New MRT)

**Table 6.** Soil textural analysis of the 'Penncross' creeping bentgrass/annual bluegrass green test area.

| Size Fraction | % by weight |
|---|---|
| >2 mm | 0 |
| 1-2 mm | 5.4 |
| 0.5-1 mm | 21.9 |
| 0.25-0.5 mm | 46.5 |
| 0.15-0.25 mm | 18.8 |
| 0.05-0.15 mm | 4.0 |
| Silt | 2.5 |
| Clay | 0.9 |

**Table 7.** Precipitation rate, daily high temperatures, and daily low temperatures for the duration of the study in 2011.

| April | Precip. (in.) | Daily High (°C) | Daily Low (°C) | May | Precip. (in.) | Daily High (°C) | Daily Low (°C) | June | Precip. (in.) | Daily High (°C) | Daily Low (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4/7/2011 | 0.03 | 6.8 | -5.1 | 5/1/2011 | 0 | 17.2 | 1.3 | 6/1/2011 | 0 | 30.5 | 15.8 |
| 4/8/2011 | 0 | 8.7 | 1.1 | 5/2/2011 | 0.12 | 12.4 | 7.8 | 6/2/2011 | 0 | 28.6 | 16.6 |
| 4/9/2011 | 0.88 | 4.3 | 1.7 | 5/3/2011 | 0 | 17.7 | 9.2 | 6/3/2011 | 0 | 21 | 8 |
| 4/10/2011 | 0 | 5 | 1.4 | 5/4/2011 | 0.61 | 22 | 4.8 | 6/4/2011 | 0 | 21.9 | 4.6 |
| 4/11/2011 | 0 | 13.7 | 4.4 | 5/5/2011 | 0.18 | 8.2 | 3.5 | 6/5/2011 | 0.19 | 21.4 | 5.1 |
| 4/12/2011 | 0.19 | 22.1 | 7.8 | 5/6/2011 | 0 | 15.2 | 0.6 | 6/6/2011 | 0 | 27 | 11.7 |
| 4/13/2011 | 0.4 | 13.1 | 5.6 | 5/7/2011 | 0 | 17.2 | 0.4 | 6/7/2011 | 0 | 25.7 | 7.9 |
| 4/14/2011 | 0.41 | 7.6 | 4.1 | 5/8/2011 | 0 | 16.2 | 3.8 | 6/8/2011 | 0 | 24.9 | 10.2 |
| 4/15/2011 | 0 | 17.6 | -0.9 | 5/9/2011 | 0 | 18.8 | 2.4 | 6/9/2011 | 0 | 31.1 | 12.2 |
| 4/16/2011 | 0 | 13.8 | 0.2 | 5/10/2011 | 0 | 18.9 | 2.4 | 6/10/2011 | 0.02 | 30.4 | 17.1 |
| 4/17/2011 | 0.76 | 9.3 | 3.7 | 5/11/2011 | 0 | 21.7 | 0.5 | 6/11/2011 | 0.76 | 26.4 | 14.5 |
