

## ***Pseudomonas aureofaciens* Applied by Irrigation to Extend the Window of Dollar Spot Control of Various Fungicides**

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### **Objective**

The objective of this study was to determine if nightly applications via the BioJect system of *Pseudomonas aureofaciens* strain Tx-1 could extend the window of dollar spot control of single applications of fungicides in Penneagle creeping bentgrass maintained at fairway height.

### **Rationale**

The use of biological disease control products is a popular idea due to the public's ongoing concern for safety and the environment. The integration of a "natural", biological disease control could double as a public relations tool as well as a disease control tool. *Pseudomonas aureofaciens* strain Tx-1 may be one such tool. Data from studies conducted during 1998 suggest that *P. aureofaciens* applied through the BioJect system can reduce dollar spot, but not to a level of commercially acceptable control when used without fungicide. This study is designed to evaluate the potential for *P. aureofaciens* applied via the BioJect through irrigation to extend the disease control of various commercial fungicides.

### **How It Was Done**

The study was located at the Wm. H. Daniel Turfgrass Research and Diagnostic Center at Purdue University, West Lafayette IN. The soil type was Starks-Fincastle silt loam with pH of 7.0, 163 lbs P/A, and 534 lbs K/A. The area was previously in corn with this being the initial turf planting of Penneagle creeping bentgrass established during August of 1997. The bentgrass was mowed at 0.5 inches with clippings returned. The area received annual fertilization of 0.5 lbs N per 1000 sq. ft. applied in May, 1.0 lbs N per 1000 sq. ft. applied in Sep, and 1.5 lbs N per 1000 sq. ft. applied in Nov.

Treatments were a 2x8 factorial with 2 levels of *P. aureofaciens* application (none and nightly) and 8 fungicide treatments (Table 1). Experimental design was a split block with *P. aureofaciens* as main plots and fungicides as subplots (5.0 ft x 5.0 ft). Main plots were replicated 3 times and the experiment was completed four times during the summer of 1999 on separate, but adjacent areas. Each experiment began with fungicide application occurring on Jun 2, Jun 23, Jul 14 and Aug 4, heretofore referred to as trials 1, 2, 3 and 4, respectively. Dollar spot was minimized on experimental areas with applications of Daconil Weatherstik (4 oz per 1000 sq. ft.) applied not less than 7 days before the start of each trial.

***P. aureofaciens* application.** A field bioreactor (BioJect system) was utilized to culture *P. aureofaciens* each day and then inject the culture into the irrigation system each evening after dusk during a two-minute/zone syringe cycle (0.05 inch of water). Plots that did not receive *P. aureofaciens* treatment received identical irrigation following the completion of the injected syringe cycle. Additional irrigation was done in the morning only as needed to prevent drought stress. Bacterial applications during 1999 were initiated Jun 2 and continued throughout the trials. To reduce bacterial application to the control plots injected and non-injected irrigation zones were supplied through separate piping and tarps

were used to cover the non-injected plots for approximately 30 minutes while the injected irrigation system was running.

**Fungicide treatments** included an untreated check, BannerMaxx (0.5 oz per 1000 sq. ft.), Chipco 26GT (3.0 oz per 1000 sq. ft.), Cleary's 3336 (2.0 oz per 1000 sq. ft.), Fore (6.0 oz per 1000 sq. ft.), Daconil Weatherstik (3.0 oz per 1000 sq. ft.), Compass (0.15 oz per 1000 sq. ft.), and a tankmix of BannerMaxx (0.5 oz per 1000 sq. ft.) and Compass (0.15 oz per 1000 sq. ft.) (Table 1). Fungicide applications were made with a CO<sub>2</sub> backpack sprayer in 4 gal H<sub>2</sub>O/1000 sq. ft.

Data samples were collected weekly for Tx-1 enumeration. A sample was collected directly from the bioreactor just prior to the injection cycle. Irrigation water was collected from the injected irrigation zones by placing an autoclaved catch pan on the turf surface immediately before the injection/irrigation cycle. Samples were stored at 35±2<sup>0</sup>F for 10 hours before enumeration. *P. aureofaciens* concentrations were determined through plate counts with three replicate plates per sample utilizing 1/10<sup>th</sup> trypticase soy agar as the plating medium supplemented with rifampicin and cycloheximide each at 50 micrograms/ml. Dilution blanks consisted of 1/10<sup>th</sup> Ringer solution.

