

## 2008 Petro-Canada Product Evaluation Evaluation of Reduced Fungicide Management of Putting Green Turf

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### Objective

The objective of this study was to evaluate the potential of Petro-Canada experimental products to reduce reliance on traditional synthetic fungicides for disease management in golf course putting green turf.

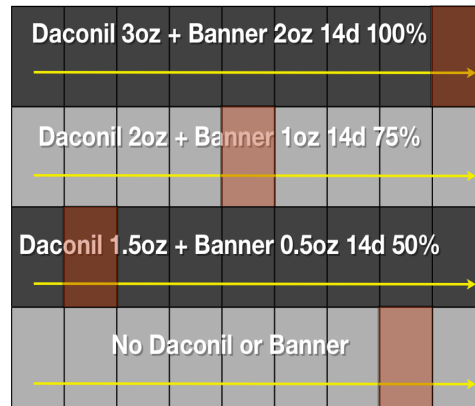
### Methodology

The study was established in a strip-split plot design with main strip plots of standard fungicide programs randomly distributed and nine split plot fungicide treatments randomly distributed within the strips with all treatments replicated three times (see figure).

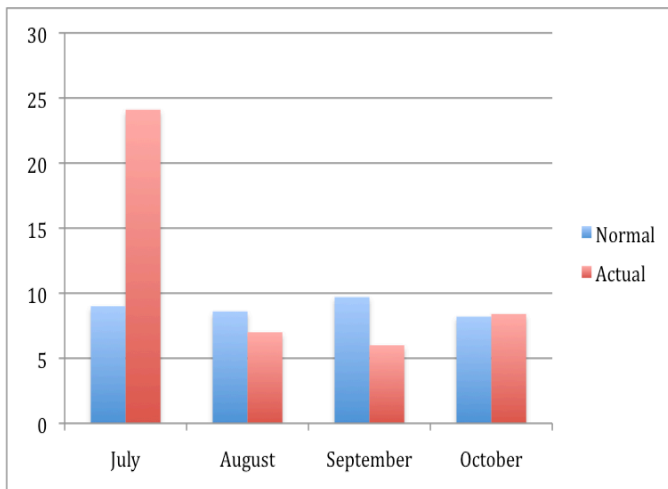
The main plot treatments were standard Daconil/Banner fungicide programs at full rate, 0.75 rate, and 0.50 rate applied at 14-day intervals. The split-plot treatments applied within the main treatment strips included a control (fertilizer only) and nine rate/interval combinations of Petro Canada products, Rhapsody, and EcoGuard. Initial treatments were made on July 4 and continued for 16 weeks (final regular treatment made on October 22).

Treatments were applied to experimental plots (4' x 4') established at the Cornell University Turfgrass Research Center in Ithaca, NY on a mixed stand of creeping bentgrass/annual bluegrass (*Agrostis palustris*/*Poa* putting green turf (pH=6.7). The research area has been heavily modified with coring and straight sand topdressing resulting in a significant sand layer above the native soil green.

The turf is mowed seven times per week at 0.130" and clippings collected.



Example of experimental plot design used for strip-split plot treatments.



Fertility program includes ammonium sulfate, iron sulfate and Primo plant growth regulator applied every 7-10 days. Annual nitrogen rate was 2.5 lbs per 1000 sq feet, iron is applied at 2-4 ounces per application and Primo at 0.125 ounces of product per 1000 square feet per application. Straight sand topdressing (pH 6.0) is applied every 14 days as straight sand, typically in conjunction with light vertical mowing or grooming. Precipitation was above normal in the early season and remained at or about normal and

therefore supplemental irrigation was not required on a regular basis.(see figure).

Golf traffic is simulated daily during the season using a modified traffic device with two 0.5 meter diameter rollers that spin at different speeds to create slipping motion. The rollers are fitted with SoftSpikes. The amount of spikes and passes used are designed to simulate 30,000 rounds of golf.

Chemical applications were made with a handheld CO<sub>2</sub> sprayer at 40 psi (276 kPa) fitted with TeeJet XR8015 nozzles calibrated to deliver 2 gallons (7.6 liters) of water per 1,000 ft<sub>2</sub> (92.9 m<sub>2</sub>).

