Project: Evaluation of Primo Rates and Application Timing Strategies for Improved Transition and Turf Quality on Common Bermudagrass Fairways

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Sponsors: Hi-Lo Desert Golf Course Superintendents Association and Novartis

Summary: A study was conducted on overseeded common bermudagrass fairways to determine the optimal rate, application timing and frequency of application for Primo to achieve improved Fall transition from common bermudagrass to ryegrass, and improved transition the following Spring, from ryegrass to bermudagrass. Of the 41 treatments tested (4 rates, 5 timing strategies and single vs. double applications), we found that Primo treatments made at the time of the first ryegrass mowing (on 10/23/96, or 1 day after the first mowing) resulted in an improved Fall transition from bermudagrass to ryegrass and significantly higher quality ryegrass during the critical winter and spring months than other treatments tested. The most economical of the highest ranked treatments was a single application of Primo Liquid at 0.5 oz/1000 sq feet, applied on 10/23/96. In contrast, Primo applications made later in the Fall (10/30/96, or 8 days after the first mow), produced a negative effect on turf quality during the 1997 Spring transition.

These results confirm that the currently labeled rate of 0.5 oz/1000 square feet for use of Primo Liquid in overseeding programs is the optimal rate for use in overseeding programs in the Low Desert, but that the currently recommended application timing (1 - 5 days before overseeding) may need to be adjusted. To confirm the results of this study, a 1997/98 trial that re-tests the highest ranked treatments from this year's study is recommended for initiation in September, 1997.

Materials and Methods:

Overseeding, Location and Design: Research plots were located at Indian Wells Country Club, Indian Wells, CA on Fairway 10, a common Bermudagrass fairway that was overseeded with perennial ryegrass (Scott's Divine) at a rate of 750 lbs/A on October 10, 1996. Seventeen days prior to seeding, irrigation to Fairway 10 was stopped (9/23/96). Once turf had dessicated sufficiently, the fairway was renovated via scalping and the use of a chain flail, a procedure that was repeated twice prior to seeding.

Plots measured 10 feet by 10 feet and were replicated three times in a randomized design. The treated area for each plot measured 7 feet by 10 feet, with an untreated strip measuring 3 feet by 10 feet that served as an internal check (Figure 1).

Application: Primo applications were made on the dates indicated in Table 1 and were applied with a bicycle sprayer equipped with 8008 vs flat fan nozzles and powered by CO_2 to deliver 30 psi at the boom and 1.7 gallons per 1000 sq ft. Calibration of each nozzle was confirmed prior to each application to be within 5% of the desired nozzle flow rate. The boom height was adjusted to 17 inches. The spray swath was 7.2 feet. Speed was monitored using a wheel driven speedometer at 2.0 mph (calibrated to be within 5% of the actual speed). Five gallon stainless steel beverage spray tanks were filled with water to the desired volume using a Great Plains Industries digital flow meter (Wichita, KS) calibrated to deliver volumes within 1% of the digital value displayed on the meter. Tanks were agitated by shaking twenty times prior to charging with compressed CO_2.

An application of Subdue 2E (2 oz/1000 sq ft) was made to all plots on 10/18/96 to protect turfgrass from attack by *Pythium*. Subdue was applied with a bicycle sprayer arranged as described above, but with 8001 VS nozzles delivering 0.3 gallons volume per 1000 sq ft. A schedule of events associated with this trial appears in Table 2 below.

Treatments: Forty-one different treatments, selected to evaluate 4 rates of Primo Liquid (0.25, 0.5, 0.75 and 1.0 oz/1000 sq ft), 5 different timing strategies (17 days before overseeding, the day of overseeding, 4 days before the 1st mow, 1 day after the 1st mow, and 8 days after the 1st mow) and single vs. double applications were tested (Table 1).

Table 2. Treatment and evaluation schedule.

