Management of *Poa annua* on Overseeded Fairways

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Sponsors: AgrEvo, Hi-Lo GCSA, Novartis, Rhone-Poulenc

Summary: Product labels for several pre-emergent herbicides currently contain warnings that applications made less than 4 months before overseeding may result in damage to turf. In other words, applications must be made no later than June -- too early to obtain season long control in Southern California. Data from the southeastern U.S. suggests that both Ronstar and Barricade can be applied as late as 6 - 8 weeks before overseeding without damaging emerging ryegrass. This replicated trial was set up to confirm these results under southwestern weather and turf management conditions and to investigate the following questions:

1. Which herbicides can be applied closest to the overseeding date, without damaging turf?
2. Which herbicides provide the best control of *Poa annua*?

Key results include the following:

- If the correct rates of pre-emergence herbicides are used (50-100 lbs/A Ronstar G, less than 2 lb/A Barricade 65 G), these products can be applied much closer to overseeding (4 - 8 weeks before overseeding) than their labels currently indicate. This strategy will result in little or no turf damage, and good weed control through April or May, or as much as 9 months post-application.

- Of the thirty-six different treatments that were evaluated, the best poa control was observed with both pre-emergence herbicides (Ronstar and Barricade) and the post-emergent herbicide Prograss.

- Turf quality (damage to ryegrass) was significantly influenced by the rate of Ronstar G used, with a significant negative correlation between rate and turf quality. Interestingly, the timing of application of Ronstar G had little negative impact on turfgrass quality, even when applications were made 10, 8, 6, 4 and 2 weeks before overseeding.

- Higher rates of pre-emergence herbicides (Ronstar G at >100 lb/A and Barricade 65 G at 2 lb/A) caused severe damage to ryegrass when applied 2 - 10 weeks before overseeding.

- Split applications of Ronstar (50 lb/A, 4-8 weeks before overseeding and 100 lb/A 6-12 weeks after overseeding) provided excellent poa control, with consistent lack of phytotoxicity. This strategy appears to be the most likely to ensure good weed control, without any concomitant damage to turf.

Materials and Methods:

Location: The trial was conducted on Fairway 12 of Desert Dunes Golf Club, Desert Hot Springs, CA. The bermudagrass fairway was overseeded with perennial ryegrass on September 29, 1997, at a rate of 750 lb/A.

Experimental design and application: Plots (measuring 7 by 10 feet) were replicated three times in a randomized design (Figure 1), with a non-treated plot of 3 by 10 feet adjacent to each treated plot (Figure 2).

Sprayable products were applied with a bicycle sprayer using a single boom and 8008 flat fan nozzles on a 20 inch spacing, powered by CO_2 to deliver 22 psi at the boom and 1.76 gallons/1000 square feet. 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 (periodically calibrated to be within 5% of the actual speed). Five gallon stainless steel beverage spray tanks were filled with water to the

desired dilution 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 20 times prior to charging with compressed CO_2. The spray lines were purged with CO_2 and then water prior to changing treatments.

Ronstar G was applied with two passes of a Gandy drop spreader, forming two 33 inch swaths. Calibration to deliver 50, 100 or 200 lb/A Ronstar G resulted in Gandy settings of 15.5, 20 and 26.5, respectively. The accuracy of calibration was confirmed to be within + 5% of the desired rate by conducting 3 passes of 15 linear feet each at the specified settings, collecting the product in question and weighing it. All treatments were irrigated with 1/10" water immediately following application.

Figure 1. Plot plan. Circled area indicates plot areas where insufficient irrigation resulted in enhanced turf stress and phytotoxicity to ryegrass.

