2015 Final Project Summary: Evaluation of Preventative and Curative DMI Applications for Management of *Sclerotinia homoeocarpa* Populations Insensitive to the DMI Fungicide Class

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Introduction and Objectives

Dollar spot (caused by *Sclerotinia homoeocarpa*) is a major turfgrass disease causing significant damage to turfgrass swards from May to October on New England golf courses (Smiley et al., 2005; Walsh et al., 1999). Cultural practices often do not provide adequate dollar spot control and multiple fungicide applications are made each year to maintain acceptable turf quality. Frequent fungicide applications on golf courses have led to the development of fungicide resistance and recent monitoring work (funded by the NERTF) of New England golf courses revealed that 100% of the courses assayed in 2011 and 2012 were comprised of *S. homoeocarpa* populations with reduced sensitivity to the DMI class. We have also observed (2009-2012) that DMI field efficacy is reduced by 20-50% (low label rate of propiconazole) on sites that contain *S. homoeocarpa* isolates with reduced DMI sensitivity (Popko et al, 2012). Two recent studies have used isolates sampled from New England golf courses with confirmed DMI resistance and determined that an ATP binding cassette (ABC) transporter gene (*ShatrD*) and pleiotropic drug transporter gene (*ShPDR1*) are overexpressed in the presence of propiconazole (Hulvey et al., 2012 and Sang et al., 2014). Transporter genes have been shown to efflux ("pump out") fungicides in other fungal systems, which may explain why DMI fungicides show reduced control as opposed to a complete failure (i.e. benzimidazole) following application. *Sclerotinia homoeocarpa* isolates with increased expression of ABC transporter genes are likely to overcome DMI fungicides and shorten control intervals, therefore we observe reduced control, but not complete failure.

Results from the fungicide rotation strategy study (NERTF funded; initiated in 2012 by the Jung Lab) indicate that DMI fungicides can be effective if used in rotation with other active ingredients. The data further indicates that DMIs applied preventatively or with low infection centers resulted in better dollar spot control than curative applications. The amount of inoculum played a major role in these results but also provides insight for developing a research-based recommendation for golf course superintendents who can use application timing to manage *S. homoeocarpa* populations with reduced sensitivity to DMI fungicides. Another facet of optimizing dollar spot control on DMI insensitive populations is determining which DMI active ingredients are most effective in the field. Previous work by Ok et al. (2011) determined the *in vitro* sensitivity correlation of the six DMI fungicides (metconazole, myclobutanil, propiconazole, tebuconazole, triadimefon and triticonazole), which are labeled for solo use (non-premixed products). However, none of the aforementioned active ingredients are applied in the field at the same rate of active ingredient. Thus correlating *in vitro* sensitivity to field efficacy of DMI fungicides is nearly impossible. Therefore, a more practical solution

would be to examine all DMI fungicides that can be applied alone at their most commonly used rates. Our main objectives are:

1. Determine field efficacy of preventative vs. curative applications of DMI fungicides for controlling dollar spot
2. Determine which DMI active ingredients are the most effective at their most commonly used rates

Materials and Methods

Locations of project

Field efficacy testing was conducted at the Ranch Golf Club (Southwick, MA) and Rockledge Country Club (West Hartford, CT). Both sites are resistant to the benzimidazole fungicide class and insensitive to the DMI fungicide class. The trial was conducted on creeping bentgrass (Ranch Golf Club) and creeping bentgrass and annual bluegrass (Rockledge Country Club) mowed two-three times per week at fairway height (0.5 inches). Irrigation was provided as needed. A total of 1.75 lbs of N/1,000 ft^2 was applied at the Ranch Golf Club and 1.5 lbs of N/1,000 ft^2 was applied at the Rockledge Golf Club in 2013. A total of 1.25 lbs of N/1,000 ft^2 was applied at the Ranch Golf Club and 1.5 lbs of N/1,000 ft^2 was applied at the Rockledge Golf Club in 2014. Management of turfgrass insects and weeds was at the discretion of the superintendent.

Field Efficacy Testing

Treatments were applied at two different starting times. Preventative treatments for both locations in 2013 began on 22 May and curative treatments were initiated after 10-20 infection centers (average over 4 replicated plots) were observed in test plots. In 2014, preventative treatments were applied on 30 May at Rockledge Golf Club and 17 June at the Ranch Golf Club. All treatments were applied on a 21-day application interval with the exception of the 2nd curative treatment (applied 14 days after 1st application). Field trial plots were arranged in a randomized complete block design, with four replications. Plot size measured 3 x 6 feet with 1 foot buffer strips between each plot. Ratings were taken each week that a detectable amount of dollar spot was observed. Turf quality data was taken, but will not be presented. Phytotoxicity was not observed and as a result disease severity predominantly affected turf quality, therefore, presenting both ratings was avoided.

Dollar spot severity was visually rated by counting number of dollar spot infection centers once per week. Towards the end of the 2013 and 2014 trials at Rockledge Golf Club and the 2013 trial at the Ranch Golf Club Percent Dollar Spot was assessed due to high dollar spot counts and coalescence of infection centers. To summarize disease severity over time, area under the disease progress curve (AUDPC) was calculated for the number of infection centers at each location using the following formula $\Sigma[(y_i + y_{i+1})/2](t_{i+1} - t_i)$, where $i = 1, 2, 3, \ldots, n\text{-}1$ and y_i is the amount of disease (number of infection centers) at the time t_i (days) of the i_{th} rating. AUDPC values were converted into relative control (RC%) percentage with the following formula: [(untreated – fungicide treated)/untreated] x 100 = RC% and were subject to an analysis of variance and means were separated using Fisher's LSD test ($P < 0.05$).