Date	Event
9/23/96	Pre-overseeding application of Primo made to appropriate plots
9/23/96	Irrigation to research plots stopped
10/10/96	Research plots overseeded with Scott's "Divine" perennial ryegrass; Primo applied to treatment 41 plots immediately before overseeding
10/18/96	Pre-mow application of Primo made to appropriate plots; Subdue 2E applied to all plots
10/22/96	First mowing of research plots
10/23/96	First post-mowing application of Primo made to appropriate plots; first evaluation made to plots
10/30/96	Second post-mowing application of Primo to appropriate plots; second evaluation date
11/10/96	Third evaluation date
11/27/96	Fourth evaluation date
12/10/96	Fifth evaluation date
4/11/97	Sixth evaluation date
6/3/97	Final evaluation date

Evaluations and Statistical Analysis: On each of seven evaluation dates (see Table 2 above), turf quality (color, density, uniformity and fineness of turf) was rated for each plot on the basis of a 0 - 9 scale, with 0 = dead turf and 9 = best possible turf quality. Percent ryegrass vs. percent bermudagrass stands were also evaluated.

To gain an overview of the turf quality data, mean quality ratings for each treatment were averaged over all 7 evaluation dates to produce an average turf quality rating for each treatment (Table 3).

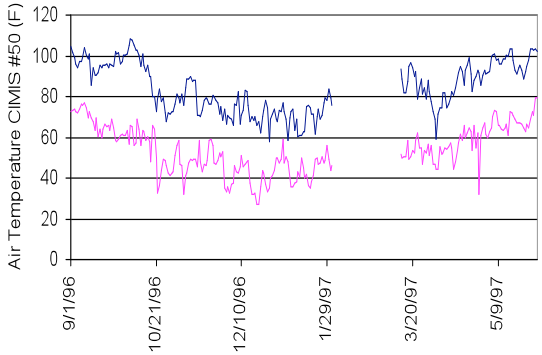
The factorial design of the trial allowed us to examine the data in greater depth, via factor analysis. Step-wise multiple linear regression analysis was conducted, with factors (rate, timing) added into the regression model if the probability that the partial correlation was due to chance was less than 0.05. A significant ($P<0.05$) positive correlation identified those treatments where rate and timing had a positive effect on turfgrass quality, while a significant negative correlation indicated that rate and/or timing had a negative impact on turfgrass quality (Table 4).

The results of the multiple linear regression were used to identify those treatments that produced the highest quality turf most consistently for the duration of the trial. These 15 treatments were compared against the non-treated check and against one another using analysis of variance, with treatment means separated using Fisher's LSD, where $P<0.05$ (Table 5).

Results and Discussion:

Overall turf conditions: Due to relatively warm winter temperatures (Figure 2) during the course of the trial, Bermudagrass did not enter complete dormancy, and comprised 50% or more of the turf in all treatments throughout the trial. It is believed that warm season grasses show the typical signs of dormancy (color change to tan or white, minimal growth) when temperatures are below 55° F (Beard, 1982). As shown in Figure 2, while minimum temperatures sometimes dipped below this 55° F threshold, maximum temperatures never did, thus resulting in minimal exposure of turf to dormancy-inducing temperatures.

Figure 2. Maximum (black line) and minimum (gray line) air temperatures (° F) from CIMIS station # 50 (Thermal, CA) from 9/1/96 - 6/30/97. Warm season grasses enter dormancy when temperatures are below 55° F. Note that data from February, 1997 is missing due to CIMIS equipment failure during that time period.



Mean turf quality ratings: At first glance, the large number of treatments tested and multiple evaluation dates makes interpretation of the data daunting (Table 3). However, several trends emerge from examination of this data including:

- over half of the treatments tested appeared to perform at least as well, if not better, than the non-treated control (treatment 1), with average turf quality ratings of 6.05 or over.

- 16 of the treatments tested appeared to perform as well, or worse than the non-treated control, with average turf quality ratings of less than 6.05.

- A treatment made on the day of seeding (treatment 41) had no impact -- positive or negative -- on turf quality when compared to the non-treated control (treatment 1).

Factor analysis: To gain more insight into the performance of each treatment, and to determine whether any of the treatments was statistically superior to the non-treated control, further statistical analysis, in the form of factor analysis, was conducted (Table 4). The results of this analysis indicated the following:

- Primo applications may exert a negative effect on turf quality, in the form of a lighter, or more yellowed appearance, in the first 2 - 4 weeks after application. This negative effect is heightened as the rate of Primo is increased from 0.25 oz/1000 sq ft to 1.0 oz/1000 sq ft, as indicated by the significant negative correlation between turf quality and rate during and around the time period when Primo applications were being made (see turf quality ratings for 10/23/96, 10/30/96, and 11/10/96). This negative effect, which appears to be reversible, is not the direct effect of phytotoxicity. Instead, we believe that the normally senescing turf (especially the lower leaves) simply becomes more obvious in Primo treated turf, due to the desired slow-down in growth of new, green leaves in these plots.