Dollar spot disease severity was recorded two times per week following the application of fungicide treatments at the beginning of each trial. Disease severity was measured as the number of dollar spots per plot up to 300. Area under the disease progress curve (AUDPC) was calculated as  $\sum^n [(x_2-x_1)y_1 + (x_2-x_1)(y_2-y_1)/2]$  using eight ratings in all trials. To determine the number of days after fungicide application to reach thresholds of 25 and 50 spots per plot, interpolation of the disease severity data was done per plot and then analyzed.

A Box-Cox evaluation was applied to the disease severity and AUDPC data (*Y*) prior to other analyses. The linear regression of the log of the standard deviation of *Y* on the log of the mean of *Y* was significant on the majority of dates, suggesting a logarithmic transformation would provide the most homogeneous error variance. Disease severity and AUDPC data were transformed to log<sub>10</sub>(*Y*+1) for further analysis. One was added to *Y* to prevent the occurrence of log<sub>10</sub>(0). Threshold data were not found to be appropriate for transformation. Analysis of variance was performed on the transformed disease severity data with PROC ANOVA of SAS (SAS Institute, Inc., Cary, NC) and threshold data with PROC GLM of SAS due to several plots that did not reach the thresholds.

## Results

***P. aureofaciens* production.** Bacterial counts of culture from the bioreactor ranged from low 10<sup>7</sup> cfu/ml to low 10<sup>9</sup> cfu/ml while bacterial counts of the irrigation applied to the experimental area were generally low 10<sup>6</sup> to mid 10<sup>7</sup> cfu/ml and the counts were fairly uniform across the area on most sampling dates. Lower counts on Jul 5 and Aug 2 seemed to correspond to older Tx-1 inoculum use for incubation.

**Dollar Spot Disease severity.** As expected, disease severity varied among the fungicide treatments with Chipco 26GT, Cleary's 3336 and BannerMaxx alone and tank mixed with Compass performing the best throughout all four trials. *P. aureofaciens* reduced dollar spot 5, 23 and 26 days after fungicide application

during the Trial 1 (Table 2). Numerical reductions in disease severity were present on 9, 12, 16 and 19 days after fungicide application during the same trial. There was no significant reduction in disease severity due to the application of *P. aureofaciens* in Trials 2-4 (Tables 3-5). There were no significant interactions between *P. aureofaciens* and fungicide application in any of the trials of this study. This suggests that the effects of *P. aureofaciens* are not enhanced nor worsened by different fungicides or vice versa.

**Area under the disease progress curve (AUDPC).** AUDPC data was consistent with the disease severity data. The application of *P. aureofaciens* via the BioJect reduced AUDPC values during Trial 1 (Table 6). There was no significant reduction of AUDPC due to the application of *P. aureofaciens* in Trials 2-4. There were no significant interactions between *P. aureofaciens* and fungicide application in any of the trials of this study.

**Days to reach 25 and 50 spots per plot (Table 7 and 8).** The application of *P. aureofaciens* via the BioJect increased the time to reach the 50 spot threshold by over two days in Trial 1. Although *P. aureofaciens* numerically increased the number of days to reach both 25 and 50 spots per plot in Trials 3 and 4, elevated dollar spot disease pressure during trials 2, 3 and 4 reduced *P. aureofaciens* effect. As mentioned with the disease severity and AUDPC data, there were no significant interactions between *P. aureofaciens* and fungicide application.

## Summary

The BioJect unit operated very well during the course of this study with no applications being missed due to the bioreactor. *P. aureofaciens* applied via the BioJect system reduced dollar spot severity and is capable of extending control of dollar spot by commercial fungicides. Control was extended in Trial 1 by over two days due to the *P. aureofaciens* applied through the BioJect. However, this trial occurred during relatively low disease pressure in June and *P. aureofaciens* had no effect on disease control during the high disease pressure of July and August. Therefore, we can conclude that *P. aureofaciens* applied via the BioJect system may provide only minimal control of dollar spot under relatively low disease pressure.

