Project: Phytotoxicity Screen of Soil Surfactants

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Summary: A non-replicated screening study was conducted on a putting green of *Poa annua* and bentgrass (75%/25%) to determine the relative phytotoxicity of experimental products ACA 1820 and ACA 1847, when compared against the commercial standard, Primer. Key results include:

- When applied at the standard application rate of 6 oz/1000 sq ft, none of the products tested produced phytotoxicity on either *Poa annua* or bentgrass mowed at greens height.
- Linear regression analysis indicates that rates as high as 10.9 - 11.8 oz/1000 sq ft (for ACA 1820) and as high as 12.5 oz/1000 sq ft (for ACA 1847) could be used while maintaining turf at acceptable levels of quality (quality rating of 6.5 or higher).
- Based on the linear regression equations, only very high rates of these products (20 - 26.5 oz/1000 sq ft for ACA 1820 and 28.1 oz/1000 sq ft for ACA 1847) would result in unacceptable damage to turf
- There was a significant negative correlation between rate and turf quality for both products on certain rating dates, however, indicating that as expected, higher rates of these products can produce increasingly higher levels of turf damage.
- There was a lag time in the appearance of this damage; for ACA 1820, significant damage was apparent only after 2 days (the turf appears to have begun to recover by 7 days after treatment), while for ACA 1847,the damage took 7 days to become apparent, and was not obvious at any of the earlier evaluation dates.

Materials and Methods:

Treatments:

	PRODUCT	RATE/1000 SQ FT
1.	No treatment	
2.	Primer 604	6 oz
3.	ACA 1820	2 oz
4.	ACA 1820	4 oz
5.	ACA 1820	6 oz
6.	ACA 1820	8 oz
7.	ACA 1820	12 oz
8.	ACA 1820	16 oz
9.	ACA 1820	20 oz
10.	ACA 1820	24 oz
11.	ACA 1820	32 oz
12.	ACA 1847	2 oz
13.	ACA 1847	4 oz
14.	ACA 1847	6 oz
15.	ACA 1847	8 oz
16.	ACA 1847	12 oz
17.	ACA 1847	16 oz
18.	ACA 1847	20 oz
19.	ACA 1847	24 oz
20.	ACA 1847	32 oz

Experimental design and application: The trial was conducted at Balboa Park Golf Club in San Diego (Candice Combs, superintendent) on a putting green that consisted of approximately 75% *Poa annua* and 25% bentgrass. This was a non-replicated mini-plot test where plots measured 6" X 6" and were arranged side-by-side, as illustrated in Figure 1.

All products were applied on 9/26/01, at which time the air temperature was 83F (11:00am), and soil temperatures at 2" and 6" depths were 76F and 73F respectively. During the course of the trial, air temperatures at mid-day ranged from 76F - 83F.

Products were delivered to a 5" diameter circle in a volume of 2 gallons/1000 sq ft (at 10 psi) via the use of a CO_2-powered DeVilbiss (#152) atomizer that delivered 1 ml of spray solution to each plot (Figures 2 and 3). Spray lines were purged with CO_2 and then water prior to changing treatments.

To confirm that this apparatus would deliver spray solutions uniformly and effectively, a quick spray test was performed, delivering 1 ml of spray solution colored with 0.5% Safranin O as a marker.

In Test 1, Safranin colored water was sprayed onto a paper towel, and in Test 2, a solution of ACA 1847 (equivalent to 32 oz/1000 sq ft) colored with Safranin O was sprayed (Figure 4). Based on the evenness of the spray patterns that were observed, the apparatus described above was used in the tests, without modification.

Evaluations: Turf quality was measured immediately prior to treatment, as well as 1 hour, 1 day, 2 days and 7 days after application. Ratings were made visually (on a 0 - 9 scale, with 0 = dead and 9 = best possible turf).

Data analysis: Data was subjected to linear regression analysis for rate vs. turf quality on each rating date. The regression was considered significant when the probability due to chance (P) was less than 0.05.