Data were collected for turf quality, turf color, disease and clipping production. Data analysis was conducted using linear mixed models with compound symmetric covariance structure to assess over treatment effects when repeated measurements were made on the same experimental unit over time. Treatment differences at individual measurement events (where there was no rate x treatment interaction) were evaluated using analysis of variance and Fisher's protected least significant difference (LSD). The MIXED and GLM procedures in SAS/STAT software version 9.1 (SAS, Cary, NC) were used to perform the analyses.

Table 1. Treatment list

Trt#	Product	Rate/1000 (oz/1000)	Interval (days)
1	Untreated, fertilizer only	-	-
2	Rhapsody	3	14
3	Rhapsody	5	14
4	PC2: Pack A	7.25	
	PC2: Pack B	0.91	14
5	PC2: Pack A	14.5	
	PC2: Pack B	1.8	14
6	PC2: Pack A	21.75	
	PC2: Pack B	2.7	21
7	PC2: Pack A	7.25	
	PC2: Pack B	0.91	7
8	PC2: Pack A	21.75	
	PC2: Pack B	2.7	28
9	PC1	8.7	14
10	EcoGuard	20	14
Fungicide Strips			
Rate	Product	Rate/1000 (oz/1000)	Interval (days)
0	Untreated, fertilizer only	-	-
0.50	Daconil	1	
	Banner	0.5	14
0.75	Daconil	2	
	Banner	1	14
Full	Daconil	3	
	Banner	2	14

## Results

### Turf Quality

Turf quality was assessed on 3 occasions using a scale of 1 to 9; where 1 = poor quality, 9 = excellent quality, and 6 = acceptable quality. For each rating date and when ratings were averaged over all rating dates there was a significant split-plot treatment x Daconil/Banner rate interaction. Means followed by the same

letter are not significantly different based on Fisher's protected least significant difference (LSD), where  $p=0.05$ .

Close inspection of each rating date reveals a strong trend in improved turfgrass quality with PC 2 products independent of Daconil/Banner treatment. Specifically, the PC2 treatment 7 applied at 7 day intervals consistently provided the highest quality turf with treatments 8 (high rate, 21 day intervals), 5 (mid-rate, 14 day intervals), and treatment 4 (low rate, 14 day intervals) also providing acceptable quality turf with minimal contribution from Daconil/Banner programs.

Interestingly, these data reveal an obvious 50 percent reduction in Daconil/Banner use is possible with the incorporation of PC2 products whilst maintaining acceptable (at least 6 rating) and in some cases very good (>7 rating) turfgrass quality.

Within the PC products it appears that the low rate PC2 treatment is an excellent option for putting green programs that apply weekly, while the high rate program offers a 28 day application interval that possibly more modest budget golf course might consider as a means to reduce labor costs. This response is also consistent with some fairway turfgrass quality data reported in a sister study conducted at Cornell University in 2008.

Figure 1. Treatment effects on turfgrass quality ratings by Daconil Banner rate for July 24

Trt		Rate = 0		Trt		Rate = 0.50		Trt		Rate = 0.75		Trt		Rate = 100	
1	1.4	a		3	3.1	a		2	3.6	a		1	6.7	a	
2	3.0	b		2	3.2	a		1	5.3	b		3	6.8	a	
3	3.2	b		1	3.3	a		3	5.8	c		4	6.8	a	
6	4.5	c		6	6.0	b		9	6.5	d		2	6.9	a	
5	4.7	c		5	6.1	b		6	6.6	d		10	6.9	a	
9	5.0	c		4	6.2	b		10	6.7	d		9	7.0	a	
4	5.1	c d		9	6.4	b		4	7.0	d e		5	7.1	a	
10	5.1	c d		10	6.4	b		5	7.5	e		6	7.1	a	
8	5.6	c d		8	7.0	b c		8	7.5	e		8	7.5	b	
7	5.9	d		7	7.3	c		7	7.7	e		7	8.2	c	

Figure 2. Split-plot treatment effects on turfgrass quality ratings for July 24

Rate	Trt 1		Rate	Trt 2		Rate	Trt 3		Rate	Trt 4		Rate	Trt 5		
0	1.4	a		0	3.0	a		0.50	3.1	a		0	5.1	a	
0.50	3.3	b		0.50	3.2	a		0	3.2	a		0.50	6.2	b	
0.75	5.3	c		0.75	3.6	a		0.75	5.8	c		100	6.8	c	
100	6.7	d		100	6.9	b		100	6.8	d		0.75	7.0	c	