Table 1. Treatments used to evaluate the combination of *P. aureofaciens* and various fungicides for control of dollar spot.

<i>Pseudomonas aureofaciens</i>	Fungicide Treatments	
Nightly application via Bioject unit	BannerMaxx	0.5 oz per 1000 sq. ft.
None	Chipco 26GT	3.0 oz per 1000 sq. ft.
	Cleary's 3336	2.0 oz per 1000 sq. ft.
	Fore	6.0 oz per 1000 sq. ft.
	Daconil Weatherstik	3.0 oz per 1000 sq. ft.
	Compass	0.15 oz per 1000 sq. ft.
	Compass/BannerMaxx	0.5 oz+0.15 oz per 1000 sq. ft.
	Untreated Check	-----

Table 2. Pseudomonas and fungicide effects on dollar spot severity in Trial 1 initiated Jun 2, 1999 on Penneagle creeping bentgrass.<sup>wx</sup>

Days after Fungicide App.			2			5			9		
Fungicide (F)	P+	P-	F mean <sup>y</sup>	P+	P-	F mean	P+	P-	F mean		
Check	0.0	0.0	0.0 a	4.1	13.7	7.6 c	9.8	31.3	17.7 c		
Banner	0.0	0.0	0.0 a	2.1	3.0	2.5 ab	0.6	1.9	1.2 ab		
Chipco 26GT	0.0	0.0	0.0 a	3.6	2.2	2.8 ab	0.0	0.0	0.0 a		
Cleary's 3336	0.0	0.0	0.0 a	1.8	3.5	2.5 ab	0.0	0.0	0.0 a		
Fore	0.0	0.0	0.0 a	3.1	7.8	5.0 bc	9.0	11.4	10.2 c		
Daconil Weatherstik	0.0	0.0	0.0 a	2.1	3.6	2.8 ab	0.8	0.9	0.9 ab		
Compass	0.0	0.0	0.0 a	2.3	2.3	2.3 a	3.0	3.4	3.2 b		
Compass/Banner	0.0	0.0	0.0 a	2.0	2.6	2.3 a	0.8	2.0	1.3 ab		
Pseudomonas (P) mean <sup>z</sup>	0.0 a	0.0 a		2.5 a	4.0 b		2.6 a	4.6 a			

<sup>w</sup> All means listed in the table are back-transformed from log<sub>10</sub>(Y+1).

<sup>x</sup> There are no significant Pseudomonas x fungicide interactions.

<sup>y</sup> Fungicide means within each trial followed by the same letter are not significantly different at P > .05.

<sup>z</sup> Pseudomonas means within each trial followed by the same letter are not significantly different at P > .05.

Table 2. (continued).

Days after Fungicide App.			12			16			19		
Fungicide (F)	P+	P-	F mean <sup>y</sup>	P+	P-	F mean	P+	P-	F mean		
Check	10.9	35.9	19.9 c	14.0	47.5	25.9 d	34.3	77.6	51.6 d		
Banner	0.0	0.0	0.0 a	0.0	0.0	0.0 a	0.0	0.0	0.0 a		
Chipco 26GT	0.0	0.0	0.0 a	0.0	0.0	0.0 a	0.0	0.0	0.0 a		
Cleary's 3336	0.0	0.0	0.0 a	0.0	0.0	0.0 a	0.0	0.0	0.0 a		
Fore	11.9	8.3	10.0 bc	12.8	19.2	15.7 cd	32.6	41.5	36.8 cd		
Daconil Weatherstik	3.0	2.5	2.8 b	6.6	8.7	7.6 bc	16.8	21.2	18.9 bc		
Compass	4.0	4.6	4.3 b	6.7	7.0	6.8 bc	14.2	7.4	10.3 b		
Compass/Banner	0.0	0.0	0.0 a	0.0	0.0	0.0 a	0.0	0.0	0.0 a		
Pseudomonas (P) mean <sup>z</sup>	6.5 a	8.1		a9.5 a	15.6 a		22.8 a	27.1 a			

Table 2. (continued).

