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Edited by William C. Young III

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DEFINING OPTIMUM NITROGEN FERTILIZATION PRACTICES FOR PERENNIAL RYEGRASS AND TALL FESCUE SEED PRODUCTION SYSTEMS IN THE WILLAMETTE VALLEY

W.C. Young III, M.E. Mellbye, G.A. Gingrich, T.B. Silberstein, S.M. Griffith, T.G. Chastain and J.M. Hart

Introduction

Oregon grass seed growers typically do not monitor crop or soil nitrogen (N) levels during the growing season and often apply fertilizer N in excess of recommended rates. Excessive fertilizer N use may result in leaching losses. This study has three objectives: 1) Determine the level of spring applied nitrogen fertilizer needed for optimizing both crop and economic returns; 2) Update OSU Extension Service Fertilizer Guidelines; and 3) Develop educational programs to reduce excessive N fertilization.

Large scale on-farm plots were established in three perennial ryegrass and three tall fescue fields. The fields were selected to represent soil types typically used for seed production in the Willamette Valley. Spring fertilizer treatments of 0, 45, 90, 135, 180, 225, and 270 lb N/a were split-applied (50/50) using precision application equipment. Normal grower equipment was used to swath and combine plots. Yields were measured using a weigh-wagon. Crop and soil samples were obtained for N uptake, soil N levels, and yield components. Results from the first-year (1998) crop indicated N levels above 135-180 lb N/a for perennial ryegrass and 90-135 lb N/a for tall fescue did not statistically increase seed yield. Perennial ryegrass was able to take up more N in above-ground biomass than tall fescue. Levels of soil NO_3-N were increased by the highest N rate (270 lb N/a) but were below 10 ppm. Based on sampling in the fall, the potential for leaching losses of N from normal application rates of N fertilizer does not appear to be a problem. These results presented below are from the second year of a multi-year study.

Procedure

Large scale on-farm plots averaging 4.2 acres per site were established at 6 locations (3 perennial ryegrass, 3 tall fescue) prior to fertilizer applications. One North Valley and two South Valley sites for each species were established, encompassing soils in poorly drained to moderately well drained conditions (e.g., Concord-Amity and Woodburn soil types). All sites were in the second crop year and specific information for each site is shown in Table 1.

Plots were approximately 22 ft wide by 300 ft long (depending on fit in the field and grower equipment size). Spring fertilizer treatment rates of 0, 45, 90, 135, 180, 225, and 270 lb N/a were used. The seven treatments were replicated three times in a randomized complete block. Experimental data was analyzed using appropriate statistical analyses (e.g., ANOVA, Regression).

All sites were fertilized between March 23 and April 19 at the pre-determined rates using a split application (50/50) about four weeks apart. Applications were done between approximately 400 and 800 growing degree days (GDD) as is generally recommended. The 400 GDD and 800 GDD points were March 13 and April 26, 1999, respectively. Accumulated GDD using the T_{sum} method was calculated by summing the daily degree day values obtained by adding the maximum and minimum temperatures for the day, dividing by two and subtracting the base temperature, which for temperate grass is 0°C. Accumulated GDD was calculated beginning January 1. Additional details regarding calendar dates of N application and harvest at each site are shown in Table 2. Fertilizer was applied using a Gandy Orbit-air spreader pulled by a four-wheeler or small Kubota tractor. In addition to fertilizer N treatments, each site was also fertilized with 275 lb/a of 0-15-20-10 at the same time as the first N application to ensure there were no other nutrient limitations. The plots were managed the same as the rest of the field for all other cultural management practices (weed control, fall fertilizers, disease control, etc.) by the grower-cooperator.

Table 1. Site information for the perennial ryegrass and tall fescue locations.

Location	County	Variety	Planted	Soil type
Perennial ryegrass				
J Bar V Farms	Marion	Cutter	Fall 97	Woodburn silt loam
L3 Farms	Linn	DLF-1	Fall 97	Concord and Amity silt loam
Venell Farms	Benton	SR 4200	Fall 97	Dayton silt loam
Tall fescue				
Malpass Farms	Linn	Kittyhawk SST	Fall 96	Bashaw silty clay
Nixon Farms	Lane	Duster	Spring 97	Malabon silty clay loam
Roselawn Farms	Marion	Tomahawk	Fall 98	Woodburn silt loam

Table 2. Dates of fertilization, windrowing, and combining for optimum N study, 1999.