Results

2013 Rockledge Golf Club

Disease was also slow to develop in the early portion of the trial; however, heavy dollar spot pressure was observed from early August to the remainder of the trial. Preventative treatments performed significantly better than curative treatments ($P < 0.001$) and active ingredients were analyzed separately within application timing. Torque, Bayleton Flo and Banner MAXX II ranked as the top three DMI performers in both the preventive and curative timings among DMI active ingredients (Table 1). It should be noted that DMI active ingredients were clustered tightly together for both application timings with exception of myclobutanil. In terms of non-DMI active ingredients, Emerald was observed to control dollar spot best among non-DMI treatments. Secure also provided good dollar spot control and was significantly better than Daconil Ultrex in both application timings.

2014

Disease pressure was very high throughout the duration of the trial. Preventative treatments numerically controlled dollar spot better than curative, however, significant statistical differences were not observed ($P = 0.0625$). Tourney, Bayleton Flo, Torque and Banner MAXX were the top performing DMI treatments in the trial, however, some drop-off in control was observed for Tourney and Bayleton Flo in the curative portion. Secure was the top performing non-DMI ingredient, however it should be noted that Curalan and Emerald closely followed Secure in both portions of the trial. Lastly, the amount of dollar spot infection observed at Rockledge GC was by far the most dollar spot we observed during the 2014 season.

Plot photo take on 6 Aug, 2014.

Ranch Golf Club

2013

Disease was slow to develop in the early portion of the season and increased significantly from late July to the conclusion of the experiment. There was a significant gradient in disease and the curative portion of the plot contained significantly less dollar spot. As a result, the merit of preventative and curative applications could not be properly examined. Nonetheless, DMI active ingredients within application timing were still examined. Bayleton Flo and Torque were the top performing DMI treatments in the preventative trial, however, none of the DMI treatments provided similar control to the Emerald, Secure or the rotation treatments in the preventative trial. Results in the curative trial were more variable than the preventative trial due to inconsistent disease pressure throughout the trial area. However, some consistencies were observed, such as Bayleton, Torque and Banner MAXX ranking as the top 3 DMI active ingredients in terms of control. Control trends in the curative trial mirrored observations from the preventative trial.

2014

Similar to the 2013 trial, dollar was very slow to develop and unfortunately dollar spot infection was very uneven among the test plots. For instance, we observed more dollar spot (higher AUDPC value) infection on the untreated plots in the curative trial than in the preventative trial, despite the fact that the preventative trial was started a month earlier. Banner MAXX was the only DMI treatment to perform consistent in both trials and was the top performing DMI. Among non-DMI fungicides, Emerald was the top performing non-DMI.

Summary

Overall, we observed a fairly consistent trend among the intrinsic activity of DMI active ingredients for both sites and application timings. Banner MAXX, Bayleton Flo, Torque and Tourney consistently ranked higher than Myclobutanil 20EW, Triton Flo and Trinity and in some cases differences were subtle. We would like to note that lower label rates were used in this study to encourage differences among DMI treatments and better control may be observed with higher rates. However, this does give greater insight on the most intrinsically active DMI fungicides for dollar spot control. Furthermore, during lower disease pressure (May-June), the more intrinsically active DMI fungicides often performed comparably to the non-DMI options included in this trial. The application-timing portion of the experiment did not yield consistent results at both locations. However, we did observe more consistent disease pressure at Rockledge GC and in those instances, preventative DMI treatments outperformed curative DMI treatments.

Table 1. Fungicide treatment, fungicide class and application rate.

Trt #	Treatment[z]	Group name	Rate (oz/1,000 ft^2)	Timing
1	Untreated	---	---	---
2	Myclobutanil 20EW	DMI	1.2	Preventative/Curative
3	Tourney	DMI	0.18	Preventative/Curative
4	Banner MAXX II	DMI	1.0	Preventative/Curative
5	Bayleton Flo	DMI	0.5	Preventative/Curative
6	Torque	DMI	0.6	Preventative/Curative
7	Triton Flo	DMI	0.5	Preventative/Curative
8	Trinity	DMI	1.0	Preventative/Curative
9	Fungicide Rotation[y]	Mix	---	Preventative/Curative
10	Secure	2,6-dinitroaniline	0.5	Preventative/Curative
11	Curalan	Dicarboximide	1.0	Preventative/Curative
12	Emerald	SDHI	0.18	Preventative/Curative
13	Daconil Ultrex	Nitrile	3.0	Preventative/Curative

[z] All treatments applied on a 21-day interval.

[y] Rotation schedule: 1.) Emerald (0.13 oz/M), 2.) Torque (0.6 oz/M), 3.) Velista (0.5 oz/M) + Secure (0.5 oz/M), 4.) Curalan (1.0 oz/M) and 5.) Emerald (0.18 oz/M).