| 4/18/2011 | 0 | 11.6 | 1.3 | 5/12/2011 | 0 | 23 | 7.8 | 6/12/2011 | 0.42 | 25.3 | 15.9 |
| 4/19/2011 | 0 | 16.7 | -0.3 | 5/13/2011 | 0 | 22.8 | 9.4 | 6/13/2011 | 0.13 | 24.6 | 11.6 |
| 4/20/2011 | 0.36 | 10.2 | 3.3 | 5/14/2011 | 0 | 18.7 | 13.3 | 6/14/2011 | 0 | 19.2 | 8.6 |
| 4/21/2011 | 0 | 21.2 | 5.6 | 5/15/2011 | 0.01 | 14.1 | 12.8 | 6/15/2011 | 0 | 18.3 | 7.1 |
| 4/22/2011 | 0 | 10 | -1.3 | 5/16/2011 | 0.67 | 17.7 | 12.4 | 6/16/2011 | 0 | 23.5 | 4.1 |
| 4/23/2011 | 0.21 | 3.6 | -2.4 | 5/17/2011 | 0.01 | 16.1 | 8.8 | 6/17/2011 | 0.42 | 18.9 | 11 |
| 4/24/2011 | 0.16 | 19 | 2.3 | 5/18/2011 | 0.45 | 14.5 | 8.6 | 6/18/2011 | 0 | 22.4 | 11.8 |
| 4/25/2011 | 0 | 19.6 | 10.4 | 5/19/2011 | 0.76 | 16.1 | 10.7 | 6/19/2011 | 0 | 25.5 | 12.8 |
| 4/26/2011 | 0.02 | 26.1 | 10.3 | 5/20/2011 | 0.25 | 15.8 | 8.4 | 6/20/2011 | 0 | 25.3 | 12.7 |
| 4/27/2011 | 0.31 | 25.5 | 11.4 | 5/21/2011 | 0.28 | 19.2 | 10 | 6/21/2011 | 0.44 | 23.8 | 15.7 |
| 4/28/2011 | 0.03 | 24 | 12.6 | 5/22/2011 | 0.01 | 23.1 | 7.1 | 6/22/2011 | 0.08 | 27.1 | 16.7 |
| 4/29/2011 | 1.21 | 20 | 5.6 | 5/23/2011 | 0 | X | X | 6/23/2011 | 0.01 | 26.7 | 19.2 |
| 4/30/2011 | 0.01 | 9.2 | 3.6 | 5/24/2011 | 0.48 | 23 | 14.3 | 6/24/2011 | 0.08 | 24.9 | 16.3 |
| | | | | 5/25/2011 | 0 | 22 | 13.7 | 6/25/2011 | 0.06 | 20.9 | 14.8 |
| | | | | 5/26/2011 | 0 | 24.9 | 11.1 | 6/26/2011 | 0 | 18.6 | 11.4 |
| | | | | 5/27/2011 | 0.18 | 27.8 | 15.5 | 6/27/2011 | 0 | 19.5 | 11.4 |
| | | | | 5/28/2011 | 0.76 | 22.8 | 14.7 | 6/28/2011 | 0 | 22.5 | 9.1 |
| | | | | 5/29/2011 | 0.02 | 24.4 | 14.3 | 6/29/2011 | 0 | 27.1 | 16.5 |
| | | | | 5/30/2011 | 0 | 27.9 | 18.2 | 6/30/2011 | 0 | 22.8 | 11.4 |
| | | | | 5/31/2011 | 0 | 30.2 | 17.4 | | | | |