Location	Variety	Fertilizer application		Windrow	Combine
		1st date	2nd date		
Perennial ryegrass					
J Bar V Farms	Cutter	3/23	4/14	7/17	8/3
L3 Farms	DLF-1	4/7	4/19	7/15	8/3
Venell Farms	SR 4200	3/25	4/16	7/19	8/17
Tall fescue					
Malpass Farms	Kittyhawk SST	4/7	4/19	7/12	7/20
Nixon Farms	Duster	3/25	4/16	7/12	7/21
Roselawn Farms	Tomahawk	3/23	4/14	7/10	7/21

Plant samples were taken approximately 4 weeks following the second N application, and at maturity (June 11-17). Yield components samples were obtained at or following pollination during June. Plots were swathed into windrows between July 10 and July 19 and combined between July 20 and August 17 using grower equipment (Table 2). Seed yield from each plot was measured using a Brent YieldCart and adjusted for clean seed yield following an assessment of percent cleanout from sub-samples taken at harvest. Sub-samples taken at harvest were also used to determine seed size and are currently at the OSU Seed Testing Laboratory for purity and germination analysis.

Results and Discussion

Crop yield and response

Perennial ryegrass: Seed yield in perennial ryegrass increased as fertilizer rates increased up to the 135 lb N/a rate. Yield at rates higher than 135 lb/a was not significantly different (Table 3) at three locations. Regression analysis of these data (Table 4) resulted in the response curves (not shown) which will be used for economic analysis at the completion of this study. Higher spring N application rates resulted in more biomass and increased N uptake by the crop as shown in Table 6. With harvest index remaining constant (Table 7), increased biomass generally increased seed yield.

Table 3. Seed yield (lb/a) of perennial ryegrass following varied rates of spring applied N, 1999.

Spring N rate (lb/a)	L3 Farms	Venell Farms	J Bar V Farms	3-site average
0	913 d*	653 c	593 d	720
45	1219 c	1163 b	1120 c	1167
90	1323 bc	1353 ab	1384 b	1353
135	1461 ab	1403 a	1759 a	1541
180	1561 a	1383 ab	1775 a	1573
225	1582 a	1416 a	1878 a	1625
270	1581 a	1382 ab	1887 a	1617
LSD 0.05	180	221	134	--

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values (p=0.05).

Table 4. Seed yield statistical summary for perennial ryegrass and tall fescue, 1999.

Location (variety)	ANOVA	Regression analysis Linear (r^2)	Quadratic (r^2)
Perennial ryegrass			
L3 Farms	**	** (0.75)	** (0.87)
Venell Farms	**	** (0.49)	** (0.78)
J Bar V Farms	**	** (0.82)	** (0.96)
Tall fescue			
Malpass Farms	*	NS	*(0.36)
Nixon Farms	**	**(0.86)	**(0.93)

NS = not significant P value 0.05
* = P value < 0.05
** = P value <0.01

Tall fescue: Seed yield responses in tall fescue were more dependent on location compared to perennial ryegrass. At the Malpass Farms site, yields were maximized at the 90 to 135 lb N/a rate. Also, at the Malpass Farms site, as the N rate continued to increase, the yield declined some. At the Nixon Farms site there was a yield response up to 180 lb N/a which is in stark contrast to last year (1998) when there was no seed yield response to increased N at that site. The data from the Roselawn Farms site is not presented here as it is not yet fully analyzed. However other data from the Roselawn site is reported below. Regression analysis of these data (Table 4) resulted in response curves (not shown) which will be used for economic analysis at the completion of this study.

Table 5. Seed yield (lb/a) of tall fescue following varied rates of spring applied N, 1999.

Spring N rate (lb/a)	Malpass Farms	Nixon Farms	2-site average
0	939 c*	689 e	814
45	1182 ab	912 d	1047
90	1275 ab	1267 c	1271
135	1361 a	1511 b	1436
180	1130 b	1651 ab	1391
225	1133 b	1710 a	1422
270	1161 b	1743 a	1452
LSD 0.05	184	197	--

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values (p=0.05).