Table 2. 2013 and 2014 Relative Control Percentage of Dollar Spot at Rockledge Golf Club.

	Relative Control %[z]			
	2013		2014	
Treatment	Preventative	Curative	Preventative	Curative
Untreated	---	---	---	---
Myclobutanil 20EW	47 g	17 e	37 f	41 ef
Tourney	67 e	43 d	75 a-c	53 c-f
Banner MAXX II	72 c-e	47 cd	65 c-e	59 b-e
Bayleton Flo	69 de	61 bc	66 b-d	41 ef
Torque	78 b-d	57 cd	71 a-d	67 a-e
Triton Flo	66 ef	43 d	46 ef	29 f
Trinity	56 fg	44 d	54 d-f	45 d-f
Rotation	83 b	84 a	72 a-d	58 b-e
Secure	83 ab	80 a	89 a	88 a
Curalan	80 bc	75 ab	85 a-c	82 ab
Emerald	94 a	89 a	85 ab	79 a-c
Daconil Ultrex	53 g	60 c	65 b-e	68 a-d

[z] AUDPC values were converted into relative control (RC%) percentage with the following formula: [(untreated – fungicide treated)/untreated] x 100 = RC%. RC % is reported as a mean of 4 replications.

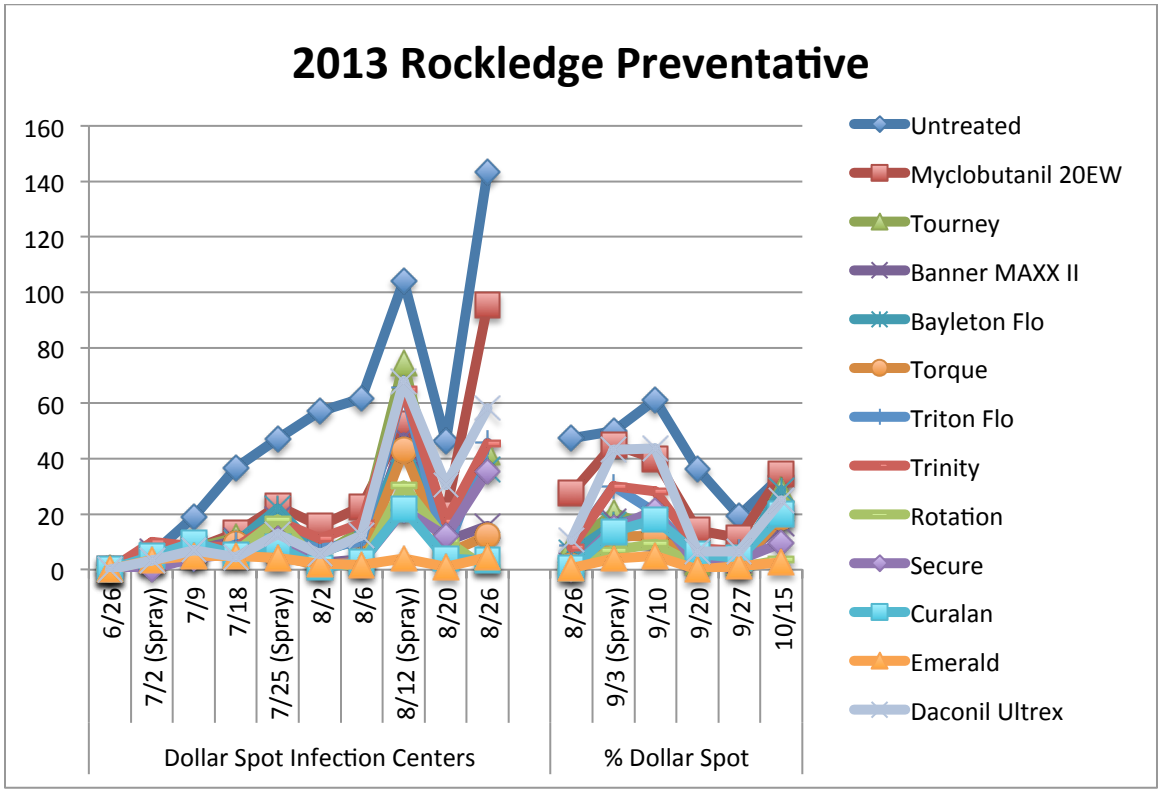
[Y] Means followed by the same letter are not significantly different according to Fisher's Protected LSD.