Rate	Trt 6		Rate	Trt 7		Rate	Trt 8		Rate	Trt 9		Rate	Trt 10		
0	4.5	a		0	5.9	a		0	5.6	a		0	5.1	a	
0.50	6.0	b		0.50	7.3	b		0.50	7.0	b		0.50	6.4	b	
0.75	6.6	c		0.75	7.7	b c		0.75	7.5	c		0.75	6.5	b	
100	7.1	d		100	8.2	c		100	7.5	c		100	7.0	c	

Figure 3. Treatment effects on turfgrass quality ratings by Daconil Banner rate for August 29

Trt	Rate = 0		Trt	Rate = 0.50		Trt	Rate = 0.75		Trt	Rate = 100	
1	1.7	a	3	4.1	a	2	5.5	a	2	5.9	a
3	2.0	a	2	4.2	a	4	6.0	b	3	5.9	a
2	2.5	a	1	4.6	a	8	6.1	b	4	6.1	a
4	5.0	b	4	5.7	b	3	6.2	b	8	6.3	a
5	5.1	b	8	5.9	b	1	6.4	b c	1	6.6	a
8	5.4	b	6	6.1	b	9	6.4	b c	5	6.6	a
6	5.7	b	9	6.1	b	5	6.5	b c	6	6.6	a
9	5.8	b	5	6.3	b c	6	6.5	b c	9	6.6	a
10	6.2	b c	10	6.6	b c	10	6.7	b c	10	6.6	a
7	6.5	c	7	7.3	c	7	7.6	c	7	8.6	b

Figure 4. Split-plot treatment effects on turfgrass quality ratings for August 29

Rate	Trt 1		Rate	Trt 2		Rate	Trt 3		Rate	Trt 4		Rate	Trt 5	
0	1.7	a	0	2.5	a	0	2.0	a	0	5.1	a	0	5.9	a
0.50	4.6	b	0.50	4.2	b	0.50	4.1	b	0.50	5.7	b	0.50	6.3	b
0.75	6.4	c	0.75	5.5	c	100	5.9	c	0.75	6.0	b c	0.75	6.5	b
100	6.6	c	100	5.9	c	0.75	6.2	c	100	6.1	c	100	6.6	b

Rate	Trt 6		Rate	Trt 7		Rate	Trt 8		Rate	Trt 9		Rate	Trt 10	
0	5.7	a	0	6.5	a	0	5.4	a	0	5.8	a	0	6.2	a
0.50	6.1	b	0.50	7.3	b	0.50	5.9	b	0.50	6.1	a	0.50	6.6	b
0.75	6.5	c	0.75	7.6	b	0.75	6.1	b c	0.75	6.4	a b	100	6.6	b
100	6.6	c	100	8.6	c	100	6.3	c	100	6.6	b	0.75	6.7	b

Figure 5. Treatment effects on turfgrass quality ratings by Daconil Banner rate for September 17

Trt	Rate = 0		Trt	Rate = 0.50		Trt	Rate = 0.75		Trt	Rate = 100	
1	4.4	a	2	4.5	a	2	6.0	a	2	6.1	a
2	5.3	b	1	4.8	a	3	6.1	a	3	6.2	a
3	5.4	b	3	4.9	a	4	6.4	a	1	6.7	b
4	5.4	b	4	5.9	b	8	6.6	a b	6	6.7	b
8	5.9	c	8	6.0	b	9	6.6	a b	4	6.8	b
9	5.9	c	6	6.3	b	5	6.7	a b	8	6.9	b
6	6.0	c	9	6.4	b c	10	6.7	a b	9	6.9	b
5	6.3	c	5	6.6	b c	1	6.9	a b	5	7.0	b c
10	6.4	c d	10	6.6	b c	6	6.9	a b	10	7.0	b c
7	6.8	d	7	7.8	c	7	8.4	b	7	9.0	c

Figure 6. Split-plot treatment effects on turfgrass quality ratings for September 17