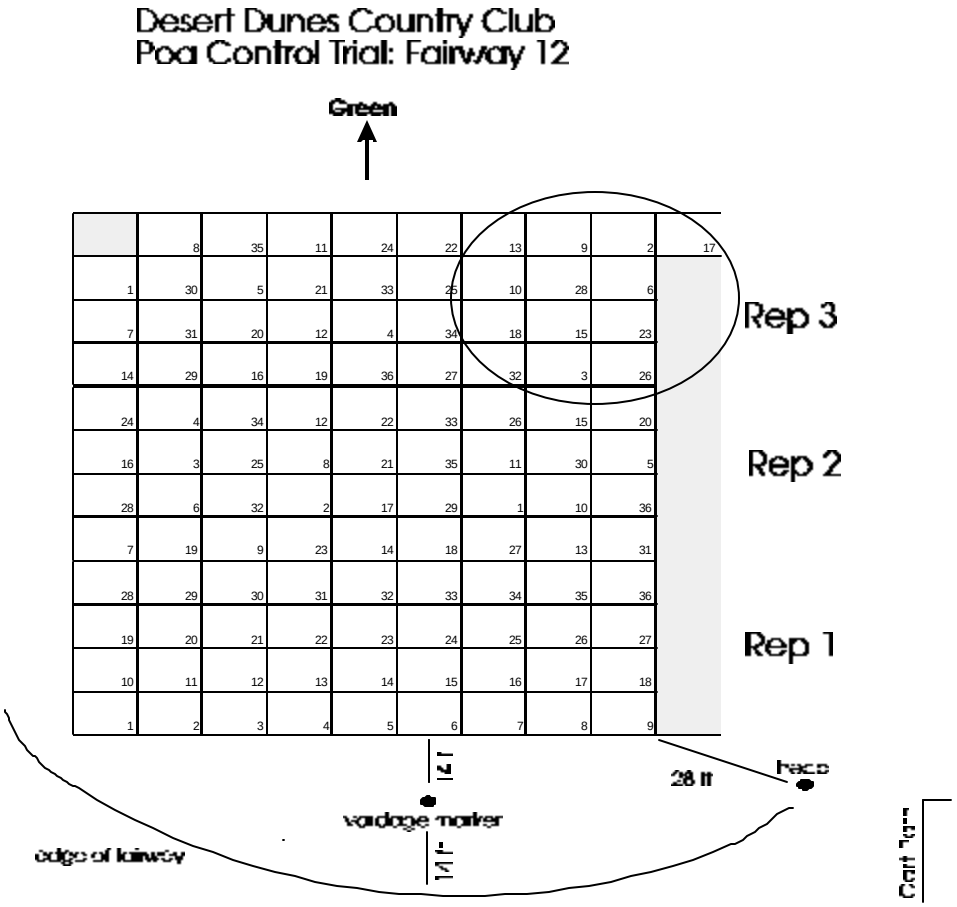
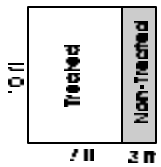


Figure 2. Illustrates the placement of a non-treated buffer plot adjacent to each treated plot.



Treatments: Treatments and application dates are listed in Table 1 below. Although the original protocol called for treatments to be initiated 12 weeks before overseeding, an earlier than expected overseeding date made this impossible. For this reason, the earliest treatments made were 10 weeks before overseeding took place. To compensate for the lack of treatments 12 weeks before overseeding, treatments made 2 weeks before overseeding were added to the trial.

Table 1. Treatment List: Treatment dates are indicated by shaded boxes. Overseeding occurred on 9/29/97.