Days after Fungicide App.			23			26		
Fungicide (F)	P+	P-	F mean <sup>y</sup>	P+	P-	F mean		
Check	122.1	197.5	155.3 d	148.8	232.3	185.9 c		
Banner	13.4	29.4	19.9 b	16.7	63.6	32.8 b		
Chipco 26GT	14.1	26.5	19.4 b	35.5	66.8	48.8 b		
Cleary's 3336	1.0	0.7	0.8 a	2.4	1.9	2.1 a		
Fore	137.8	182.2	158.5 d	172.1	197.2	184.2 c		
Daconil Weatherstik	93.3	143.8	115.8 cd	123.4	164.6	142.5 c		
Compass	69.5	93.4	80.5 c	116.5	122.6	119.5 c		
Compass/Banner	11.4	14.7	13.0 b	26.5	28.9	27.7 b		
Pseudomonas (P) mean	28.7 a	41.8 b		45.7 a	64.9 b			

Table 3. Pseudomonas and fungicide effects on dollar spot severity in Trial 2 initiated Jun 23, 1999 on Penneagle creeping bentgrass.<sup>wx</sup>

Days after Fungicide App.	2			5			9		
Fungicide (F)	P+	P-	F mean <sup>y</sup>	P+	P-	F mean	P+	P-	F mean
Check	9.5	14.8	11.9 a	24.5	23.4	24.0 c	60.8	67.5	64.1 c
Banner	3.2	5.6	4.3 a	1.1	0.3	0.6 ab	0.0	0.0	0.0 a
Chipco 26GT	3.9	6.7	5.2 a	0.0	0.0	0.0 a	0.0	0.0	0.0 a
Cleary's 3336	2.5	1.5	1.9 a	0.0	0.0	0.0 a	1.9	0.0	0.7 a
Fore	3.7	6.1	4.8 a	2.3	11.0	5.3 bc	6.9	26.2	13.6 bc
Daconil Weatherstik	0.7	14.7	4.2 a	0.0	2.1	0.8 ab	5.2	14.7	8.9 b
Compass	7.1	3.5	5.0 a	7.6	1.5	3.6 b	26.0	18.9	22.1 bc
Compass/Banner	4.8	1.3	2.6 a	0.0	0.0	0.0 a	0.0	0.0	0.0 a
Pseudomonas (P) mean <sup>z</sup>	3.8 a	5.2 a		3.3 a	3.9 a		10.9 a	13.2 a	

<sup>w</sup> All means listed in the table are back-transformed from  $\log_{10}(Y+1)$ .

<sup>x</sup> There are no significant pseudomonas effects and pseudomonas x fungicide interactions.

<sup>y</sup> Fungicide means within each trial followed by the same letter are not significantly different at  $P > .05$ .

<sup>z</sup> Pseudomonas means within each trial followed by the same letter are not significantly different at  $P > .05$ .

Table 3. (continued).

Days after Fungicide App.	12			16			19		
Fungicide (F)	P+	P-	F mean <sup>y</sup>	P+	P-	F mean	P+	P-	F mean
Check	144.6	156.2	150.3 b	119.8	136.9	128.1 b	164.6	183.4	173.7 b
Banner	1.0	2.2	1.5 a	1.2	0.8	1.0 a	2.7	4.2	3.4 a
Chipco 26GT	0.0	0.0	0.0 a	2.3	0.8	1.4 a	4.4	0.7	2.0 a
Cleary's 3336	4.0	0.0	1.2 a	4.1	0.4	1.7 a	4.5	0.0	1.3 a
Fore	26.2	71.1	43.3 b	26.1	140.1	60.8 b	27.8	151.4	65.2 b
Daconil Weatherstik	35.5	127.6	67.5 b	44.7	127.5	75.7 b	85.5	150.5	113.5 b
Compass	131.5	77.3	100.9 b	150.0	109.1	127.9 b	166.3	115.8	138.8 b
Compass/Banner	0.0	0.0	0.0 a	0.0	0.0	0.0 a	3.9	0.4	1.7 a
Pseudomonas (P) mean	23.0 a	25.7 a		17.9 a	19.1 a		19.9 a	15.8 a	

Table 3 (continued).