**Table 7 cont.** Precipitation rate, daily high temperatures, and daily low temperatures for the duration of the study in 2011.

| July | Precip. (in.) | Daily High (°C) | Daily Low (°C) | August | Precip. (in.) | Daily High (°C) | Daily Low (°C) | September | Precip. (in.) | Daily High (°C) | Daily Low (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7/1/2011 | 0 | 23.8 | 8 | 8/1/2011 | 0 | 28.7 | 11.7 | 9/1/2011 | 0 | 23.5 | 8 |
| 7/2/2011 | 0 | 26.1 | 7.2 | 8/2/2011 | 0.12 | 29.1 | 14.3 | 9/2/2011 | 0.07 | 23.3 | 14.1 |
| 7/3/2011 | 0 | 27.8 | 7.4 | 8/3/2011 | 0.01 | 28.4 | 13.8 | 9/3/2011 | 0 | 20.9 | 17.9 |
| 7/4/2011 | 0 | 27.6 | 16.2 | 8/4/2011 | 0.45 | 22.1 | 17.6 | 9/4/2011 | 0 | 29 | 18.8 |
| 7/5/2011 | 0 | 25.5 | 13.1 | 8/5/2011 | 0 | 25.2 | 18.6 | 9/5/2011 | 0.47 | 27.4 | 18.2 |
| 7/6/2011 | 0 | 28 | 13.1 | 8/6/2011 | 0 | 23.7 | 17.4 | 9/6/2011 | 0.78 | 19.3 | 12.1 |
| 7/7/2011 | 0 | 30.2 | 11.1 | 8/7/2011 | 0.42 | 23.8 | 17.7 | 9/7/2011 | 1.23 | 13.2 | 11.8 |
| 7/8/2011 | 0 | 28.4 | 14.1 | 8/8/2011 | 0.05 | 27.2 | 17.9 | 9/8/2011 | 1.96 | 15.3 | 12.1 |
| 7/9/2011 | 0.01 | 21.9 | 16.4 | 8/9/2011 | 0 | 27.3 | 16.1 | 9/9/2011 | 0.4 | 20.1 | 14.6 |
| 7/10/2011 | 0 | 28.4 | 12.2 | 8/10/2011 | 0.18 | 25.1 | 15.3 | 9/10/2011 | 0.05 | 22.4 | 16.3 |
| 7/11/2011 | 0 | 28.8 | 10.8 | 8/11/2011 | 0 | 24.1 | 12.7 | 9/11/2011 | 0.11 | 22.6 | 14.5 |
| 7/12/2011 | 0 | 30.7 | 14.2 | 8/12/2011 | 0 | 22.9 | 8.6 | 9/12/2011 | 0.01 | 21.2 | 11.9 |
| 7/13/2011 | 0 | 29.6 | 18.3 | 8/13/2011 | 0 | 24.6 | 6.4 | 9/13/2011 | 0.01 | 22.7 | 9.5 |
| 7/14/2011 | 0 | 26.6 | 12.9 | 8/14/2011 | 0.07 | 22.4 | 10.9 | 9/14/2011 | 0 | 25.2 | 10.1 |
| 7/15/2011 | 0 | 26.6 | 7.8 | 8/15/2011 | 1.33 | 24.2 | 14.4 | 9/15/2011 | 0.11 | 23.9 | 12.8 |
| 7/16/2011 | 0 | 26.3 | 9.8 | 8/16/2011 | 0.29 | 20.8 | 14.3 | 9/16/2011 | 0.35 | 15.7 | 2.8 |
| 7/17/2011 | 0 | 27.6 | 9.6 | 8/17/2011 | 0 | 26.3 | 12.4 | 9/17/2011 | 0 | 13.9 | 1.5 |
| 7/18/2011 | 0 | 30.1 | 13.8 | 8/18/2011 | 0 | 26.3 | 9.6 | 9/18/2011 | 0 | 14.2 | 5.7 |
| 7/19/2011 | 0 | 31 | 15.2 | 8/19/2011 | 0 | 26.4 | 13.7 | 9/19/2011 | 0 | 16.6 | 2.9 |
| 7/20/2011 | 0.3 | 31 | 20.2 | 8/20/2011 | 0.2 | 25.4 | 12.2 | 9/20/2011 | 0.22 | 16 | 5.3 |
| 7/21/2011 | 0 | 33.1 | 16.9 | 8/21/2011 | 0 | 26.1 | 12.4 | 9/21/2011 | 0.08 | 20.2 | 12.4 |
| 7/22/2011 | 0 | 34.9 | 16.6 | 8/22/2011 | 0.47 | 24.9 | 15.3 | 9/22/2011 | 0.01 | 20.8 | 13.7 |
| 7/23/2011 | 0 | 36.9 | 23.2 | 8/23/2011 | 0 | 21.1 | 8.8 | 9/23/2011 | 0 | 22.2 | 12.9 |
| 7/24/2011 | 0 | 32 | 19.8 | 8/24/2011 | 0 | 22.9 | 6 | 9/24/2011 | 0.24 | 18.8 | 12.6 |
| 7/25/2011 | 0 | 31 | 20 | 8/25/2011 | 0 | 23.9 | 12.8 | 9/25/2011 | 0 | 20.6 | 11.5 |
| 7/26/2011 | 1.03 | 26.1 | 17.7 | 8/26/2011 | 0.37 | 25.2 | 13.7 | 9/26/2011 | 0 | 22.4 | 13.9 |
| 7/27/2011 | 0.13 | 27.7 | 13.7 | 8/27/2011 | 0.01 | 25.5 | 11.2 | 9/27/2011 | 0 | 23.9 | 17.6 |
| 7/28/2011 | 0 | 27.1 | 10.6 | 8/28/2011 | 0.2 | 23.5 | 14.1 | 9/28/2011 | 1.04 | 20 | 16.1 |
| 7/29/2011 | 0.77 | 21.7 | 16 | 8/29/2011 | 0.65 | 21.6 | 8 | 9/29/2011 | 0.54 | 20.6 | 14 |
| 7/30/2011 | 0 | 30.6 | 18 | 8/30/2011 | 0 | 21.1 | 5.6 | 9/30/2011 | 0.07 | 16.9 | 9.2 |
| 7/31/2011 | 0 | 29.3 | 14.8 | 8/31/2011 | 0 | 24.3 | 5.4 | | | | |