Crop nitrogen uptake

The data presented here are from tissue uptake levels from samples taken in mid-May. Final crop uptake levels have are not yet analyzed and will be included in later reports. At heading, the tissue N% (Table 8) varied from 0.9% to 2.9% in perennial ryegrass and form 0.8% to 3.4% in tall fescue. N concentrations closely followed N application rates as expected. The average amount of nitrogen (see Table 9) in the aboveground biomass at this point in time (heading) ranged from 43 lb/a in the 0 N rate to 208 lb N/a in the 270 N rate for perennial ryegrass sites and 60 lb/a in the 0 N rate to 231 lb N/a in the 270 N rate for the tall fescue sites. As shown by the 0 N rate, without any spring N added there was an average of 43 lb N/a (perennial ryegrass) and 60 lb N/a (tall fescue) taken up in the plant, indicating a fair level of mineralized N is available to the plant in the spring.

Soil NO_3-N

Soil samples were obtained in the fall from three treatments: 0, 135, 270 lb N/a and at three depths: 0-1, 1-2, 2-3 ft. Results are detailed in Tables 10-13. The J Bar V site was not sampled as it was plowed out shortly after harvest. All other sites are presented here. At all perennial ryegrass and tall fescue sites, the highest fertilizer rate (270 lb N/a) generally increased the levels of NO_3-N in the top 12 inches of soil (see Tables 12 and 13). In contrast to last year, this year the 1-2 ft and 2-3 ft profiles had increased levels of NO_3-N from the 270 lb spring N rate. According to OSU guidelines[1] actual residual concentrations are considered low (<10 ppm), medium (10 to 20 ppm), high (20-30 ppm) or excessive (>30 ppm) levels. As indicated in Tables 10 and 11, the residual levels from the 270 lb N/a rate in the top foot of soil is considered excessive at the Malpass Farms site, high at the Roselawn Farms site, medium at the Vennel Farms and Nixon Farms sites and low at the L3 Farms site. This variability may be due to the different soils and their capacity to utilize these excessively high N rates. When normal rates of N are used (135 lb N/a) all the NO_3-N levels are in the low range except for one location in the medium range (Malpass Farms - a high organic matter soil). Even though there is efficient soluble nitrogen removal by the fibrous root systems of these perennial grass seed crops during crop growth, excessive levels of applied nitrogen can increase the concentrations of NO_3-N in the soil following harvest and be available for leaching in the fall if the plant is unable to utilize it when the rains start. Use of recommended N rates will result in little potential for leachable N being available in the soil after harvest.

[1]Marx, E.S., J. Hart and R.G. Stevens. 1996. Soil Test Interpretation Guide. Table 1. Oregon State University Extension Service, EC 1478.

Table 10. Soil NO_3-N concentrations (ppm) at three soil depths of perennial ryegrass following varied rates of spring applied N, 1999.

Spring N Rate (lb/a)	Post havest sample depth 0-12 in.	13-24 in.	25-36 in
L3 Farms			
0	1.5	0.7	0.5
135	2.4	1.0	1.0
270	8.2	4.6	3.0
LSD 0.05	2.3	1.8	0.6
Venell Farms			
0	2.5	1.0	0.7
135	6.6	1.5	1.2
270	18.5	4.9	2.2
LSD 0.05	2.6	2.4	2.2
2-site average			
0	2.0	0.8	0.6
135	4.5	1.3	1.1
270	13.3	4.8	2.6

Table 11. Soil NO_3-N concentrations (ppm) at three soil depths of tall fescue following varied rates of spring applied N, 1999.

Spring N rate (lb/a)	Post havest sample depth 0-12 in.	13-24 in.	25-36 in
Malpass Farms			
0	6.7	3.0	2.8
135	12.0	3.3	11.5
270	31.4	11.5	6.7
LSD 0.05	19.6	NS	NS
Nixon Farms			
0	2.1	1.1	1.2
135	4.3	1.3	1.3
270	14.9	3.0	1.9
LSD 0.05	6.8	1.1	0.2
Roselawn Farms			
0	2.5	0.6	0.5
135	5.9	1.5	0.9
270	25.0	8.4	2.0
LSD 0.05	3.3	1.0	0.7
3 site average			
0	3.8	1.6	1.7
135	7.4	2.0	1.6
270	23.8	7.6	3.5

Table 12. Soil NO_3-N concentrations (ppm) from spring N fertilizer rate and depth of sampling of perennial ryegrass, 1999.

Treatment	L3 Farms	Venell Farms	2-site average
Spring N rate (lb/a)			
0	0.9	1.4	1.1
135	1.5	3.1	2.3
270	5.2	8.5	6.9
LSD 0.05	*1	*1	--
Soil sample depth			
0-1 ft	4.0	9.2	6.6
1-2 ft	2.1	2.5	2.3
2-3 ft	1.5	1.4	1.4
LSD	*1	*1	--

*1 Interaction of rate x depth significant at $P \leq 0.05$ (see Table 10)

Table 13. Soil NO_3-N concentrations (ppm) from spring N fertilizer rate and depth of sampling of tall fescue, 1999.