Product (before / after overseed)	**Rate/A** (before / after overseed)	**# weeks before overseeding**						**# weeks after overseeding**				
		7/18	7/31	8/14	8/31	9/11	9/24	10/31	11/14	11/26	12/10	12/20
1. Ronstar G	50 lb	■										
2. Ronstar G	100 lb	■										
3. Ronstar G	200 lb	■										
4. Ronstar G	50 lb		■									
5. Ronstar G	100 lb		■									
6. Ronstar G	200 lb		■									
7. Ronstar G	50 lb			■								
8. Ronstar G	100 lb			■								
9. Ronstar G	200 lb			■								
10. Ronstar G	50 lb				■							
11. Ronstar G	100 lb				■							
12. Ronstar G	200 lb				■							
13. Ronstar G	50 lb					■						
14. Ronstar G	100 lb					■						
15. Ronstar G	200 lb					■						
16. Ronstar G/Ronstar G	50 lb /100 lb		■						■			
17. Ronstar G/Ronstar G	100 lb /100 lb		■						■			
18. Ronstar G/Ronstar G	200 lb /100 lb		■						■			
19. Ronstar G/Ronstar G	50 lb /100 lb			■						■		
20. Ronstar G/Ronstar G	100 lb /100 lb			■						■		
21. Ronstar G/Ronstar G	200 lb /100 lb			■						■		
22. Ronstar G/Ronstar G	50 lb /100 lb				■						■	
23. Ronstar G/Ronstar G	100 lb /100 lb				■						■	
24. Ronstar G/Ronstar G	200 lb /100 lb				■						■	
25. Ronstar G/Ronstar G	50 lb /100 lb					■						■
26. Ronstar G/Ronstar G	100 lb /100 lb					■						■
27. Ronstar G/Ronstar G	200 lb /100 lb					■						■
28. Ronstar G/ Barricade 65	100 lb / 1.15 lb			■						■		
29. Ronstar G / Pendulum DG	100 lb / 2.5 lb			■						■		
30. Ronstar G / Primo L	100 lb / 22 oz			■				■		■		■
31. Ronstar G / Prograss	100 lb / 0.5 ga			■						■		■
32. Ronstar G / Prograss	100 lb / 0.25 ga			■						■	■	■
33. Barricade 65 G	2.0 lb	■										
34. Primo L	22 oz / 22 oz						■	■		■		■
35. Prograss	0.5 ga							■		■		■
36. No treatment												

A listing of the products tested and their active ingredients is printed below.

Product	Active Ingredient	% AI
Ronstar G	oxadiazon	2%
Barricade 65 G	prodiamine	65%
Pendulum 60 DG	pendimethalin	60%
Primo L	trinexapac-ethyl	12%
Prograss	ethofumesate	19%

Evaluations: Turf was rated for overall quality (color and density) on a 0-7 scale (where 7 was the highest quality fairway turf and 0 was the worst quality turf) in 1997 (10/31, 11/14, 11/26 and 12/20) and 1998 (2/12). Percent poa control was rated on 4/14/98. Although a high percentage of *Poa annua* was present in non-treated plots earlier than 4/14/98, an unanticipated golf course-wide application of Embark (mefluidide) at 6 oz/A on February 2, 1998, prevented seed head formation until April, 1998. On rating dates in February and March, it was determined that accurate assessment of percent poa infestations could be made only when seedheads had formed.

Percent poa control data was transformed prior to statistical analysis using the arcsine (square root) of the proportion. All data was subjected to analysis of variance, and treatments means separated using Fisher's LSD, where $P<0.05$.

Factor analysis was utilized to further evaluate the significance of Ronstar rate and application timing for turfgrass quality and percent poa control. 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. A significant ($P<0.05$) positive correlation identified those treatments where rate and timing had a positive effect on either turfgrass quality or poa control, while a significant negative correlation indicated that rate and/or timing had a negative impact on turfgrass quality or poa control.

Irrigation malfunction: On 10/31/97 and subsequent sampling dates, severe ryegrass damage was observed in one corner of replicate 3, in an area encompassing treatments 2,3,6,9,10, 15, 17, 18, 23, 26, 28, 32 (see Figure 1). The superintendent indicated that a sprinkler head just outside this portion of the test plot area did not function properly for several weeks during the late Fall, resulting a significant drought stress to these plots. The combination of drought stress plus herbicide applications appeared to have exacerbated phytotoxicity symptoms in these plots (see discussion below).