Rate	Trt 1		Rate	Trt 2		Rate	Trt 3		Rate	Trt 4		Rate	Trt 5	
0	4.4	a	0.50	4.5	a	0.50	4.9	a	0	5.4	a	0	6.3	a
0.50	4.8	b	0	5.3	b	0	5.4	a	0.50	5.9	b	0.50	6.6	a
100	6.7	c	0.75	6.0	c	0.75	6.1	b	0.75	6.4	c	0.75	6.7	a b
0.75	6.9	c	100	6.1	c	100	6.2	b	100	6.8	d	100	7.0	b

Rate	Trt 6			Rate	Trt 7			Rate	Trt 8			Rate	Trt 9			Rate	Trt 10		
0	6.0	a		0	6.8	a		0	5.9	a		0	5.9	a		0	6.4	a	
0.50	6.3	b		0.50	7.8	b		0.50	6.0	a		0.50	6.4	a b		0.50	6.6	a	
100	6.7	c		0.75	8.4	c		0.75	6.6	b		0.75	6.6	b		100	6.7	a	
0.75	6.9	d		100	9.0	d		100	6.9	c		100	6.9	b		0.75	7.0	a	

Figure 7. Treatment effects on turfgrass quality ratings by Daconil Banner rate averaged cross all dates

Trt	Rate = 0			Trt	Rate = 0.50			Trt	Rate = 0.75			Trt	Rate = 100		
1	2.4	a		2	4.0	a		2	5.1	a		3	6.4	a	
3	3.4	b		3	4.0	a		3	6.1	b		2	6.5	a	
2	3.5	b		1	4.2	a		1	6.3	b		4	6.7	a b	
4	5.1	c		4	5.9	b		4	6.5	c		1	6.8	b	
6	5.3	c		6	6.1	b		9	6.6	c		6	6.9	b	
9	5.5	c		5	6.3	b c		6	6.7	c		5	7.0	b	
5	5.6	c		8	6.3	b c		8	6.8	c		8	7.0	b	
8	5.6	c		9	6.3	b c		10	6.8	c		9	7.0	b	
10	5.8	c d		10	6.5	b c		5	7.0	c d		10	7.0	b	
7	6.3	d		7	7.5	c		7	8.0	d		7	8.8	c	

Figure 8. Split-plot treatment effects on turfgrass quality ratings averaged across all dates

Rate	Trt 1			Rate	Trt 2			Rate	Trt 3			Rate	Trt 4			Rate	Trt 5		
0	2.4	a		0	3.6	a		0	3.4	a		0	5.3	a		0	5.7	a	
0.50	4.2	b		0.50	4.0	a		0.50	3.9	a		0.50	6.0	b		0.50	6.4	b	
0.75	6.2	c		0.75	5.0	b		0.75	5.9	b		0.75	6.5	c		0.75	7.0	c	
100	6.6	c		100	6.3	c		100	6.2	b		100	6.6	c		100	7.0	c	

Rate	Trt 6			Rate	Trt 7			Rate	Trt 8			Rate	Trt 9			Rate	Trt 10		
0	5.5	a		0	6.6	a		0	5.7	a		0	5.6	a		0	6.0	a	
0.50	6.2	b		0.50	7.7	b		0.50	6.3	b		0.50	6.4	b		0.50	6.6	b	
0.75	6.8	c		0.75	8.1	c		0.75	6.8	c		0.75	6.6	b		0.75	6.8	b	
100	6.9	c		100	8.8	d		100	6.9	c		100	6.9	c		100	6.9	b	

*Multiple Disease Ratings (including anthracnose, summer patch, dollar spot)*

Plots were rated for percent diseased turf on August 13 when a number of different pathogen symptoms were obvious and separating them was difficult. There was a significant split-plot treatment x Daconil/Banner rate interaction. Therefore, results are presented by rate and treatment. Means followed by the same letter are not significantly different.

EcoGuard from Novozymes applied at the 20 ounce rate at 14 day intervals afforded the highest overall level of control of a broad spectrum of diseases observed in the study area. Specifically greater than 90% control was achieved with EcoGuard in the absence of a Daconil/Banner program. Among the PC treatments, the high rate PC2 treatment applied at 21 day intervals and the low rate PC2 treatment applied at 7 day intervals provided about 85 percent control without Daconil/Banner treatments. It is worth noting that EcoGuard provides about 0.07 lbs of nitrogen per 1000 square feet with each application. While we have observed

increases in growth associated with PC 2 treatments it is not clear yet if the PC response is strictly nutritional.