**Table 7 cont.** Precipitation rate, daily high temperatures, and daily low temperatures for the duration of the study in 2011.

| October | Precip. (in.) | Daily High (°C) | Daily Low (°C) | November | Precip. (in.) | Daily High (°C) | Daily Low (°C) |
|---|---|---|---|---|---|---|---|
| 10/1/2011 | 0.01 | 13.7 | 7.4 | 11/1/2011 | 0 | 5.5 | -5.8 |
| 10/2/2011 | 0.4 | 7.4 | 3.3 | 11/2/2011 | 0 | 11 | -4.5 |
| 10/3/2011 | 0.74 | 6 | -0.3 | 11/3/2011 | 0 | 12.9 | -5.1 |
| 10/4/2011 | 0.07 | 10.9 | 2.8 | 11/4/2011 | 0 | 15.1 | -2.1 |
| 10/5/2011 | 0 | 13.9 | 4.6 | 11/5/2011 | 0 | 8.4 | -2.7 |
| 10/6/2011 | 0.01 | 19.4 | 4.4 | 11/6/2011 | 0 | 8.1 | -7.1 |
| 10/7/2011 | 0 | 17.9 | -1.6 | 11/7/2011 | 0 | 10.6 | -1.3 |
| 10/8/2011 | 0 | 19.9 | 1.2 | 11/8/2011 | 0 | 17 | -5.5 |
| 10/9/2011 | 0 | 21.9 | 2.1 | 11/9/2011 | 0 | 18.5 | -1.3 |
| 10/10/2011 | 0 | 24.8 | 4.1 | 11/10/2011 | 0 | 16.2 | -1.6 |
| 10/11/2011 | 0 | 22 | 4.5 | 11/11/2011 | 0.05 | 10.4 | -1 |
| 10/12/2011 | 0 | 19.1 | 5.5 | 11/12/2011 | 0 | 3.5 | -3.4 |
| 10/13/2011 | 0.54 | 15.9 | 9.6 | 11/13/2011 | 0 | 13.3 | -2.9 |
| 10/14/2011 | 0.29 | 15.8 | 10.1 | 11/14/2011 | 0 | 15.1 | 5.2 |
| 10/15/2011 | 0.28 | 15.9 | 6.1 | 11/15/2011 | 0.09 | 18.3 | 10.2 |
| 10/16/2011 | 0 | 12.5 | 7.3 | 11/16/2011 | 0.21 | 12 | 7.5 |
| 10/17/2011 | 0.18 | 16.3 | 6.2 | 11/17/2011 | 0.23 | 10.5 | 3.8 |
| 10/18/2011 | 0.01 | 15.3 | 3.9 | 11/18/2011 | 0 | 3.8 | -3.1 |
| 10/19/2011 | 0 | 18.9 | 8 | | | | |
| 10/20/2011 | 0.92 | 16.1 | 9.8 | | | | |
| 10/21/2011 | 0.04 | 9.8 | 5 | | | | |
| 10/22/2011 | 0 | 6.8 | 3.6 | | | | |
| 10/23/2011 | 0 | 9.8 | -0.6 | | | | |
| 10/24/2011 | 0 | 13.2 | -3.5 | | | | |
| 10/25/2011 | 0.05 | 14.5 | 2.6 | | | | |
| 10/26/2011 | 0 | 14.3 | 2.6 | | | | |
| 10/27/2011 | 0 | 15.6 | 1.9 | | | | |
| 10/28/2011 | 0.4 | 13.8 | -1.3 | | | | |
| 10/29/2011 | 0 | 4.4 | -4.2 | | | | |
| 10/30/2011 | 0.43 | 1.3 | -6.1 | | | | |
| 10/31/2011 | 0.21 | 5.4 | -8.9 | | | | |

*Figure 1: $CO_2$ powered boom sprayer used for application of liquid materials.*

*Figure 2: Bent and poa showing phytotoxicity after treatment of MRC at 55 oz applied APR/4/12 WAT. Photo taken 5/12/11*