Days after Fungicide App.	23			26		
Fungicide (F)	P+	P-	F mean <sup>y</sup>	P+	P-	F mean
Check	184.2	204.7	194.2 c	300.0	298.0	299.0 a
Banner	15.1	18.1	16.5 b	202.2	168.7	184.7 a
Chipco 26GT	20.4	12.5	16.0 b	235.3	178.1	204.7 a
Cleary's 3336	7.7	0.4	2.5 a	200.3	71.7	119.9 a
Fore	30.8	189.0	76.8 c	107.2	297.6	178.8 a
Daconil Weatherstik	93.4	187.7	132.5 c	259.0	296.3	277.0 a
Compass	166.9	165.5	166.2 c	300.0	290.4	295.1 a
Compass/Banner	12.0	10.3	11.1 ab	174.3	176.1	175.2 a
Pseudomonas (P) mean	36.2 a	37.8 a		212.5 a	203.2 a	

Table 4. Pseudomonas and fungicide effects on dollar spot severity in Trial 3 initiated Jul 14, 1999 on Penneagle creeping bentgrass.<sup>wx</sup>

Days after Fungicide App.	2			5			9		
Fungicide (F)	P+	P-	F mean <sup>y</sup>	P+	P-	F mean	P+	P-	F mean
Check	0.0	0.0	0.0 a	23.0	139.7	57.1 c	210.2	199.5	204.8 c
Banner	0.0	0.0	0.0 a	0.0	0.0	0.0 a	0.0	0.0	0.0 a
Chipco 26GT	0.0	0.0	0.0 a	0.0	0.0	0.0 a	2.0	0.9	1.4 b
Cleary's 3336	0.0	0.0	0.0 a	0.0	0.0	0.0 a	0.0	0.0	0.0 a
Fore	0.0	0.0	0.0 a	38.0	8.1	17.9 bc	187.1	130.2	156.1 c
Daconil Weatherstik	0.0	0.0	0.0 a	0.0	8.0	2.0 ab	36.3	60.3	46.8 b
Compass	0.0	0.0	0.0 a	7.3	2.6	4.4 abc	124.2	105.1	114.2 bc
Compass/Banner	0.0	0.0	0.0 a	1.8	0.0	0.7 ab	0.0	1.0	0.4 a
Pseudomonas (P) mean <sup>z</sup>	0.0 a	0.0 a		6.3 a	7.4 a		31.2 a	25.3 a	

<sup>w</sup> All means listed in the table are back-transformed from log<sub>10</sub>(Y+1).

<sup>x</sup> There are no significant pseudomonas effects and pseudomonas x fungicide interactions.

<sup>y</sup> Fungicide means within each trial followed by the same letter are not significantly different at P > .05.

<sup>z</sup> Pseudomonas means within each trial followed by the same letter are not significantly different at P > .05.

Table 4. (continued).

Days after Fungicide App.	12			16			19		
Fungicide (F)	P+	P-	F mean <sup>y</sup>	P+	P-	F mean	P+	P-	F mean
Check	300.0	251.2	274.5 e	300.0	300.0	300.0 d	300.0	300.0	300.0 e
Banner	0.9	2.2	1.5 ab	3.4	15.8	7.6 b	42.9	59.8	50.7 b
Chipco 26GT	12.8	8.3	10.3 c	39.3	39.7	39.5 c	174.2	122.0	145.8 cd
Cleary's 3336	0.0	0.0	0.0 a	0.0	0.0	0.0 a	11.8	11.6	11.7 a
Fore	300.0	254.0	276.0 e	300.0	300.0	300.0 d	300.0	300.0	300.0 e
Daconil Weatherstik	94.0	125.8	108.8 d	214.2	190.2	201.8 d	246.3	253.5	249.9 de
Compass	218.0	211.6	214.8 de	267.2	250.7	258.8 d	300.0	300.0	300.0 e
Compass/Banner	0.0	7.8	2.0 b	2.6	79.9	16.0 bc	83.7	162.5	116.6 c
Pseudomonas (P) mean	32.8 a	45.2 a		31.5 a	75.8 a		71.9 a	82.0 a	

Table 4. (continued).