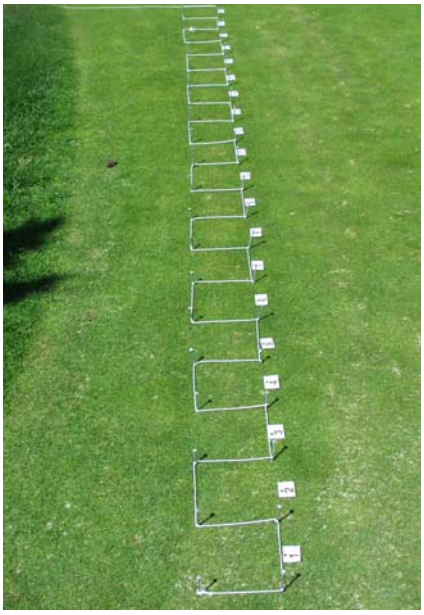


Figure 1. Arrangementof 6" X 6" plots, numbered consecutively according to treatment number from 1 - 20, on a poa/bentgrass putting green. Note that the green had been aerified and topdressed with sand approximately one week prior to trial initiation. This did not affect the results of the study, however.

Figure 2. Application equipment. The entire volume (1 ml of spray solution, seen here in a 8.5 ml test tube) was delivered to the turf below via a CO_2-powered DeVilbiss atomizer that was placed inside a 5" diameter cylinder at a height of 12" from the turf. A towel was used to prevent spray mist from escaping from the top of the cylinder.

Figure 3. Close up of spray solution, showing the apparatus immediately prior to spraying (left) and as the final volume of spray solution is being drawn up into the atomizer (right). Note that in the photo to the left, the spray solution has just begun to move through the uptake tube and towards the atomizer. In the photo to the right, there is no spray solution remaining in the test tube, and the last remnants of spray solution can be seen in the uptake tube.

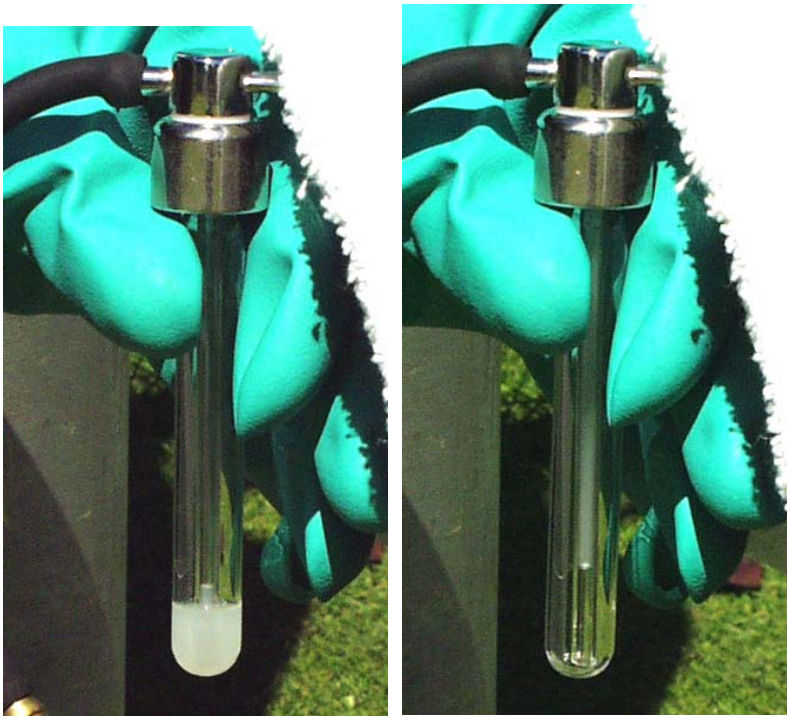
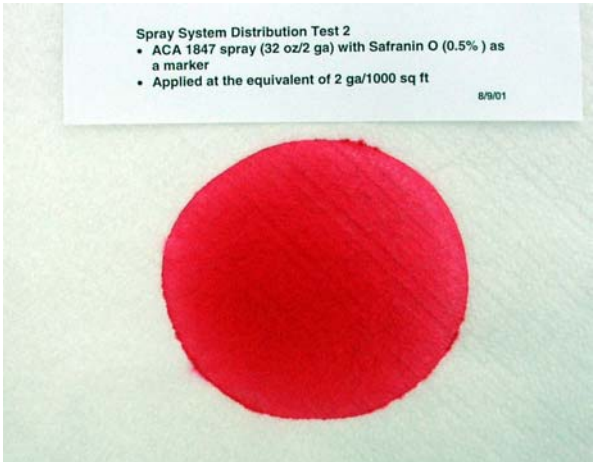