- During the Fall transition from Bermudagrass to ryegrass, following some initial discoloration of turf due to Primo applications, turf quality was significantly improved under several rate and timing regimes. In particular, Primo applications made on 10/23/96 demonstrated significantly positive correlations with turf quality on four evaluation dates (11/10/96, 11/27/96, 12/10/96 and 4/11/97). None of the other timing regimes tested produced such consistent results, with applications made on 10/30/96 producing statistically significant positive correlations on only two dates (11/27 and 12/10/96), or on only one date (for applications made on 10/18 or 9/23). Based on this analysis, treatments made on 10/23/96 (1 day after the first mow, or 13 days after overseeding) provided the most consistently positive results, and were examined further using analysis of variance (see below).

- During the Spring transition back to Bermudagrass, results were less dramatic, with only one timing regime (applications made on 10/23/96) producing a significant positive correlation on one evaluation date (4/1/97). Surprisingly, applications made on 10/30/96 produced a significant negative correlation on the 6/3/97 evaluation date, indicating that treatments made too late in the Fall (10/30/96 [8 days after the first mow] or later) may have the ability to slow down the transition back to Bermudagrass in the Spring. A possible explanation for this observation is that the increasingly cooler weather (see Figure 2; showing temperature dips in late October and early November), decreasing day length and 10/30/96 Primo application interacted to place maximum stress on the Bermudagrass, placing it at a disadvantage during the spring transition in 1997. Whether this effect will carry over into the summer months of 1997 could not be determined based on this data set, which incorporates data only through 6/3/97.

Analysis of variance: To determine which of the treatments made on 10/23/97 produced the best results, analysis of variance for these 15 treatments (Table 5) was conducted. Results indicated that six different treatments (treatments 6,17, 26, 27, 35 and 36) produced turf quality that was significantly better than the non-treated control on one or more evaluation dates. However, only two of these treatments (treatment 6 and treatment 27) produced turf quality that was consistently better than the non-treated control on two evaluation dates. It is interesting to note that while treatment 27 consisted of two treatments of Primo (0.75

oz/1000 before seeding, followed by 0.75 oz/1000 on 10/23/96), treatment 6 consisted of only one application of Primo (0.5 oz/1000 on 10/23/96). From the standpoint of efficacy and economics, the use of a single application of Primo at 0.5 oz/1000 is the most desirable of the 41 treatments tested in this trial. However, it will be necessary to evaluate this strategy for an additional 1 - 2 years to confirm the consistency of performance under varying weather and overseeding strategy conditions.

Conclusions:

- When applied at the appropriate time in the overseeding cycle (10/23/96, or 1 day after the first mow), a single Primo application (0.5 - 0.75 oz/1000 sq ft of the liquid formulation) resulted in an improved transition from Bermudagrass to ryegrass, with significantly improved turf quality during the winter and spring months. The value of double applications of Primo (an initial treatment of Primo prior to overseeding, followed by a second application after overseeding) was not clear under the weather and overseeding conditions experienced during the trial.

- Applications of Primo made on the day of seeding had no impact -- positive or negative -- on turfgrass quality.

- Applications of Primo made later in the Fall (8 days after the first mow, or 10/30/96) may have a negative impact on the Spring transition from ryegrass to Bermudagrass, as indicated by a negative correlation between rate and turf quality on 6/3/97 for applications made on 10/30/96.

- The current Primo label recommends a rate of 0.5 oz/1000 for use in overseeding programs, which is confirmed by the data presented above. However, the optimal timing of this application may be later in the year than the current label recommendation of 1 - 5 days before overseeding.

- To confirm the results obtained in the 1996/97 test, we recommend that the most promising of the treatments tested in this trial be re-evaluated in a trial conducted during 1997/98. The recommended treatments for this trial are listed in Table 6. Treatments to be tested focus on the 0.5 oz/1000 sq foot rate, as well as on the most successful application timing we tested this year, 1 day after the first mowing.