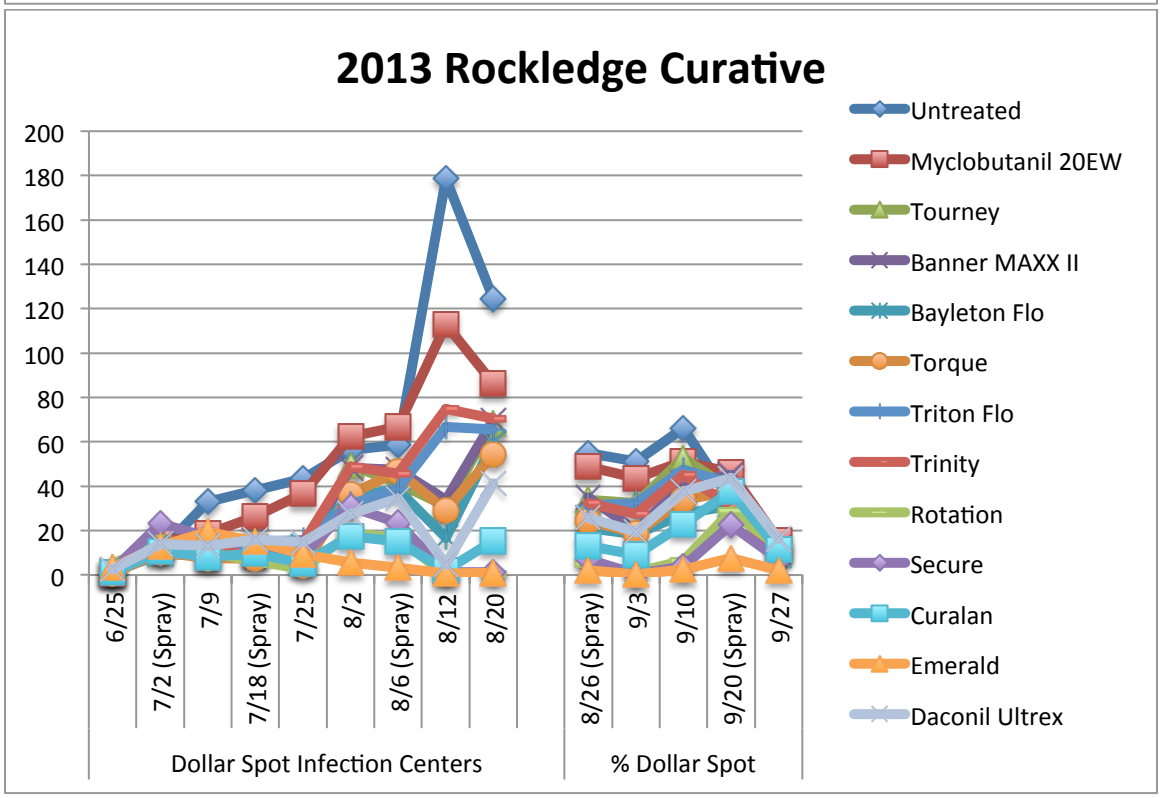
Table 3. 2013 and 2014 Relative Control Percentage of Dollar Spot at the Ranch Golf Club

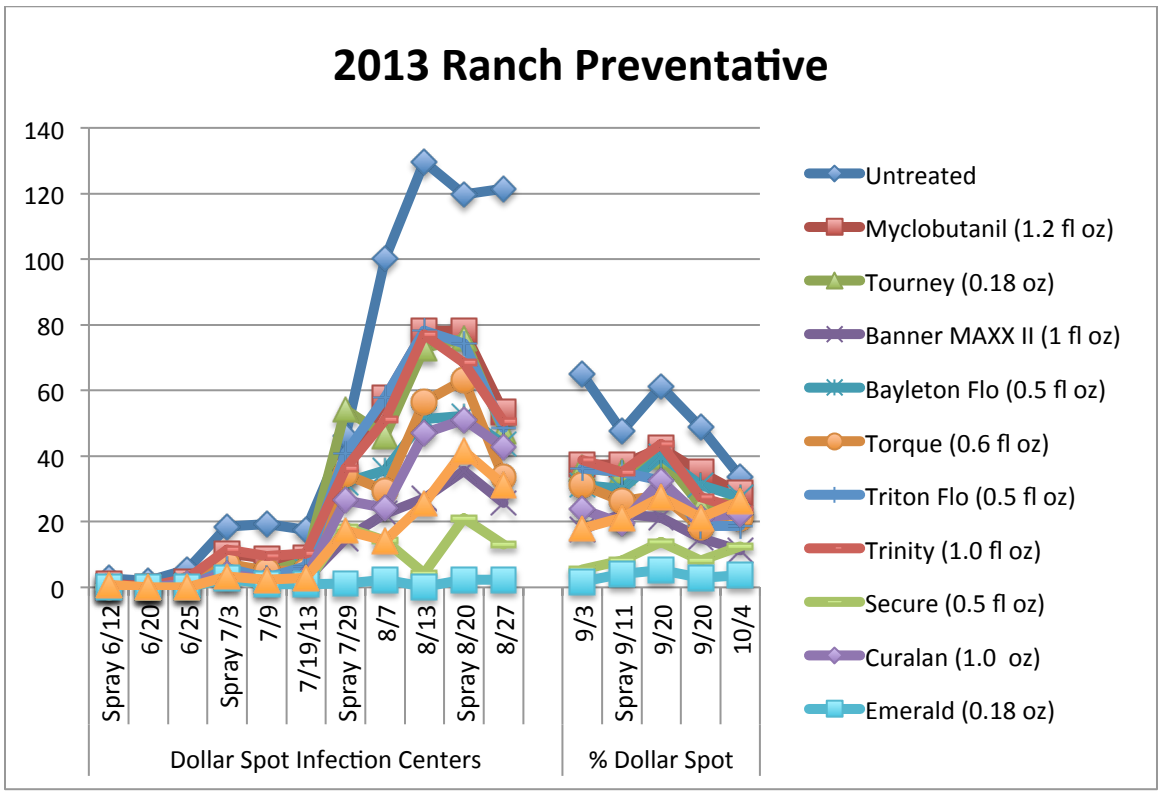
	Relative Control %[z]			
	2013		2014	
Treatment	Preventative	Curative	Preventative	Curative
Untreated	---	---	---	---
Myclobutanil 20EW	17 d[y]	34 d-f	4 c-e	43 de
Tourney	43 d	48 c-e	-13 de	3 f
Banner MAXX II	46 cd	76 ab	70 a-c	65 a-d
Bayleton Flo	60 bc	57 b-d	36 a-d	55 b-e
Torque	57 cd	57 b-e	19 b-d	49 b-e
Triton Flo	42 d	18 f	-58 e	45 c-e
Trinity	44 d	31 ef	-23 de	28 ef
Rotation	83 a	91 a	82 ab	71 a-d
Secure	79 a	92 a	74 a-c	79 a-c
Curalan	75 ab	81 ab	69 a-c	83 ab
Emerald	89 a	95 a	96 a	92 a
Daconil Ultrex	59 c	69 a-c	41 a-d	54 b-e