Days after Fungicide App.	23			26		
Fungicide (F)	P+	P-	F mean <sup>y</sup>	P+	P-	F mean
Check	300.0	300.0	300.0 d	300.0	300.0	300.0 d
Banner	60.7	80.3	69.8 b	91.8	95.2	93.5 b
Chipco 26GT	197.5	183.5	190.4 cd	227.4	224.1	225.8 cd
Cleary's 3336	25.0	33.5	29.0 a	46.0	52.6	49.2 a
Fore	300.0	300.0	300.0 d	300.0	300.0	300.0 d
Daconil Weatherstik	284.6	291.1	287.8 d	300.0	300.0	300.0 d
Compass	300.0	300.0	300.0 d	300.0	300.0	300.0 d
Compass/Banner	120.2	191.9	151.9 c	151.3	191.6	170.3 c
Pseudomonas (P) mean	101.0 a	122.9 a		110.0 a	121.3 a	

Table 5. Pseudomonas and fungicide effects on dollar spot severity in Trial 4 initiated Aug 4, 1999 on Penneagle creeping bentgrass.<sup>wx</sup>

Days after Fungicide App.	2			5			9		
Fungicide (F)	P+	P-	F mean <sup>y</sup>	P+	P-	F mean	P+	P-	F mean
Check	0.0	0.0	0.0 a	1.6	3.3	2.4 a	31.3	32.6	31.9 b
Banner	0.0	0.0	0.0 a	0.0	0.0	0.0 a	0.0	0.0	0.0 a
Chipco 26GT	0.0	0.0	0.0 a	0.0	0.0	0.0 a	0.0	0.0	0.0 a
Cleary's 3336	0.0	0.0	0.0 a	0.0	0.0	0.0 a	0.0	0.0	0.0 a
Fore	0.0	0.0	0.0 a	0.6	2.3	1.3 a	15.1	26.8	20.1 b
Daconil Weatherstik	0.0	0.0	0.0 a	0.0	0.0	0.0 a	0.0	0.0	0.0 a
Compass	0.0	0.0	0.0 a	0.0	0.0	0.0 a	0.6	2.3	1.3 a
Compass/Banner	0.0	0.0	0.0 a	0.0	0.0	0.0 a	0.0	0.0	0.0 a
Pseudomonas (P) mean <sup>z</sup>	0.0 a	0.0 a		1.0 a	2.8 a		8.4 a	13.6 a	

<sup>w</sup> All means listed in the table are back-transformed from log<sub>10</sub>(Y+1).

<sup>x</sup> There are no significant pseudomonas effects and pseudomonas x fungicide interactions.

<sup>y</sup> Fungicide means within each trial followed by the same letter are not significantly different at P >.05.

<sup>z</sup> Pseudomonas means within each trial followed by the same letter are not significantly different at P >.05.

Table 5 (continued).

Days after Fungicide App.	12			16			19		
Fungicide (F)	P+	P-	F mean <sup>y</sup>	P+	P-	F mean	P+	P-	F mean
Check	29.6	46.6	37.2 c	172.3	181.8	177.0 b	291.6	278.3	284.9 d
Banner	0.0	0.0	0.0 a	0.0	0.0	0.0 a	27.3	46.9	35.8 c
Chipco 26GT	0.0	0.0	0.0 a	0.0	0.0	0.0 a	10.3	16.1	12.9 b
Cleary's 3336	0.0	0.0	0.0 a	0.0	0.0	0.0 a	0.0	0.0	0.0 a
Fore	27.8	32.0	29.9 c	152.4	160.0	156.1 b	264.5	280.3	272.3 d
Daconil Weatherstik	0.0	0.0	0.0 a	25.9	104.5	52.3 b	225.3	203.0	213.9 d
Compass	2.6	6.6	4.2 b	37.4	114.0	65.5 b	117.0	282.1	181.8 d
Compass/Banner	0.0	0.0	0.0 a	0.0	0.0	0.0 a	4.8	7.4	6.0 b
Pseudomonas (P) mean	13.8 a	21.8 a		71.4 a	136.5 a		61.8 a	83.7 a	

Table 5 (continued).