Figure 4. Spray patterns achieved with plain water (left: Spray Test 1) and with a high concentration (32 oz/1000 sq ft) of ACA 1847 (right: Spray Test 2) when applied onto paper towelling. One ml of each material was applied through a CO_2-powered DeVilbiss atomizer as described above. 0.5% Safranin O was added to each spray solution as a color marker.



Results: (Table 1, Figures 5 - 7)

Phytotoxicity: When applied at the standard application rate of 6 oz/1000 sq ft, none of the products tested (ACA 1820, ACA 1847 and Primer) produced phytotoxicity on either *Poa annua* or bentgrass mowed at greens height. Because the products were applied on a warm (83F), sunny day when phytotoxicity might be expected to be at its maximum, these results are especially positive.

Linear regression analysis indicates that rates as high as 10.9 - 11.8 oz/1000 sq ft (for ACA 1820) and as high as 12.5 oz/1000 sq ft (for ACA 1847) could be used under these conditions, while maintaining turf at acceptable levels of quality (quality rating of 6.5 or higher). Based on the linear regression equations, only very high rates of these products (20 - 26.5 oz/1000 sq ft for ACA 1820 and 28.1 oz/1000 sq ft for ACA 1847) would result in unacceptable damage to turf (quality ratings $\leq$6.0) (Table 1, Figures 5 and 6)

There was a significant negative correlation between rate and turf quality for both products on certain rating dates, indicating that higher rates of these products can produce increasingly higher levels of turf damage.

Timing of phytotoxicity: There was a lag time in the appearance of this damage; for ACA 1820, significant damage was apparent only after 2 days (the turf appears to have begun to recover by 7 days after treatment), while for ACA 1847, the damage took 7 days to become apparent, and was not obvious at any of the earlier evaluation dates.

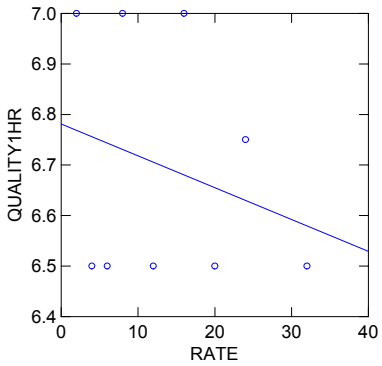
Product handling: All spray solutions were delivered through the spray apparatus without clogging the nozzle or creating any other problems. However, the higher rates tested (20 - 32 oz/1000 sq ft) were extremely viscous and might result in application problems for larger sprayers, particularly in cooler weather.

Table 1. Results of linear regression analysis of rate vs. turf quality (P<0.05). Products that showed a significant negative correlation between rate of product and turf quality for a given evaluation date are noted in red. To determine which rates of each product resulted in acceptable or higher quality turf (a rating of 6.5 or higher), the linear regression equation ***y = mx + b*** was solved for x (rate), with y = 6.5. This calculation was made only on for those dates and products that showed a significant correlation between rate and turf quality. Products were applied on 9/26/01.