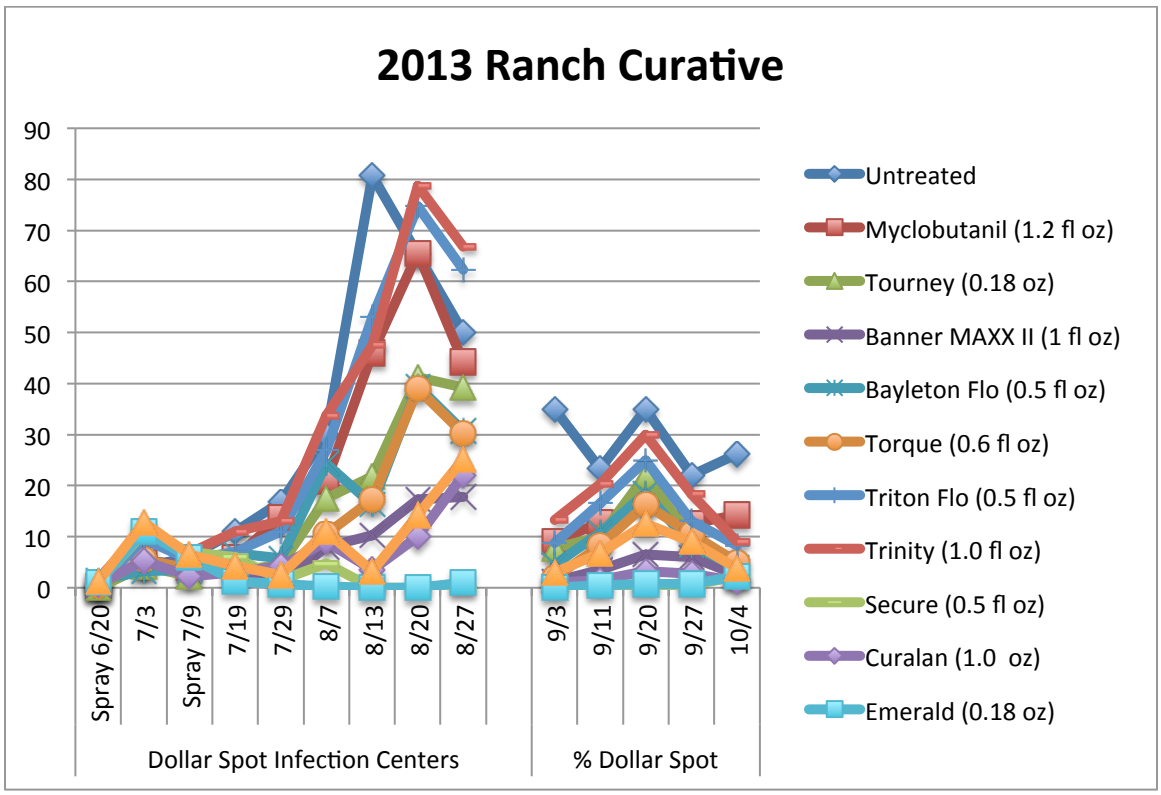
[z] AUDPC values were converted into relative control (RC%) percentage with the following formula: [(untreated – fungicide treated)/untreated] x 100 = RC%. RC % is reported as a mean of 4 replications.