Results and Discussion

Turf Quality (phytotoxicity to ryegrass): Turf quality ratings (which correlate directly to the degree of ryegrass damage) taken on five dates allowed us to break treatments into several groups, based on the frequency and duration of phytotoxicity. The experimental design provided internal replication, particularly of the 100 lb/A rate of Ronstar G, allowing repeated observations on product performance (Tables 2 and 3).

I. Treatments where significant ($P<0.05$) damage to ryegrass was observed on every post treatment rating date.

- Treatments 6,9,12,15, 18, 21, 24: Ronstar G, 200 lb/A: 8,6,4 and 2 weeks before overseeding.
- Treatment 17: Ronstar G, 100 lb/A: 8 weeks before overseeding, followed by Ronstar G, 100 lb/A 14 weeks later (damage probably due to irrigation malfunction)
- Treatment 28: Ronstar G, 100 lb/A: 6 weeks before overseeding, followed by Barricade 65G, 1.15 lb/A, 8 weeks after overseeding (damage probably due to irrigation malfunction)

II. Treatments where significant ($P<0.05$) damage to ryegrass was observed on two, three or four rating dates.

- Treatment 3: Ronstar G, 200 lb/A, 10 weeks before overseeding
- Treatment 14, 23, 26, 29, 30, 31, 32: Ronstar G, 100 lb/A, 2, 4 or 6 weeks before overseeding (damage in treatments 23, 26 and 32 may be due to irrigation malfunction).
- Treatment 33: Barricade 65 G, 2.0 lb/A, 10 weeks before overseeding (the rate tested was at the high end of the recommended range for overseeded turf).

III. Treatments where little (1 rating date out of 5) or no significant ryegrass damage was observed.

- Treatments 1, 4, 7, 10, 13, 16, 19, 22, 25. Ronstar G, 50 lb/A, 10,8,6,4 and 2 weeks before overseeding
- Treatments 2, 5,8,11, 20, Ronstar G, 100 lb/A, 10, 8, 6, 4 weeks before overseeding
- Treatment 34: Primo L, 22 oz/A
- Treatment 35: Prograss, 0.5 ga/A

For the most part, a significant rate response was observed for Ronstar G, with higher rates producing more damage to ryegrass. However, the application date appeared to have little impact on phytotoxicity, with no significant differences observed among Ronstar treatments applied at the same rate, but on different dates (Table 2). This data suggests that the rate of Ronstar used, rather than the application date, will determine the level of phytotoxicity observed.

The 200 lb/A rate of Ronstar G consistently caused ryegrass damage and resulted in bermudagrass damage as well (see below). Even at the last rating date (6/11/98, or 11 months after trial initiation), damage from 200 lb treatments was still evident.

In terms of phytotoxicity, the inconsistent performance of the 100 lb/A rate was mystifying, until the irrigation malfunction (see Materials and Methods) in the third replicate was taken into consideration. Examination of the raw data (see Appendix) indicates that ryegrass damage ratings for replicate 3 of the 100 lb/A treatments 17, 23, 26, 28 and 32 was higher than for these same treatments in replicates 1 and 2. In other words, due to the unanticipated drought stress suffered in replicate 3, several of the 100 lb/A treatments appeared to be more damaging to ryegrass than they would be under non-stressed conditions. It should be noted however that the 100 lb rate of Ronstar G did cause some damage to ryegrass in some treatments, particularly at the 2 week before overseeding application date. Based on this data, the 100 lb/A rate may be damaging to turf that is stressed.

Phytotoxicity to bermudagrass: On April 14 and June 11, 1998, plots were assessed for damage to bermudagrass. The only treatments which produced damage to bermudagrass were Ronstar G at 200 lb/A, applied at all application timings prior to overseeding (10, 8, 6, 4 and 2 weeks before overseeding).