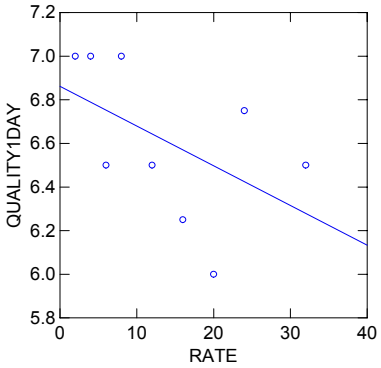
				Rates (/1000 sq ft)that produce turf quality	
	Slope	**Intercept**	**P**	**= 6.5**	**= 6.0**
ACA 1820					
1 hr post trt	–0.01	6.8	0.486		
1 day post trt	–0.018	6.9	0.156		
2 day post trt	**–0.055**	**7.1**	**0.000**	**10.9 oz**	**20 oz**
7 day post trt	**–0.034**	**6.9**	**0.032**	**11.8 oz**	**26.5 oz**
ACA 1847					
1 hr post trt	–0.021	6.9	0.149		
1 day post trt	–0.019	6.9	0.194		
2 day post trt	–0.011	6.5	0.238		
7 day post trt	**–0.032**	**6.9**	**0.006**	**12.5 oz**	**28.1 oz**

Figure 5. Linear regression of Rate vs. Turf Quality for ACA 1820 at 1 hour, 1 day, 2 days and 7 days post-treatment.

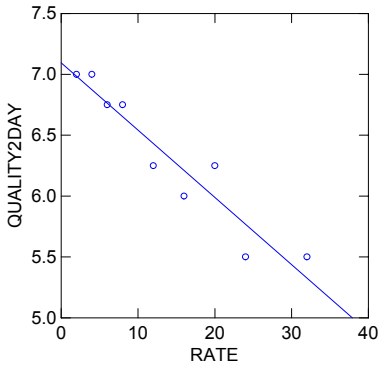
1 hour post-treat



1 day post-treat



2 days post treat



7 days post-treat

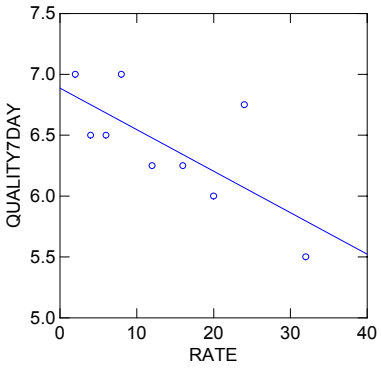
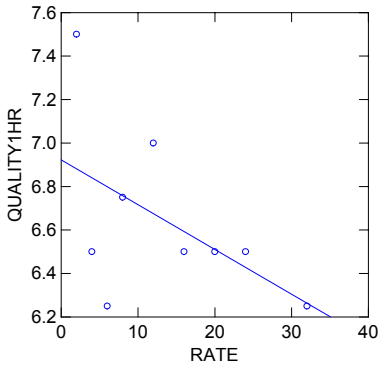
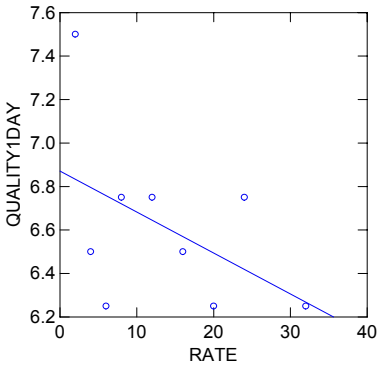


Figure 6. Linear regression of Rate vs. Turf Quality for ACA 1847 at 1 hour, 1 day, 2 days and 7 days post-treatment.