Table 1. Timing and rates of Primo applications.

	Primo rate 17 d before seeding 9/23/96				Primo rate 4 d before 1st mow 10/18/96				Primo rate 1 d after 1st mow 10/23/96				Primo rate 8 d after 1st mow 10/30/96			
Trt #	**0.00**	**0.50**	**0.75**	**1.00**	**0.00**	**0.25**	**0.50**	**0.75**	**0.00**	**0.25**	**0.50**	**0.75**	**0.00**	**0.25**	**0.50**	**0.75**
1	X				X											
2	X					X										
3	X						X									
4	X							X								
5	X									X						
6	X										X					
7	X											X				
8	X													X		
9	X														X	
10	X															X
11		X			X											
12		X				X										
13		X					X									
14		X						X								
15		X								X						
16		X									X					
17		X										X				
18		X												X		
19		X													X	
20		X														X
21			X		X											
22			X			X										
23			X				X									
24			X					X								
25			X							X						
26			X								X					
27			X									X				
28			X											X		
29			X												X	
30			X													X
31				X	X											
32				X		X										
33				X			X									
34				X				X								
35				X						X						
36				X							X					
37				X								X				
38				X										X		
39				X											X	
40				X												X
41	Primo @ 0.5 oz/1000 sq feet, treated day of seeding (10/10/96)															

Table 3. Mean quality ratings for all treatments on each of 7 evaluation dates, and the mean turf quality rating for each treatment, averaged across all dates.

	17 d before seeding 9/23/96				4 d before 1st mow 10/18/96				1 d after 1st mow 10/23/96				8 d after 1st mow 10/30/96				MEAN QUALITY RATINGS for EACH EVALUATION DATE							AVG of ALL DATES
Trt	**0.00**	**0.50**	**0.75**	**1.00**	**0.00**	**0.25**	**0.50**	**0.75**	**0.00**	**0.25**	**0.50**	**0.75**	**0.00**	**0.25**	**0.50**	**0.75**	**10/23/96**	**10/30/96**	**11/10/96**	**11/27/96**	**12/10/96**	**4/11/97**	**6/3/97**	
1	X				X												6.33	5.83	6.00	6.00	6.00	6.00	6.17	6.05
2	X					X											5.33	5.67	6.00	6.00	6.33	6.00	6.17	5.93
3	X						X										5.33	5.67	6.33	6.00	6.83	6.00	5.67	5.98
4	X							X									5.00	5.67	6.00	6.00	6.83	6.33	6.00	5.98
5	X									X							6.00	5.50	6.33	6.00	6.50	6.50	6.00	6.12
6	X										X						6.33	5.50	6.33	7.00	7.17	6.33	5.67	6.33
7	X											X					6.00	5.67	6.00	6.33	6.67	6.67	5.67	6.14
8	X													X			5.67	6.00	5.33	6.33	6.50	6.00	6.17	6.00
9	X														X		5.67	5.17	5.00	7.00	7.17	6.00	6.00	6.00
10	X															X	6.00	5.67	5.00	7.00	7.50	6.00	5.67	6.12
11		X			X												6.33	6.00	6.00	6.00	6.17	6.00	6.00	6.07
12		X				X											5.67	5.50	6.00	6.00	6.83	6.33	6.00	6.05
13		X					X										5.00	4.50	6.00	6.67	6.83	6.00	5.67	5.81
14		X						X									5.00	5.17	7.00	6.33	6.50	6.67	5.67	6.05
15		X								X							5.67	5.83	6.33	6.33	6.83	6.33	6.00	6.19
16		X									X						5.67	5.33	5.67	6.33	6.67	6.83	5.67	6.02
17		X										X					6.00	5.33	6.33	6.67	7.17	6.50	5.67	6.24
18		X												X			6.33	5.50	5.67	7.00	6.83	6.67	6.17	6.31
19		X													X		5.67	5.50	5.00	7.00	7.17	6.33	6.00	6.10
20		X														X	5.67	5.33	5.00	7.00	7.50	6.67	5.33	6.07
21			X		X												6.00	5.67	6.00	6.00	6.50	6.33	6.00	6.07
22			X			X											5.33	5.33	6.33	6.67	6.50	6.33	6.00	6.07
23			X				X										5.00	5.33	6.33	6.33	6.83	6.33	6.00	6.02
24			X					X									5.00	5.17	6.67	6.33	6.67	6.00	6.00	5.98
25			X							X							6.00	5.33	5.67	6.33	6.83	6.33	5.67	6.02
26			X								X						5.67	5.50	6.00	6.67	7.17	6.67	6.00	6.24
27			X									X					5.67	5.33	6.67	7.00	6.83	6.50	6.00	6.29
28			X											X			5.67	5.33	6.00	6.67	7.17	6.33	5.67	6.12
29			X												X		5.67	5.50	5.33	6.67	6.33	6.33	6.00	5.98
30			X													X	6.00	5.33	5.33	7.00	7.50	6.83	5.33	6.19
31				X	X												5.67	5.50	6.00	6.00	6.50	6.33	5.67	5.95
32				X		X											5.00	5.00	6.00	6.00	6.33	6.00	6.00	5.76
33				X			X										5.00	4.83	6.33	6.67	7.17	6.00	6.00	6.00
34				X				X									5.00	5.17	6.67	6.33	6.50	6.00	5.67	5.91
35				X						X							6.00	5.67	6.33	6.33	7.17	6.67	6.17	6.33
36				X							X						5.67	5.33	6.67	6.33	6.67	6.00	6.00	6.10
37				X								X					6.00	5.00	6.33	6.67	6.86	6.33	5.67	6.12
38				X										X			5.67	5.50	5.67	6.67	6.67	6.33	6.00	6.07
39				X											X		5.67	5.33	5.67	7.00	7.17	6.33	6.00	6.17
40				X												X	6.00	5.17	5.00	7.00	7.50	6.50	5.67	6.12
41	Primo @ 0.5 oz/1000 sq feet, treated the day of seeding (10/10/96)																6.00	5.67	6.00	6.00	6.17	6.17	5.83	5.98