Control of *Poa annua*: Very high (>50% in most plots) poa infestations were observed on the 4/14/98 rating date, when seedhead production allowed us to accurately evaluate control levels. Many of the products and timing regimes tested resulted in good to excellent poa control (Table 2), with only a few treatments (Ronstar, 50 lb/A at 10 weeks or 4 weeks before overseeding and Primo L) producing less than acceptable control. In general, there was a significant rate response with Ronstar G vs. poa control (Table 3), with increasing rates providing increasing levels of poa control.

Reasons for the inconsistent performance of the 50 lb/A rate of Ronstar G are not obvious. However, it is likely that this low rate may be on the borderline between an effective rate and an ineffective rate.

Thirteen of the thirty-six treatments tested resulted in good to excellent poa control as well as little or no phytotoxicity to ryegrass (Table 2). These high performing treatments included:

- A single application of Ronstar G at 50 lb/A when applied 8,6 or 2 weeks before overseeding (treatments applied 10 weeks or 4 weeks before overseeding provided significantly worse poa control).
- A single application of Ronstar G at 100 lb/A when applied 10, 8, 6, or 4 weeks before overseeding (treatments applied 2 weeks before overseeding produced unacceptable damage to ryegrass)
- Split applications of Ronstar G, with 50 lbs/A applied either 8,6, 4, or 2 weeks before overseeding and 100 lb/A Ronstar applied 14 weeks later.
- Split applications of Ronstar G, with 100 lbs/A applied at 6 weeks before overseeding and 100 lbs/A applied 14 weeks later. All other split applications involving the 100 lb/A rate applied pre-overseeding produced unacceptable damage to ryegrass. As discussed above, this result may be partially due to an irrigation malfunction that produced increased stress in many of the split-application treatments involving the 100 lb/A rate.
- Three post-emergent applications of Prograss at 0.5 gallons/A. This treatment is the current standard in the Palm Springs area.

The inconsistent poa control performance of the 50 lb/A rate of Ronstar, and the possibility of phytotoxicity of the 100 lb/A rate suggests that split applications of Ronstar may be the best strategy for insuring good poa control, without damage to turf. Based on the results from this trial, an application of Ronstar G at 50 lb/A, 4 - 8 weeks before overseeding, followed 14 weeks later by another application of Ronstar at 50-100 lb/A, may be the most effective pre-emergence herbicide strategy. However, this conclusion should be confirmed in multiple locations in the southwest in 1998.

The performance of Prograss, the current standard, was excellent, as were several of the Ronstar treatments tested. Although Prograss should remain an important component of poa control programs in the Desert, incentives for golf course superintendents to consider rotation of Prograss with a pre-emergent herbicide include:

- Ease of use: The correct timing of application of Prograss appears to be a bit of an art, with superintendents reporting varying levels of poa control, depending on the stage of poa, the weather, and other variables at the time of application. In contrast, the application timing of pre-emerge herbicides is pre-determined.
- Resistance management: Over-reliance on Prograss has resulted in development of poa-resistant biotypes in the southeastern U.S., although no resistance has been detected in the Western U.S. To avoid repeating this situation elsewhere, superintendents should consider rotation of herbicides with different modes of action.
- Bermudagrass green-up: Incorrect timing of Prograss applications can result in some injury to bermudagrass, resulting in a delayed spring transition. In contrast, when used at the correct rates, the pre-emergence herbicides tested in this trial did not cause any phytotoxicity to bermudagrass, with the exception of the high rate of Ronstar G (200 lb/A).

Table 2. Turf quality and percent poa control ratings on ryegrass overseeded fairways. Turf was rated on a 0-7 scale, with 0 = worst turf possible and 7 = best turf possible. Values in yellow shaded boxes had significantly more damage to ryegrass than the non-treated check (P<0.05). Values in pink shaded boxes had the best (P<0.05) poa control among all treatments tested. Treatments in green shaded boxes resulted in good to excellent poa control, with little or no damage to turf.