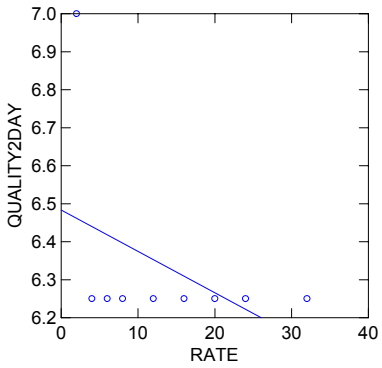
1 hour post-treat



1 day post treat



2 days post-treat



7 days post-treat

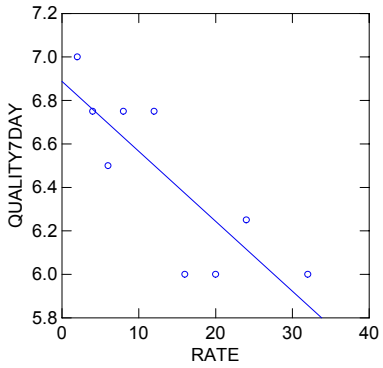
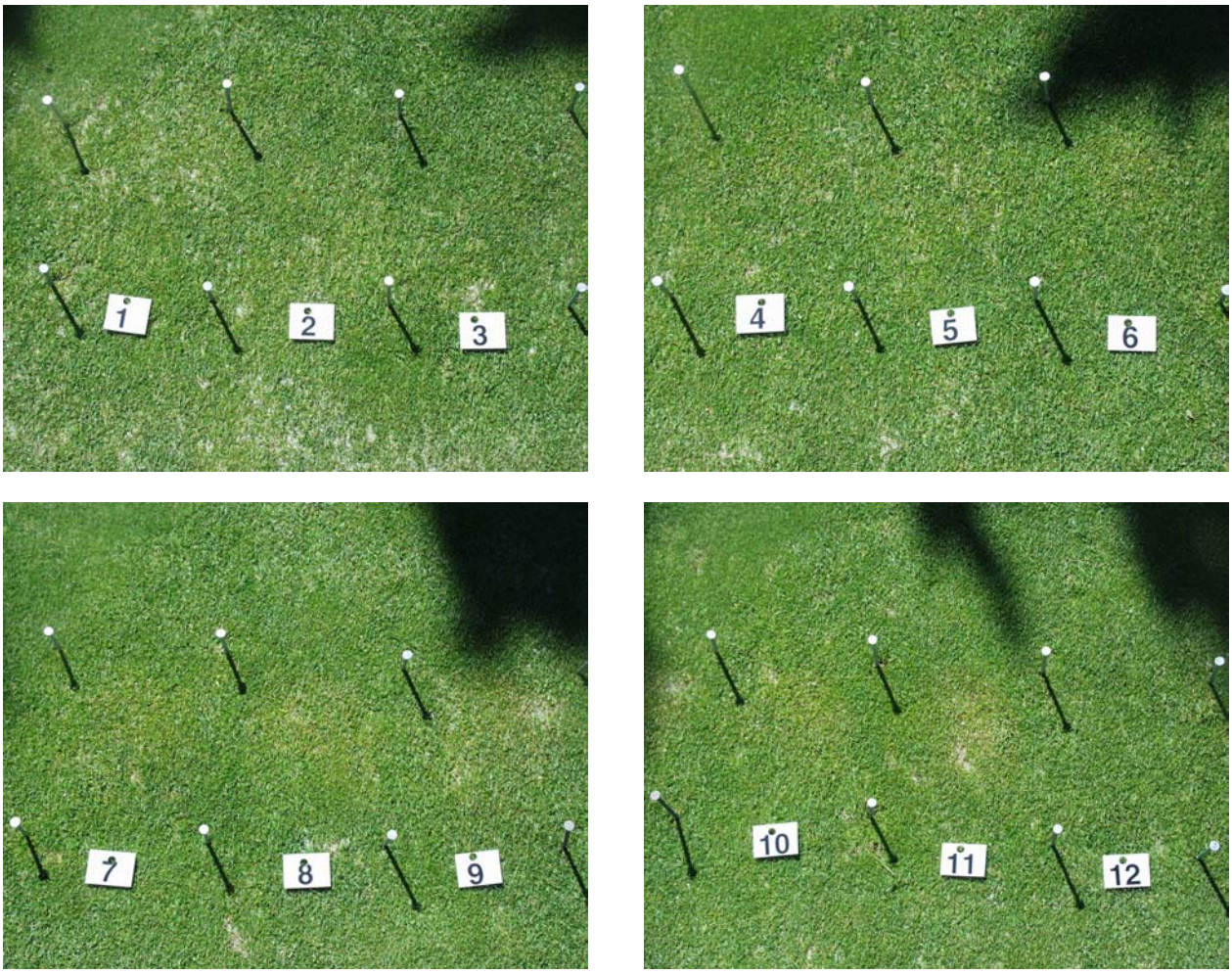