Interestingly, in contrast with turfgrass quality data the high rate PC2 applied at 28 day intervals did not appear to offer acceptable disease control (>80%) until Daconil/Banner was applied at 75 percent of standard rate. It appears that under high disease pressure under putting green management programs the shorter interval of high rate applications might be needed to realize fungicide reductions.

The low rate 7 day interval treatment afforded very good (>85%) control 50 percent Daconil/Banner rate. In fact many of the PC programs offered this level of control at 50 percent Daconil Banner indicating that fungicide use for a broad array of diseases, even at high pressure levels, could be managed with PC products and half the amount of traditional fungicides. Furthermore, it is worth noting that further integration of PC products with EcoGuard (a biological fungicide) might eliminate the need for traditional fungicides.

Figure 9. Treatment effects on percent diseased turf by Daconil Banner rate on August 13.

Trt	Rate = 0		Trt	Rate = 0.50		Trt	Rate = 0.75		Trt	Rate = 100	
1	83.3	a	2	48.3	a	2	51.7	a	1	10.0	a
2	81.7	a	1	46.7	a	3	41.7	a	2	9.0	a
3	71.7	b	3	40.0	a	1	40.0	a	4	7.3	a
8	31.7	c	9	15.7	b	9	11.3	a b	8	7.3	a
9	28.3	c	4	13.3	b	8	10.0	b	9	6.7	a
4	23.3	c d	8	12.3	b	4	9.0	b	3	4.7	a
6	17.3	d	5	8.3	b	5	6.7	b	6	4.3	a
7	14.0	d	6	7.7	b	6	6.3	b	5	4.0	a
5	11.7	d e	7	7.7	b	7	5.3	b	7	0.0	a b
10	7.3	e	10	7.0	b	10	0.0	b	10	0.0	b

Figure 10. Split-plot treatment effects on percent diseased turf on August 13.

Rate	Trt 1		Rate	Trt 2		Rate	Trt 3		Rate	Trt 4		Rate	Trt 5	
0	83.3	a	0	81.7	a	0	71.7	a	0	23.3	a	0	11.7	a
0.50	46.7	b	0.50	48.3	b	0.50	40.0	b	0.50	13.3	b	0.50	8.3	a b
0.75	40.0	b	0.75	51.7	b	0.75	41.7	b	0.75	9.0	b	0.75	6.7	a b
100	10.0	c	100	9.0	c	100	4.7	c	100	7.3	b	100	4.0	b

Rate	Trt 6		Rate	Trt 7		Rate	Trt 8		Rate	Trt 9		Rate	Trt 10	
0	17.3	a	0	14.0	a	0	31.7	a	0	28.3	a	0	7.3	a
0.50	7.7	b	0.50	7.7	b	0.50	12.3	b	0.50	15.7	b	0.50	7.0	a
0.75	6.3	b	0.75	5.3	b	0.75	10.0	b	0.75	11.3	b	0.75	0.0	b
100	4.3	b	100	0.0	c	100	7.3	b	100	6.7	b	100	0.0	b

### Basal Rot Anthracnose

Basal Rot Anthracnose was diagnosed and rated on July 17 by estimating the percentage of the plot affected by disease. Untreated plots had up to 25 percent of the plot infected with the disease and while this might not be considered high for some diseases it is very high pressure for anthracnose. Daconil/Banner treatments were not significant. There was no split plot treatment x Daconil/Banner rate

interactions, however there was a significant main effect of split-plot treatments. Means followed by the same letter are not significantly different.

The PC treatments independent of Daconil/Banner programs afforded between 87 and 99 percent control. In fact there was no statistical difference among PC treatments.

Basal rot anthracnose is among the most problematic diseases to be managed on annual bluegrass putting greens in northern climates. Typically, a multiple product rotation program applied on frequent intervals is required to prevent the disease from “taking hold”. The ability of the PC product line to provide high levels of anthracnose control without Daconil/Banner is a strong indication that there is significant potential for using the “induced systemic resistance” properties known to occur.