Days after Fungicide App.	23			26		
Fungicide (F)	P+	P-	F mean <sup>y</sup>	P+	P-	F mean
Check	300.0	300.0	300.0 d	300.0	300.0	300.0 c
Banner	157.1	195.1	175.1 c	251.2	299.4	274.2 bc
Chipco 26GT	157.0	169.9	163.3 c	260.1	284.3	271.9 bc
Cleary's 3336	25.6	25.8	25.7 a	135.6	184.6	158.2 a
Fore	300.0	300.0	300.0 d	300.0	300.0	300.0 c
Daconil Weatherstik	300.0	252.1	275.0 cd	300.0	300.0	300.0 c
Compass	300.0	300.0	300.0 d	300.0	300.0	300.0 c
Compass/Banner	88.1	90.3	89.2 b	168.9	196.5	182.2 ab
Pseudomonas (P) mean	111.3 a	114.7 a		196.7 a	235.8 a	

Table 6. Pseudomonas and fungicide effects on area under the disease progress curve (AUDPC) in Penneagle creeping bentgrass.<sup>wx</sup>

Fungicide (F)	Trial 1			Trial 2		
	P+	P-	F mean <sup>y</sup>	P+	P-	F mean
Check	1036	1818	1372 d	3009	3244	3124 c
Banner	83	228	138 b	415	364	388 ab
Chipco 26GT	120	210	159 b	505	351	421 ab
Cleary's 3336	10	19	14 a	558	108	246 a
Fore	1054	1292	1167 cd	549	2603	1196 bc
Daconil Weatherstik	626	904	752 cd	1404	2663	1934 c
Compass	586	650	617 c	2879	2248	2544 c
Compass/Banner	83	106	94 b	344	335	339 a
Pseudomonas (P) mean <sup>z</sup>	208a	330b		848a	835a	

<sup>w</sup> All means listed in the table are back-transformed from  $\log_{10}(Y+1)$ .

<sup>x</sup> There are no significant pseudomonas x fungicide interactions.

<sup>y</sup> Fungicide means within each trial followed by the same letter are not significantly different at  $P > .05$ .

<sup>z</sup> Pseudomonas means within each trial followed by the same letter are not significantly different at  $P > .05$ .

Table 6. (continued).

Fungicide (F)	Trial 3			Trial 4		
	P+	P-	F mean	P+	P-	F mean
Check	5687	5703	5695 d	3446	3520	3483 d
Banner	532	712	615 b	1065	1361	1204 c
Chipco 26GT	1951	1618	1777 c	985	1084	1033 c
Cleary's 3336	197	241	218 a	295	373	332 a
Fore	5654	5093	5366 d	3190	3407	3297 d
Daconil Weatherstik	3611	4036	3817 d	2450	2499	2474 d
Compass	4970	4693	4829 d	2273	3023	2622 d
Compass/Banner	996	2014	1416 c	594	660	626 b
Pseudomonas (P) mean <sup>z</sup>	1814a	2047a		1353a	1548a	

Table 7. Pseudomonas and fungicide effects on days to reach 25 spots per plot during the summer of 1999 in Penneagle creeping bentgrass.<sup>v</sup>

Fungicides (F)	Trial 1 <sup>w</sup>			Trial 2		
	P+	P-	F mean <sup>x</sup>	P+	P-	F mean
Check	12.3	9.0	10.7 a	5.3	4.0	4.7 a
Banner	na <sup>y</sup>	na	na	22.7	22.0	22.3 c
Chipco 26GT	24.7	22.7	23.7 c	21.3	22.7	22.0 c
Cleary's 3336	na	na	na	18.3	23.3	20.8 c
Fore	14.3	13.3	13.8 ab	5.8	6.7	6.2 a
Daconil Weatherstik	18.3	18.0	18.2 b	12.3	9.0	10.7 b
Compass	16.3	16.7	16.5 b	5.3	8.3	6.8 ab
Compass/Banner	26.7	23.7	25.2 c	23.0	22.7	22.8 c
Pseudomonas (P) mean <sup>z</sup>	18.8a	17.2a		14.3a	14.8a	

<sup>v</sup> There are no significant pseudomonas effects and no pseudomonas x fungicide interactions.