Treatment	Malpass Farms	Nixon Farms	Roselawn Farms	3-site average
Spring N rate (lb/a)				
0	4.4	1.5	1.2	2.3
135	6.0	2.3	2.7	3.7
270	16.5	6.6	11.8	11.7
LSD 0.05	*1	*1	*1	--
Soil sample depth				
0-1 ft	16.7	7.1	11.1	11.6
1-2 ft	6.0	1.8	3.5	3.8
2-3 ft	4.3	1.5	1.1	2.3
LSD 0.05	*1	*1	*1	--

*1 Interaction of rate x depth significant at $P \leq 0.05$ (see Table 11)

Summary

Optimum levels of spring applied N for seed production were 135-180 lb N/a in the perennial ryegrass and 90-135 lb N/a in the tall fescue. Applying more than the optimum rates did not ensure increased yield and it is difficult to predict if the added input will result in a better yield as was the situation at the Nixon Farms site. Seed yields at the normal N rates were a little above 1999 state averages of 1496 lb/a (perennial ryegrass) and 1347 lb/a (tall fescue) as reported in estimates by

OSU. Soil test results show efficient use of applied N and potential for leaching losses reported appear low for recommended use rates. These sites are being continued for a third crop year (except for the perennial ryegrass site at J Bar V Farms which rotated out of production) to determine the long-term economic and agronomic effects of these treatments. These results are from the second year in a three year trial and will be used to establish better recommendations for optimizing inputs in grass seed crops.

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Table 6. Total biomass (ton/a) at maturity of perennial ryegrass and tall fescue following varied rates of spring applied N, 1999.

Spring N rate (lb/a)	Perennial Ryegrass				Tall Fescue			
	L3 Farms	Vennel Farms	J Bar V Farms	3-site average	Malpass Farms	Nixon Farms	Roselawn Farms	3-site average
0	3.1	2.5	2.2	2.6	2.6	2.8	6.0	3.8
45	4.2	4.5	4.7	4.5	3.5	3.1	7.2	4.6
90	4.9	5.8	5.7	5.4	4.1	4.9	7.8	5.6
135	6.4	5.9	5.1	5.8	4.2	6.0	8.3	6.2
180	5.4	4.6	5.3	5.1	4.4	7.2	9.5	7.0
225	5.4	7.2	7.0	6.5	4.2	6.5	9.5	6.7
270	5.6	5.7	5.3	5.5	3.2	6.2	9.5	6.3
LSD 0.05	1.7	1.6	1.7	---	0.9	1.6	NS	---

Table 7. Harvest index (%) of perennial ryegrass and tall fescue following varied rates of spring applied N, 1999.

Spring N rate (lb/a)	Perennial Ryegrass				Tall Fescue			
	L3 Farms	Vennel Farms	J Bar V Farms	3-site average	Malpass Farms	Nixon Farms	Roselawn Farms	3-site average
0	15	13	14	14	18	12	18	16
45	15	14	12	14	17	16	16	16
90	15	12	12	13	16	13	16	15
135	12	12	18	14	16	13	14	14
180	15	15	17	16	13	12	13	12
225	15	10	14	13	14	13	13	13
270	14	12	18	15	18	14	13	15
LSD 0.05	NS	NS	NS	---	NS	NS	NS	---

Table 8. Tissue N concentration (%) in above ground biomass at heading of perennial ryegrass and tall fescue following varied rates of spring applied N, 1999.

Spring N rate (lb/a)	Perennial Ryegrass L3 Farms	Perennial Ryegrass Vennel Farms	Perennial Ryegrass J Bar V Farms	Perennial Ryegrass 3-site average	Tall Fescue Malpass Farms	Tall Fescue Nixon Farms	Tall Fescue Roselawn Farms	Tall Fescue 3-site average
0	1.1	0.9	0.9	1.0	1.4	0.8	1.0	1.1
45	1.5	1.1	1.2	1.2	1.6	1.2	1.2	1.3
90	1.5	1.5	1.4	1.5	2.1	1.5	1.6	1.7
135	1.9	1.8	1.6	1.8	2.5	1.4	1.9	1.9
180	2.4	1.6	2.0	2.0	2.7	2.0	1.9	2.2
225	2.5	2.2	2.4	2.4	3.4	2.2	2.1	2.5
270	2.9	2.4	2.9	2.7	3.4	2.6	2.4	2.8
LSD 0.05	0.6	0.4	0.3	---	0.5	0.7	0.5	---

Table 9. N uptake (lb/a) at heading in above ground biomass of perennial ryegrass and tall fescue following varied rates of spring applied N, 1999.