Figure 7. Turf quality results, 2 days after application (9/28/01). Plots were 6" squares (demarcated by a nail at each of the square's four corners), within which a circle of 5" diameter was treated. Note the gradually increasing levels of phytotoxicity in treatments 7 through 11 (rates of 12 - 32 oz/1000 sq ft of ACA 1820), and the more minor levels of phytotoxicity in treatments 17-20 (16 - 32 oz/1000 of ACA 1847).

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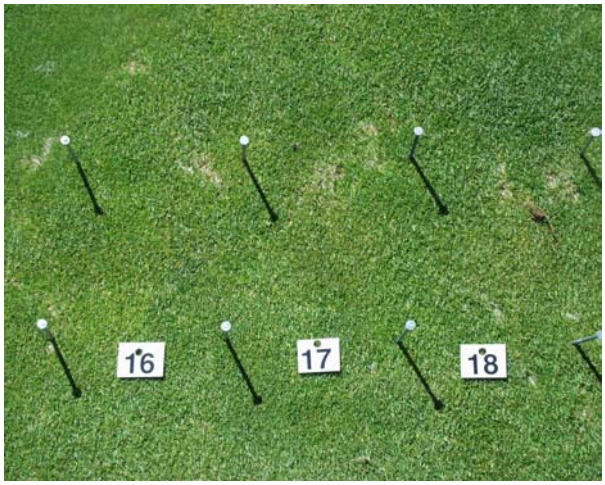
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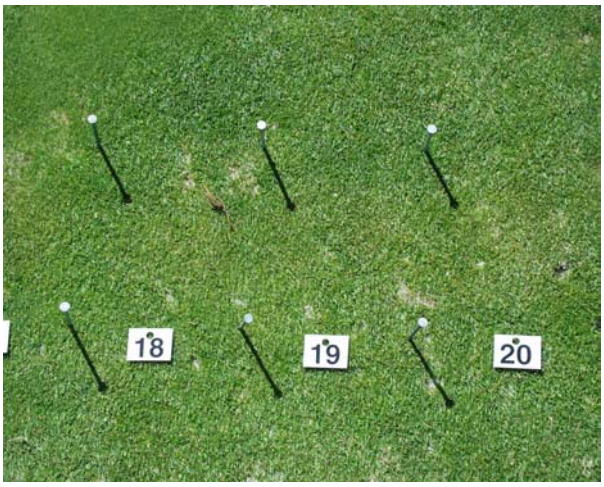
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RAW DATA

Trt	Rate (oz/1000 sq ft)	0hr (pre-treat)	1hr post-trt	1day post-trt	2days post-trt	7days post-trt
1	0	6.5	6.5	6.5	6.5	6.5
2	6	7	7	7	7	7
3	2	7	7	7	7	7
4	4	6.5	6.5	7	7	6.5
5	6	6.5	6.5	6.5	6.75	6.5
6	8	7	7	7	6.75	7
7	12	6.5	6.5	6.5	6.25	6.25
8	16	7	7	6.25	6	6.25
9	20	6.5	6.5	6	6.25	6
10	24	6.75	6.75	6.75	5.5	6.75
11	32	6.5	6.5	6.5	5.5	5.5
12	2	7.5	7.5	7.5	7	7
13	4	6.5	6.5	6.5	6.25	6.75
14	6	6.25	6.25	6.25	6.25	6.5
15	8	6.75	6.75	6.75	6.25	6.75
16	12	7	7	6.75	6.25	6.75
17	16	6.5	6.5	6.5	6.25	6
18	20	6.75	6.5	6.25	6.25	6
19	24	6.75	6.5	6.75	6.25	6.25
20	32	6.5	6.25	6.25	6.25	6