<sup>w</sup> Trials 1, 2, 3 and 4 were initiated Jun 2, Jun 24, July 14 and Aug 7, respectively.

<sup>x</sup> Fungicide means within each trial followed by the same letter are not significantly different at  $P > .05$ .

<sup>y</sup> na = not applicable because disease severity data did not reach the threshold.

<sup>z</sup> Pseudomonas means within each trial followed by the same letter are not significantly different at  $P > .05$ .

Table 7. (continued).

Fungicides (F)	Trial 3			Trial 4		
	P+	P-	F mean	P+	P-	F mean
Check	3.7	2.3	3.0 a	9.3	8.3	8.8 a
Banner	18.7	16.0	17.3 d	18.7	18.0	18.3 c
Chipco 26GT	13.7	14.0	13.8 c	19.3	19.3	19.3 c
Cleary's 3336	23.7	21.7	22.7 e	22.3	22.7	22.5 d
Fore	4.0	5.0	4.5 ab	11.0	9.3	10.2 a
Daconil Weatherstik	7.3	6.3	6.8 b	15.0	13.3	14.2 b
Compass	4.7	5.7	5.2 ab	15.0	13.0	14.0 b
Compass/Banner	16.3	13.7	15.0 cd	19.7	20.0	19.8 c
Pseudomonas (P) mean <sup>z</sup>	11.5a	10.6a		16.3a	15.5a	

Table 8. Pseudomonas and fungicide effects on days to reach 50 spots per plot during the summer of 1999 in Penneagle creeping bentgrass.<sup>v</sup>

Fungicides (F)	Trial 1 <sup>w</sup>			Trial 2		
	P+	P-	F mean <sup>x</sup>	P+	P-	F mean
Check	16.3	13.7	15.0 a	6.3	5.7	6.0 a
Banner	na <sup>y</sup>	na	na	23.3	23.3	23.3 c
Chipco 26GT	30.3	25.3	27.8 c	22.3	23.7	23.0 c
Cleary's 3336	na	na	na	19.3	24.4	21.9 c
Fore	17.0	18.3	17.7 ab	6.9	9.0	8.0 a
Daconil Weatherstik	21.0	19.7	20.3 b	14.7	9.6	12.2 b
Compass	19.3	19.7	19.5 b	10.3	11.0	10.7 b
Compass/Banner	33.5	25.0	29.3 c	24.0	23.7	23.8 c
Pseudomonas (P) mean <sup>z</sup>	22.9a	20.3b		15.9a	16.3a	

<sup>v</sup> There are no significant pseudomonas x fungicide interactions.

<sup>w</sup> Trials 1, 2, 3 and 4 were initiated Jun 2, Jun 24, July 14 and Aug 7, respectively.

<sup>x</sup> Fungicide means within each trial followed by the same letter are not significantly different at  $P > .05$ .

<sup>y</sup> na = not applicable because disease severity data did not reach the threshold.

<sup>z</sup> Pseudomonas means within each trial followed by the same letter are not significantly different at  $P > .05$ .

Table 8. (continued).

Fungicides (F)	Trial 3			Trial 4		
	P+	P-	F mean	P+	P-	F mean
Check	4.3	3.0	3.7 a	11.3	10.0	10.7 a
Banner	20.7	18.7	19.7 c	19.7	18.7	19.2 c
Chipco 26GT	14.7	16.0	15.3 c	20.3	20.0	20.2 cd
Cleary's 3336	30.7	27.7	29.2 d	23.7	24.0	23.8 e
Fore	5.0	5.7	5.3 ab	12.7	10.7	11.7 a
Daconil Weatherstik	9.3	7.7	8.5 b	15.3	14.3	14.8 b
Compass	6.0	6.7	6.3 ab	16.0	14.3	15.2 b
Compass/Banner	18.0	14.3	16.2 c	21.3	21.3	21.3 d
Pseudomonas (P) mean <sup>z</sup>	13.6a	12.5a		17.5a	16.7a	