Figure 11. Split plot treatment effect on basal rot anthracnose on July 17.

Trt		
1	23.7	a
3	16.2	a
2	14.2	a
10	9.8	a b
9	6.5	b
7	2.7	b
8	2.2	b
4	2.1	b
6	1.5	b
5	0.2	b

### *Dollar Spot*

Dollar spot was diagnosed and rated on July 17 by counting the number of spots per plot. Untreated plots were up to 30 percent infected, characterizing this as moderate dollar spot pressure. There was a significant split-plot treatment x Daconil/Banner interaction. Means followed by the same letter are not significantly different.

Dollar spot is the most common disease of cool-season golf turf. Under moderate disease pressure the PC products afforded up to 78 percent control without a Daconil/Banner program and almost 100 percent control with only 50 percent of the standard Daconil/Banner program.

Oddly, while not statistically significant, the low rate PC2 program applied at 7 day intervals did not provide acceptable dollar spot control without Daconil/Banner program. This is in contrast to anthracnose ratings and overall turfgrass quality ratings that were at least very good with this rate and interval.

Figure 12. Treatment effects on number of dollar spot infection centers per plot by Daconil Banner rate on July 17.

Trt	Rate = 0		Trt	Rate = 0.50		Trt	Rate = 0.75		Trt	Rate = 100	
3	27.0	a	2	2.7	a	10	1.7	a	4	1.3	a
7	19.0	a	10	1.3	a	3	0.7	a	1	0.7	a
1	18.3	a	7	1.0	a	6	0.7	a	2	0.0	a
10	15.3	a	3	0.7	a	1	0.0	a	3	0.0	a
5	12.3	a	1	0.0	a	2	0.0	a	5	0.0	a
2	11.7	a	4	0.0	a	4	0.0	a	6	0.0	a
4	10.0	a	5	0.0	a	5	0.0	a	7	0.0	a
9	8.0	a	6	0.0	a	7	0.0	a	8	0.0	a
6	7.0	a	8	0.0	a	8	0.0	a	9	0.0	a
8	5.7	a	9	0.0	a	9	0.0	a	10	0.0	a

Figure 13. Split-plot treatment effects on number of dollar spot infection centers per plot on July 17.

Rate	Trt 1		Rate	Trt 2		Rate	Trt 3		Rate	Trt 4		Rate	Trt 5	
0	18.3	a	0	11.7	a	0	27.0	a	0	10.0	a	0	12.3	a
100	0.7	b	0.50	2.7	a	0.50	0.7	b	100	1.3	a	0.50	0.0	b
0.50	0.0	b	0.75	0.0	a	0.75	0.7	b	0.50	0.0	a	0.75	0.0	b
0.75	0.0	b	100	0.0	a	100	0.0	b	0.75	0.0	a	100	0.0	b

Rate	Trt 6		Rate	Trt 7		Rate	Trt 8		Rate	Trt 9		Rate	Trt 10	
0	7.0	a	0	19.0	a	0	5.7	a	0	8.0	a	0	15.3	a
0.50	0.0	a	0.50	1.0	a	0.50	0.0	a	0.50	0.0	b	0.75	1.7	a
0.75	0.0	a	0.75	0.0	a	0.75	0.0	a	0.75	0.0	b	0.50	1.3	a
100	0.0	a	100	0.0	a	100	0.0	a	100	0.0	b	100	0.0	a

### Clipping Dry Weight (gm)

During the season we visually noted times when it appeared PC treated plots had significantly more top growth than non-PC treated plots. Therefore to quantify this observation clippings were collected on September 17. A strip was mowed down the center of each plot, clippings collected, dried and weighed. There was a significant split plot treatment x Daconil/Banner rate interaction.

Clipping production was significantly increased with all PC treatments in the absence of Daconil/Banner program. Interestingly, several of the PC programs provided clipping growth equal to that of the EcoGuard treatment that supplied low rates of nitrogen with each application. There is no evidence that the observed increase in growth with the PC programs is nutritional and may be associated with the induced systemic resistance by enhancing plant health.

Figure 14. Treatment effects on clipping production by Daconil Banner rate on September 17.