DATA ANALYSIS

ACA 1847: Linear regression (1 hour after treatment)

Dep Var: V1HR N: 9 Multiple R: 0.522 Squared multiple R: 0.273

Adjusted squared multiple R: 0.169 Standard error of estimate: 0.362

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	6.923	0.213	0.000	.	32.522	0.000
RATE	-0.021	0.013	-0.522	1.000	-1.620	0.149

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.345	1	0.345	2.624	0.149
Residual	0.919	7	0.131		

ACA 1847: 1 day after treatment

Dep Var: V1DAY N: 9 Multiple R: 0.477 Squared multiple R: 0.228

Adjusted squared multiple R: 0.117 Standard error of estimate: 0.373

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	6.870	0.219	0.000	.	31.321	0.000
RATE	-0.019	0.013	-0.477	1.000	-1.436	0.194

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.288	1	0.288	2.062	0.194
Residual	0.976	7	0.139		

ACA 1847: 2 days after treatment

Dep Var: V2DAY N: 9 Multiple R: 0.439 Squared multiple R: 0.192

Adjusted squared multiple R: 0.077 Standard error of estimate: 0.240

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	6.483	0.141	0.000	.	45.953	0.000
RATE	-0.011	0.008	-0.439	1.000	-1.291	0.238

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.096	1	0.096	1.666	0.238
Residual	0.404	7	0.058		

ACA 1847: 7 days after treatment

Dep Var: V7DAY N: 9 Multiple R: 0.829 Squared multiple R: 0.687

Adjusted squared multiple R: 0.643 Standard error of estimate: 0.234

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	6.888	0.137	0.000	.	50.189	0.000
RATE	-0.032	0.008	-0.829	1.000	-3.923	0.006

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.840	1	0.840	15.390	0.006
Residual	0.382	7	0.055		

ACA 1820 1 hour after treatment

Dep Var: V1HR N: 9 Multiple R: 0.261 Squared multiple R: 0.068

Adjusted squared multiple R: 0.000 Standard error of estimate: 0.251

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	6.781	0.147	0.000	.	46.046	0.000
RATE	-0.006	0.009	-0.261	1.000	-0.716	0.497

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.032	1	0.032	0.512	0.497
Residual	0.440	7	0.063		

ACA 1820, 1 day after treatment

Data for the following results were selected according to:
(TRT> 2) AND (TRT< 12)

Dep Var: V1DAY N: 9 Multiple R: 0.515 Squared multiple R: 0.265

Adjusted squared multiple R: 0.160 Standard error of estimate: 0.326

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	6.862	0.192	0.000	.	35.815	0.000
RATE	-0.018	0.011	-0.515	1.000	-1.590	0.156

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.269	1	0.269	2.529	0.156
Residual	0.745	7	0.106		

ACA 1820, 2 days after treatment

Dep Var: V2DAY N: 9 Multiple R: 0.949 Squared multiple R: 0.901

Adjusted squared multiple R: 0.886 Standard error of estimate: 0.198

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	7.094	0.116	0.000	.	61.133	0.000
RATE	-0.055	0.007	-0.949	1.000	-7.966	0.000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	2.477	1	2.477	63.451	0.000
Residual	0.273	7	0.039		

ACA 1820, 7 days after treatment

Data for the following results were selected according to:
(TRT> 2) AND (TRT< 12)

Dep Var: V7DAY N: 9 Multiple R: 0.709 Squared multiple R: 0.503

Adjusted squared multiple R: 0.432 Standard error of estimate: 0.365

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	6.886	0.214	0.000	.	32.133	0.000
RATE	-0.034	0.013	-0.709	1.000	-2.662	0.032

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.943	1	0.943	7.085	0.032
Residual	0.932	7	0.133		