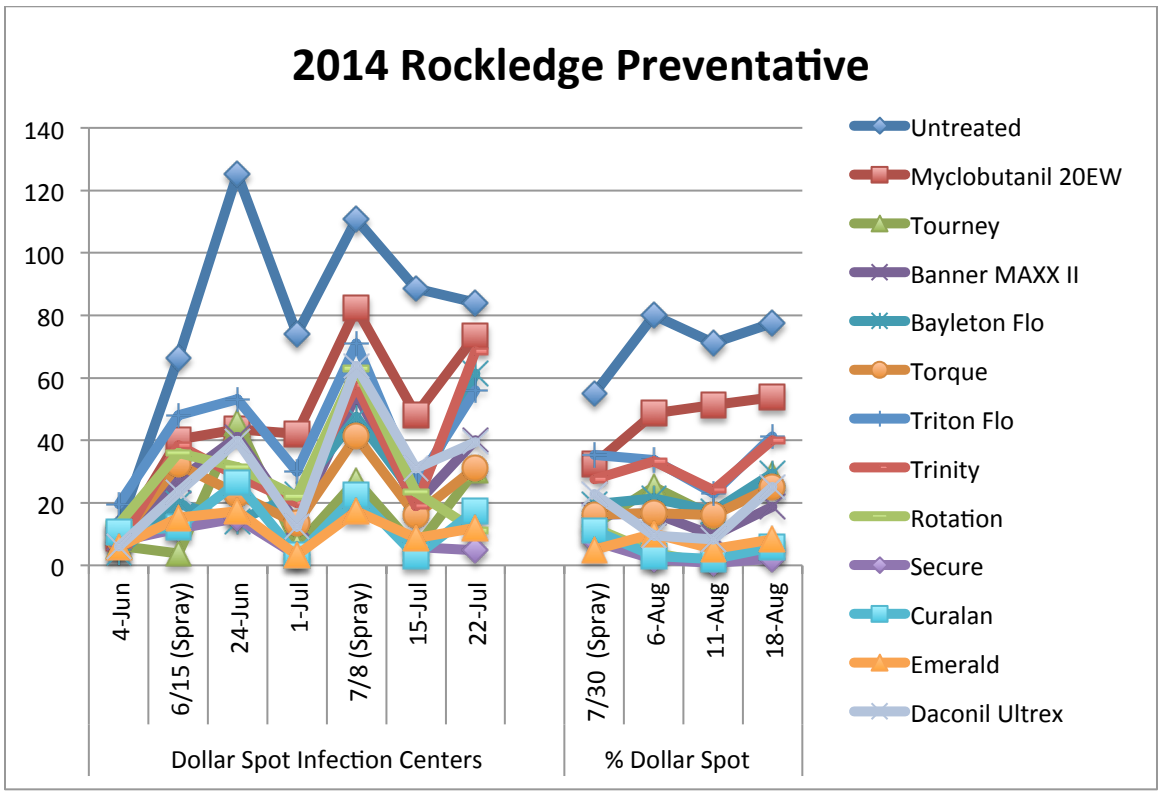
[Y] Means followed by the same letter are not significantly different according to Fisher's Protected LSD.

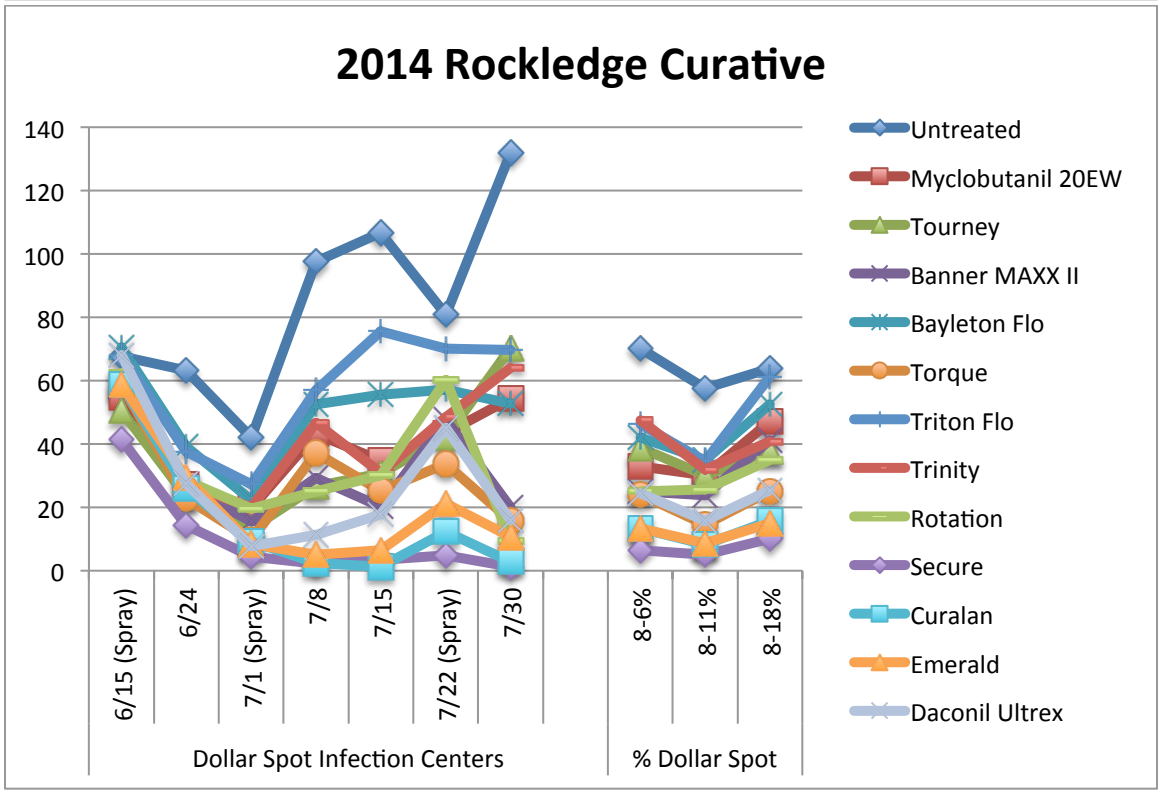

2013 Rockledge Preventative
160
140
120
100
80
60
40
20
0
6/26
7/2 (Spray)
7/9
7/18
7/25 (Spray)
8/2
8/6
8/12 (Spray)
8/20
8/26
8/26
9/3 (Spray)
9/10
9/20
9/27
10/15
Dollar Spot Infection Centers
% Dollar Spot
Untreated
Myclobutanil 20EW
Tourney
Banner MAXX II
Bayleton Flo
Torque
Triton Flo
Trinity
Rotation
Secure
Curalan
Emerald
Daconil Ultrex