Product	Rate per Acre	Quality	Quality	Quality	Quality	Quality	%Poa control
(before / after overseed)		10/31/97	11/14/97	11/26/97	12/20/97	2/12/98	4/14/98
1. Ronstar G	50 lb	5.8 ghi	6.0 e	6.2 de	6.7 efg	6.7 h	39 b
2. Ronstar G	100 lb	5.5 efghi	5.3 cde	6.2 de	6.7 fg	6.7 h	97 d
3. Ronstar G	200 lb	5.2 cdefgh	4.7 abc	5.2 abc	5.3 bcd	5.3 efg	96 d
4. Ronstar G	50 lb	6.0 hi	6.0 e	6.5 e	7.0 g	6.7 h	97 d
5. Ronstar G	100 lb	5.3 defghi	5.7 de	5.8 cde	6.0 def	5.8 efgh	97 d
6. Ronstar G	200 lb	3.8 a	4.3 ab	4.5 a	4.0 a	3.3 a	99 d
7. Ronstar G	50 lb	6.0 hi	6.0 e	6.5 e	6.7 fg	6.2 fgh	98 d
8. Ronstar G	100 lb	5.3 defghi	5.3 cde	5.8 cde	5.7 cde	6.2 fgh	97 d
9. Ronstar G	200 lb	4.5 abcd	4.0 a	4.5 a	4.0 a	3.7 ab	98 d
10. Ronstar G	50 lb	6.0 hi	6.0 e	6.2 de	6.7 fg	6.7 h	66 c
11. Ronstar G	100 lb	6.0 hi	6.0 e	5.8 cde	6.7 fg	6.8 h	79 cd
12. Ronstar G	200 lb	4.5 abcd	4.3 ab	4.5 a	4.3 ab	4.5 bcde	82 cd
13. Ronstar G	50 lb	5.8 ghi	4.0 a	5.8 cde	6.7 fg	6.2 fgh	74 cd
14. Ronstar G	100 lb	5.5 efghi	5.0 bcd	5.5 bcd	5.7 cde	5.0 de	99 d
15. Ronstar G	200 lb	4.3 abc	4.0 a	4.5 a	4.7 ab	4.0 abcd	91 d
16. Ronstar G/Ronstar G	50 lb /100 lb	6.0 hi	6.0 e	5.5 bcd	6.7 fg	6.3 gh	96 d
17. Ronstar G/Ronstar G	100 lb /100 lb	4.7 abcde	4.7 abc	4.8 ab	4.7 ab	5.2 ef	96 d
18. Ronstar G/Ronstar G	200 lb /100 lb	4.2 ab	4.0 a	4.5 a	4.0 a	3.7 ab	98 d
19. Ronstar G/Ronstar G	50 lb /100 lb	6.0 hi	5.7 de	6.2 de	6.7 fg	6.7 h	96 d
20. Ronstar G/Ronstar G	100 lb /100 lb	5.3 defghi	5.3 cde	5.8 cde	6.0 def	6.2 fgh	97 d
21. Ronstar G/Ronstar G	200 lb /100 lb	4.5 abcd	4.0 a	4.5 a	4.0 a	3.8 abc	96 d
22. Ronstar G/Ronstar G	50 lb /100 lb	6.0 hi	6.0 e	6.5 e	6.7 fg	6.7 h	94 d
23. Ronstar G/Ronstar G	100 lb /100 lb	5.3 defghi	5.0 bcd	5.5 bcd	5.7 cde	4.8 cde	97 d
24. Ronstar G/Ronstar G	200 lb /100 lb	4.7 abcde	4.7 abc	4.8 ab	5.0 bc	4.8 cde	97 d
25. Ronstar G/Ronstar G	50 lb /100 lb	5.8 ghi	5.7 de	6.2 de	6.0 def	6.2 fgh	78 cd
26. Ronstar G/Ronstar G	100 lb /100 lb	5.0 bcdefg	5.3 cde	5.5 bcd	6.3 efg	6.3 gh	91 d
27. Ronstar G/Ronstar G	200 lb /100 lb	4.3 abc	4.3 ab	4.8 ab	4.3 ab	4.0 abcd	99 d
28. Ronstar G/ Barricade 65	100 lb / 1.15 lb	5.0 bcdefg	4.7 abc	5.5 bcd	5.3 bcd	5.0 de	97 d
29. Ronstar G / Pendulum DG	100 lb / 2.5 lb	5.3 defghi	5.7 de	5.5 bcd	5.3 bcd	5.0 de	99 d
30. Ronstar G / Primo L	100 lb / 22 oz	5.7 fghi	4.3 ab	4.8 ab	5.7 cde	5.8 efgh	91 d
31. Ronstar G / Prograss	100 lb / 0.5 ga	5.2 cdefgh	4.7 abc	5.5 bcd	5.7 cde	5.5 efg	99 d
32. Ronstar G / Prograss	100 lb / 0.25 ga	4.7 abcde	5.0 bcd	5.5 bcd	5.7 cde	5.3 efg	96 d
33. Barricade 65 G	2.0 lb	4.8 bcdef	5.0 bcd	5.5 bcd	6.0 def	6.3 gh	96 d
34. Primo L	22 oz / 22 oz	6.2 i	5.0 bcd	5.8 cde	6.3 efg	6.2 fgh	16 ab
35. Prograss	0.5 ga	6.2 i	5.3 cde	5.8 cde	7.0 g	6.7 h	99 d
36. No treatment		6.0 hi	6.0 e	6.5 e	7.0 g	6.3 gh	0 a