Trt	Rate = 0		Trt	Rate = 0.50		Trt	Rate = 0.75		Trt	Rate = 100	
7	8.7	a	10	9.0	a	10	10.3	a	10	9.6	a
5	7.8	a	8	7.9	a	8	8.5	a	7	7.7	a
4	7.1	a	4	7.0	a	6	7.9	a	6	7.1	a b
6	7.1	a	2	6.5	a	5	7.9	a	5	7.1	a b
10	7.1	a	9	6.3	a	7	7.5	a	3	7.0	b

8	6.8	a	3	6.3	a	9	6.6	a	b	8	6.5	b
9	6.0	a	7	6.1	a	2	6.6	a	b	4	6.2	b
2	4.9	a	b	6	5.9	a	3	5.8	b	9	6.0	b
3	4.6	b	5	5.9	a	1	5.6	b	2	5.9	b	
1	4.1	b	1	5.6	a	4	4.9	b	1	5.6	b	

Figure 15. Split-plot treatment effects on clipping production on September 17.

Rate	Trt 1	Rate	Trt 2	Rate	Trt 3	Rate	Trt 4	Rate	Trt 5						
0	4.1	a	0	4.9	a	0	4.6	a	0.75	4.9	a	0.50	5.9	a	
0.50	5.6	a	100	5.9	a	0.75	5.8	a	100	6.2	a	100	7.1	a	
0.75	5.6	a	0.50	6.5	a	b	0.50	6.3	a	0.50	7.0	a	0	7.8	a
100	5.6	a	0.75	6.6	b	100	7.0	a	b	0	7.1	a	0.75	7.9	a

Rate	Trt 6	Rate	Trt 7	Rate	Trt 8	Rate	Trt 9	Rate	Trt 10					
0.50	5.9	a	0.50	6.1	a	100	6.5	a	0	6.0	a	0	7.1	a
0	7.1	a	0.75	7.5	a	0	6.8	a	100	6.0	a	0.50	9.0	a
100	7.1	a	100	7.7	a	0.50	7.9	a	0.50	6.3	a	100	9.6	a
0.75	7.9	a	0	8.7	a	0.75	8.5	a	0.75	6.6	a	0.75	10.3	a

### Normalized Difference Vegetation Index (NDVI)

NDVI, a measure of live green vegetation that provides an objective measure of turfgrass density and color, was assessed on September 23 using a TCM 500 meter from Spectrum Technology. Three readings per plot were used to obtain an average value. There were no significant differences among the Daconil/Banner rates, nor any interactive effects, however there were significant differences among split –plot treatments.

The NDVI measure provides objective data such as clipping production in comparison to the subjective quality and disease ratings. This data is in stark contrast to the data observed to this point with the PC treatments all providing significant lower reading when compared to untreated, Rhapsody and EcoGuard (nitrogen enhanced-biological control) treatments.

The nature of this response is not clear, however it could be related to the pigment used in the PC treatments that might be confounding the data. This might be worth further investigation as the use of remote sensing is a growing trend in golf turf management.

Figure 16. Split plot treatment effects on NDVI measurements.

Trt		
6	0.716	a
8	0.728	a
5	0.723	a
9	0.729	a
4	0.730	a
7	0.736	a b
1	0.736	b
3	0.740	b c
2	0.741	b c
10	0.757	c

## Summary

This preliminary investigation of the PC products and programs has offered an exciting look at this emerging technology, i.e., the use of induced systemic resistance. Clearly this data indicate that a minimum of 25 to 50 percent reduction in traditional fungicide use if possible depending on the disease and the level of pressure.

Excellent performance of low rate short interval treatments or mid-range rates at 14 to 21 day intervals was observed for turfgrass quality and several diseases observed during the study. It is clear that there are significant plant health advantages from the use of PC products as evidence by increased clipping production, but more research is needed to fully characterize this benefit under field conditions such as the potential to reduce nitrogen fertilizer rates and maintain health turf.

There appears to be significant potential to enhance putting green quality and reduce disease infestation while reducing reliance on traditional fungicide chemistries and thereby enhancing the environmental compatibility of disease management programs. Additional research with other biologicals and reduced risk products such as EcoGuard, Emerald, Endorse, Phosphites, etc., in combination with PC products as a part of an overall disease management program.