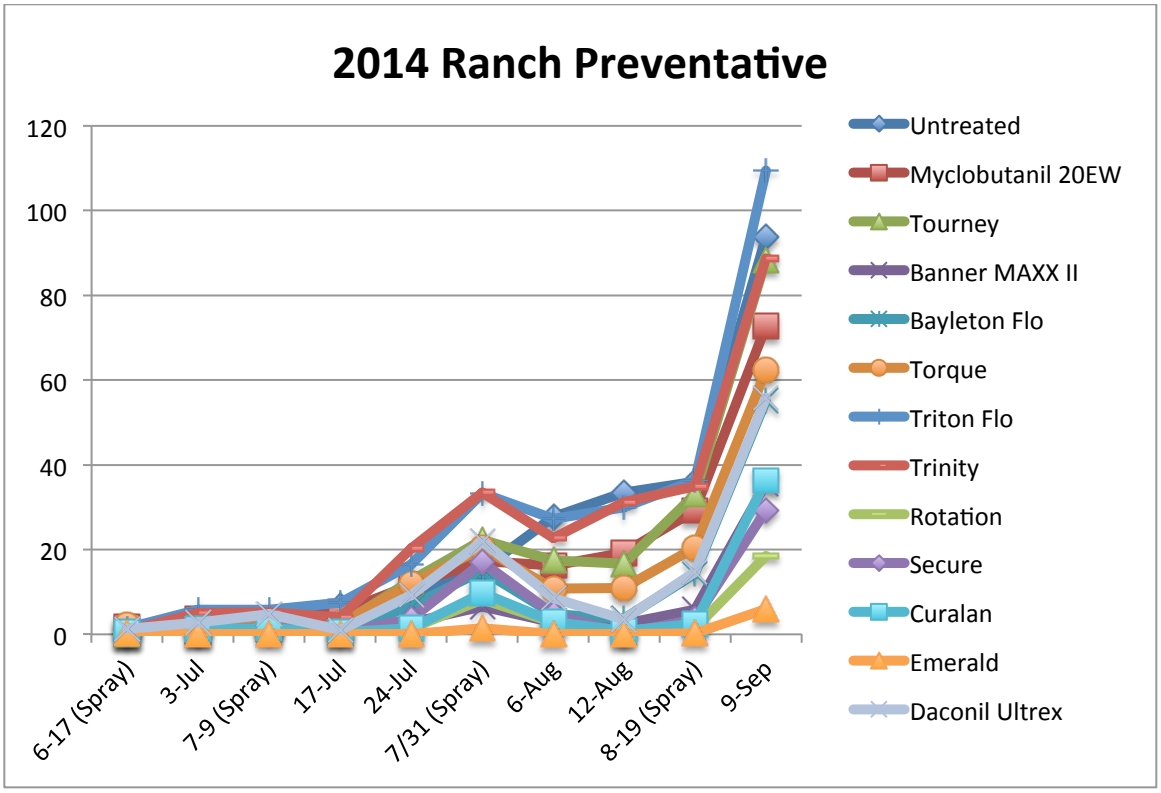

2013 Rockledge Curative
200
180
160
140
120
100
80
60
40
20
0
6/25
7/2 (Spray)
7/9
7/18 (Spray)
7/25
8/2
8/6 (Spray)
8/12
8/20
8/26 (Spray)
9/3
9/10
9/20 (Spray)
9/27
Dollar Spot Infection Centers
% Dollar Spot
Untreated
Myclobutanil 20EW
Tourney
Banner MAXX II
Bayleton Flo
Torque
Triton Flo
Trinity
Rotation
Secure
Curalan
Emerald
Daconil Ultrex