Table 4. Significance of Primo rate and application timing for turfgrass quality using factor analysis. Step-wise multiple linear regression analysis was conducted, with factors (rate, timing) added into the regression model if the probability was less than 0.05 that the partial correlation was due to chance. Values in the table below represent the correlation coefficient (top number) and the probability due to chance (bottom number in parentheses) for each factor at each quality rating date. A probability of 0.05 or less indicates that the interaction was statistically significant. A positive correlation coefficient indicates a beneficial interaction among rate, timing, and turfgrass quality; statistically significant positive correlation coefficients are highlighted in green shaded boxes below (the 11/10/96, 11/27/96, 12/10/96 and 4/11/97 evaluation dates for the 10/23/96 Primo application, for example). A negative correlation coefficient indicates that rate and/or timing had a negative impact on turfgrass quality; significant negative correlations are indicated below in blue shaded boxes (the 6/3/97 evaluation date for the 10/30/96 Primo application date, for example).

APPLICATION DATE	TURF QUALITY RATINGS						
	10/23/96	**10/30/96**	**11/10/96**	**11/27/96**	**12/10/96**	**4/11/97**	**6/3/97**
9/23/96	–0.163 (0.077)	–0.366 (0.004)	0.248 (0.042)	0.141 (0.127)	0.067 (0.469)	0.074 (0.424)	–0.032 (0.729)
10/18/96	–1.327 (0.000)	–0.417 (0.022)	0.738 (0.001)	0.120 (0.197)	0.159 (0.086)	–0.101 (0.273)	–0.075 (0.417)
10/23/96		–0.096 (0.299)	0.500 (0.024)	0.590 (0.000)	0.506 (0.016)	0.375 (0.038)	–0.169 (0.067)
10/30/96			–1.238 (0.000)	1.185 (0.000)	1.053 (0.000	0.163 (0.077)	–0.279 (0.040)

Table 5. Mean turfgrass quality ratings for all treatments made on 10/23/97. Turf was rated on a scale of 0 - 9. Reading vertically for a given date, ratings associated with the same letter are not significantly different (Fisher's LSD, P<0.05). Treatments performing significantly better than the non-treated check are indicated in boxes shaded in green.