Table 3. Significance of Ronstar 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 or poa control 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 or percent poa control; statistically significant positive correlation coefficients are highlighted in green shaded boxes below. A negative correlation coefficient indicates that rate and/or timing had a negative impact on turfgrass quality or percent poa control; significant negative correlations are indicated below in blue shaded boxes. Analysis for percent poa control was performed on data that was transformed using the arcsine (square root) of the proportion.

APPLICATION DATE (#WKS BEFORE OR AFTER OVERSEEDING)	TURF QUALITY RATINGS					% POA CONTROL
	10/31/97	11/14/97	11/26/97	12/20/97	2/12/98	4/14/98
7/18/97(-10)	—0.0066 0.0001	—0.0076 0.0014	—0.0070 0.0000	—0.0095 0.0000	—0.0086 0.0004	0.1772 0.1159
7/31/97(-8)	—0.0118 0.0000	—0.0098 0.0000	—0.0113 0.0000	—0.0170 0.0000	—0.0180 0.0000	0.0022 0.0028
8/14/97 (-6)	—0.0093 0.0000	—0.0103 0.0000	—0.0100 0.0000	—0.0162 0.0000	—0.0158 0.0000	0.0021 0.0047
8/31/97 (-4)	—0.0084 0.0000	—0.0079 0.0000	—0.0097 0.0000	—0.0130 0.0000	—0.0128 0.0000	0.0702 0.5364
9/11/97 (-2)	—0.0103 0.0000	—0.0110 0.0000	—0.0103 0.0000	—0.0143 0.0000	—0.0161 0.0000	0.0018 0.0134

Figure 1. Effect of Ronstar Rate and Timing on Quality of Overseeded Fairways
Desert Dunes Country Club