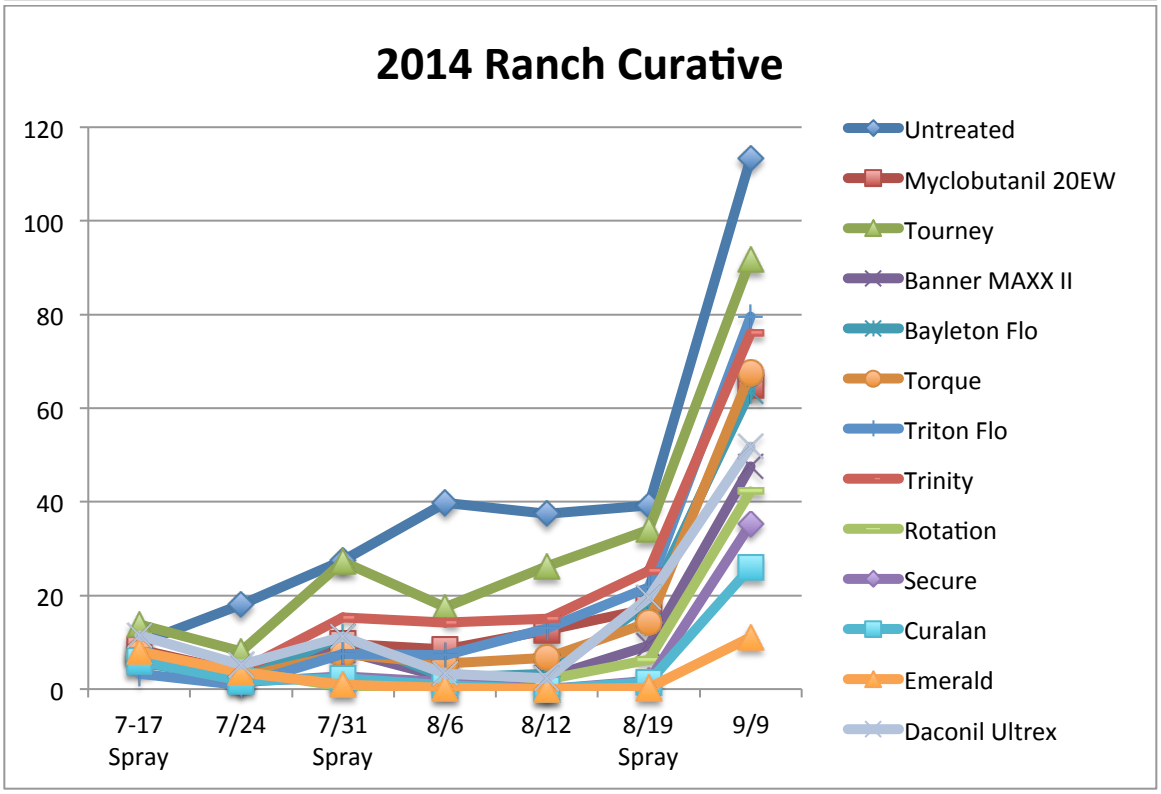

2013 Ranch Preventative
140
120
100
80
60
40
20
0
Spray 6/12
6/20
6/25
Spray 7/3
7/9
7/19/13
Spray 7/29
8/7
8/13
Spray 8/20
8/27
9/3
Spray 9/11
9/20
9/20
10/4
Dollar Spot Infection Centers
% Dollar Spot
Untreated
Myclobutanil (1.2 fl oz)
Tourney (0.18 oz)
Banner MAXX II (1 fl oz)
Bayleton Flo (0.5 fl oz)
Torque (0.6 fl oz)
Triton Flo (0.5 fl oz)
Trinity (1.0 fl oz)
Secure (0.5 fl oz)
Curalan (1.0 oz)
Emerald (0.18 oz)


2013 Ranch Curative
90
80
70
60
50
40
30
20
10
0
Spray 6/20
7/3
Spray 7/9
7/19
7/29
8/7
8/13
8/20
8/27
9/3
9/11
9/20
9/27
10/4
Dollar Spot Infection Centers
% Dollar Spot
Untreated
Myclobutanil (1.2 fl oz)
Tourney (0.18 oz)
Banner MAXX II (1 fl oz)
Bayleton Flo (0.5 fl oz)
Torque (0.6 fl oz)
Triton Flo (0.5 fl oz)
Trinity (1.0 fl oz)
Secure (0.5 fl oz)
Curalan (1.0 oz)
Emerald (0.18 oz)


2014 Rockledge Preventative
140
120
100
80
60
40
20
0
4-Jun
6/15 (Spray)
24-Jun
1-Jul
7/8 (Spray)
15-Jul
22-Jul
7/30 (Spray)
6-Aug
11-Aug
18-Aug
Dollar Spot Infection Centers
% Dollar Spot
Untreated
Myclobutanil 20EW
Tourney
Banner MAXX II
Bayleton Flo
Torque
Triton Flo
Trinity
Rotation
Secure
Curalan
Emerald
Daconil Ultrex


2014 Rockledge Curative
140
120
100
80
60
40
20
0
6/15 (Spray)
6/24
7/1 (Spray)
7/8
7/15
7/22 (Spray)
7/30
8-6%
8-11%
8-18%
Dollar Spot Infection Centers
% Dollar Spot
Untreated
Myclobutanil 20EW
Tourney
Banner MAXX II
Bayleton Flo
Torque
Triton Flo
Trinity
Rotation
Secure
Curalan
Emerald
Daconil Ultrex


2014 Ranch Preventative
120
100
80
60
40
20
0
6-17 (Spray)
3-Jul
7-9 (Spray)
17-Jul
24-Jul
7/31 (Spray)
6-Aug
12-Aug
8-19 (Spray)
9-Sep
Untreated
Myclobutanil 20EW
Tourney
Banner MAXX II
Bayleton Flo
Torque
Triton Flo
Trinity
Rotation
Secure
Curalan
Emerald
Daconil Ultrex


2014 Ranch Curative
120
100
80
60
40
20
0
7-17
Spray
7/24
7/31
Spray
8/6
8/12
8/19
Spray
9/9
Untreated
Myclobutanil 20EW
Tourney
Banner MAXX II
Bayleton Flo
Torque
Triton Flo
Trinity
Rotation
Secure
Curalan
Emerald
Daconil Ultrex

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