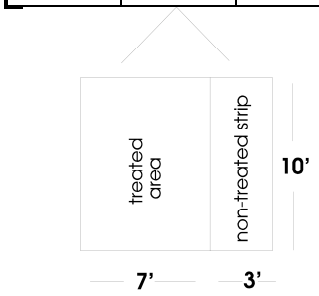
Trt#	Primo 9/23 applic. rate	Primo 10/23 applic. rate	11/10/96 Quality	11/27/96 Quality	12/10/96 Quality	4/11/97 Quality	6/3/97 Quality
1	0	0	6.00 ab	6.00 a	6.00 a	6.00 a	6.17 a
5	0	0.25	6.33 ab	6.00 a	6.50 ab	6.50 a	6.00 a
6	0	0.5	6.33 ab	7.00 b	7.17 b	6.33 a	5.67 a
7	0	0.75	6.00 ab	6.33 ab	6.67 ab	6.67 a	5.67 a
11	0.5	0	6.00 ab	6.00 a	6.17 ab	6.00 a	6.00 a
15	0.5	0.25	6.33 ab	6.33 ab	6.83 ab	6.33 a	6.00 a
16	0.5	0.5	5.67 a	6.33 ab	6.67 ab	6.83 a	5.67 a
17	0.5	0.75	6.33 ab	6.67 ab	7.17 b	6.50 a	5.67 a
21	0.75	0	6.00 ab	6.00 a	6.50 ab	6.33 a	6.00 a
25	0.75	0.25	5.67 a	6.33 ab	6.83 ab	6.33 a	5.67 a
26	0.75	0.5	6.00 ab	6.67 ab	7.17 b	6.67 a	6.00 a
27	0.75	0.75	6.67 b	7.00 b	6.83 ab	6.50 a	6.00 a
31	1	0	6.00 ab	6.00 a	6.50 ab	6.33 a	5.67 a
35	1	0.25	6.33 ab	6.33 ab	7.17 b	6.67 a	6.17 a
36	1	0.5	6.67 b	6.33 ab	6.67 ab	6.00 a	6.00 a
37	1	0.75	6.33 ab	6.67 ab	6.83 ab	6.33 a	5.67 a

Table 6. Recommended treatment list for 1997/98 follow up testing. Treatment numbers listed in left hand column have been retained from the 1996/97 study.

	Primo rate 17 d before seeding				1 d after 1st mow				8 d after 1st mow			
Trt #	**0.00**	**0.50**	**0.75**	**1.00**	**0.00**	**0.25**	**0.50**	**0.75**	**0.00**	**0.25**	**0.50**	**0.75**
1	X											
5	X					X						
6	X						X					
9	X										X	
11		X										
15		X				X						
16		X					X					
17		X						X				
18		X								X		
19		X									X	
20		X										X
25			X			X						
26			X				X					
27			X					X				
29			X								X	
35				X		X						
36				X			X					
37				X				X				
39				X							X	

Figure 1. Plot layout. Indian Wells Country Club, Indian Wells, CA. Fairway 10

39	12	38	27	15	13		R
23	1	18	34	29	6	22	E
19	7	14	3	16	26	41	P
4	25	5	28	37	10	33	3
32	21	9	2	36	11	35	
24	31	8	20	30	17	40	
25	14	8	27	39	11		R
7	3	38	2	16	6	20	E
23	19	10	37	12	34	4	P
24	18	22	32	28	15	26	2
29	31	9	1	5	40	35	
36	17	33	13	21	30	41	
36	37	38	39	40	41		R
29	30	31	32	33	34	35	E
22	23	24	25	26	27	28	P
15	16	17	18	19	20	21	1
8	9	10	11	12	13	14	
1	2	3	4	5	6	7	



enlargement of 1 replicated plot

References:

Beard, J.B. 1982. Turf Management for Golf Courses. Macmillan Publishing Company, New York. p. 454.

Photographs:

961855-1	Primo plots, Fairway 10. 10/10/96 (overseeding date)
961855-2	Primo plots, Fairway 10. 10/30/96 (8 days after 1st mow)
961855-4	Primo plots, Fairway 10. 6/3/97 (final evaluation)
961855-5	Treatment 34, 10/23/96. Positive effects of Primo applications. Note darker color of treated area
961855-6 from Primo	Treatments 9 and 10, 11/1/096 (19 days after 1st mow). Temporary off-color resulting applications.