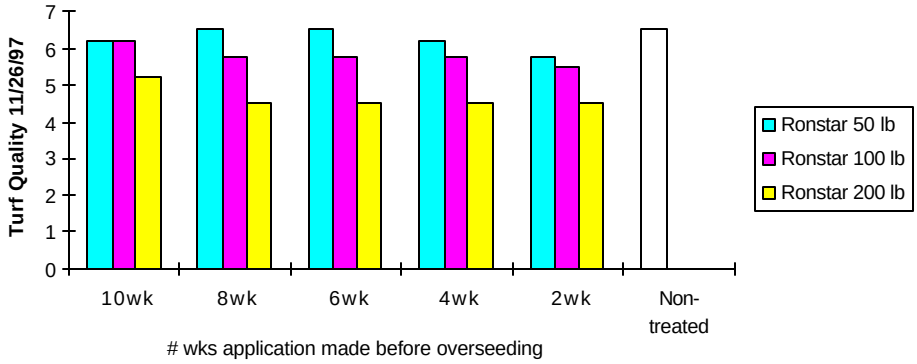


Figure 2. Effect of Ronstar Application Timing & Rate on Poa Control
Desert Dunes Golf Club

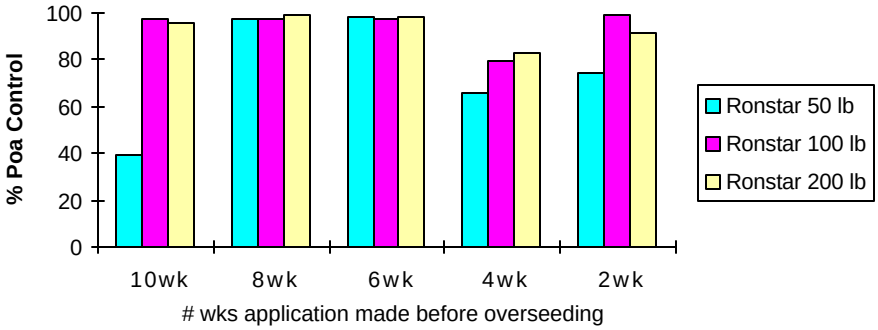


Figure 3. Effect of Split Applications of Ronstar on Turf Quality Ratings
(50 lb/100 lb)
Desert Dunes Golf Club

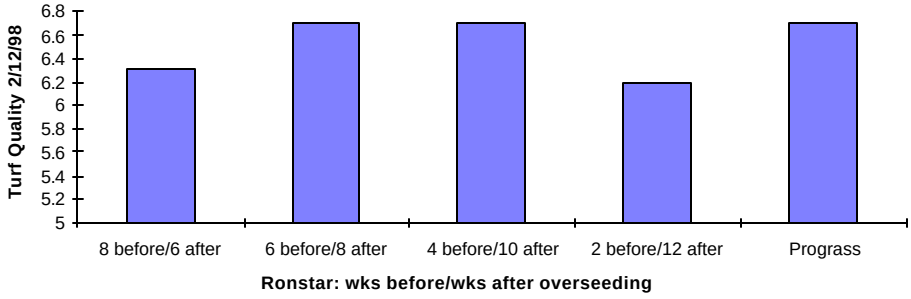


Figure 4. Effect of Split Applications of Ronstar on Poa Control
(50 lb/100 lb)
Desert Dunes Golf Club

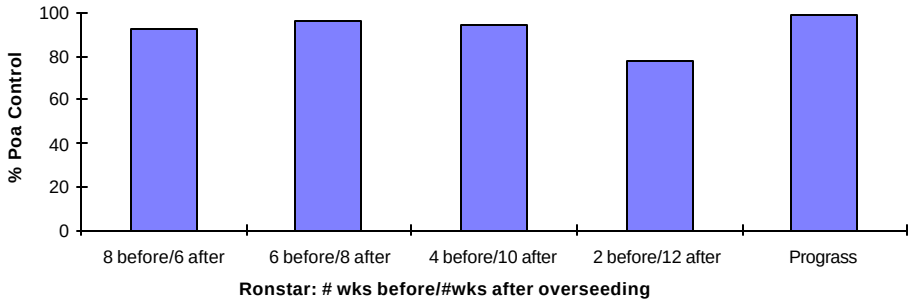


Figure 5. Poa control on overseeded fairways
Desert Dunes Golf Club