Spring N rate (lb/a)	Perennial Ryegrass L3 Farms	Perennial Ryegrass Vennel Farms	Perennial Ryegrass J Bar V Farms	Perennial Ryegrass 3-site average	Tall Fescue Malpass Farms	Tall Fescue Nixon Farms	Tall Fescue Roselawn Farms	Tall Fescue 3-site average
0	52	35	42	43	66	14	100	60
45	103	76	92	90	94	35	129	86
90	106	89	124	106	109	56	204	123
135	143	117	165	142	127	56	235	139
180	203	144	198	182	174	90	264	176
225	175	188	240	201	164	117	237	173
270	167	207	250	208	170	139	383	231
LSD 0.05	39	50	48	---	41	33	91	---

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Introduction

Oregon grass seed growers do not monitor crop or soil nitrogen (N) levels during the growing season and often apply fertilizer N in excess of recommended rates. Excessive fertilizer N use may result in leaching losses. This study has three objectives: 1) Determine the level of spring applied nitrogen fertilizer needed for optimizing both crop and economic returns; 2) Update OSU Extension Service Fertilizer Guidelines; and 3) Develop educational programs to reduce excessive N fertilization. Large scale on-farm plots were established in two fine fescue fields (one Chewings type and one creeping type). The fields were selected to represent soil types typically used for fine fescue seed production in the Willamette Valley. Spring fertilizer treatments of 0, 30, 50, 70, 90, 110, and 140 lb N/a were applied in one application using precision application equipment. Normal grower equipment was used to swath and combine plots. Yields were measured using a weigh-wagon. Crop samples were obtained for N uptake, soil N levels, and yield components. Results from the first-year crop indicated N levels above 70-90 lb N/a did not statistically increase seed yield. Although soil NO_3-N concentrations were increased to about 10 ppm by the highest N rate, this NO_3-N concentration is still considered low. Based on sampling in the fall, the potential for leaching losses of N from normal application rates of N fertilizer does not appear to be a problem. These results are from the first year of a multi-year study.

Procedure

Large scale on-farm plots were established at two locations: one Chewings type (*Festuca rubra var. commutata*) and one creeping type fine fescue (*Festuca rubra var. rubra*). Both sites were planted in the spring 1998 and are in their first crop year. Specific information for each site is shown in Table 1. Plots were approximately 23 ft wide by 600 ft long (depending on fit in the field and grower equipment size). Spring fertilizer treatment rates of 0, 30, 50, 70, 90, 110 and 140 lb N/a were used. The seven treatments were replicated three times in a randomized complete block design. Experimental data was analyzed using appropriate statistical analyses (ANOVA).

Both sites were fertilized between March 19 and 22 at the predetermined rates using a single application. Additional details regarding calendar dates of N application and harvest at each site are shown in Table 1. Fertilizer was applied using a Gandy Orbit-air spreader pulled by a four-wheeler or small tractor. In addition to fertilizer N treatments, each site was also fertilized with 275 lb/a of 0-15-20-10 at the same to ensure adequate P, K, and S levels in the soil. The plots were managed the same as the rest of the field for all other cultural management practices (weed control, fall fertilizers, disease control, etc.) by the grower-cooperator.

Yield component samples were obtained at or following pollination during June. Plots were swathed into windrows July 5 and July 22 and combined July 23 and August 10 using grower equipment (Table 1). Seed yield from each plot was measured using a Brent YieldCart and adjusted for clean seed yield following an assessment of percent cleanout from sub-samples taken at harvest. Sub-samples taken at harvest were also used to determine seed size and are currently at the OSU Seed Testing Laboratory for purity and germination analysis.

Results and Discussion

Crop yield and response

Seed yield responded to spring nitrogen only at the Chuck Sherman site. Optimum yield at that site was obtained with the 50 lb N/a rate (Table 2). Higher applications did not increase seed yield and even showed a decline in yield as the application rate exceeded 70 lb N/a. In contrast to this, yields at the Taylor site were unaffected by any of the spring N applications. Yields at both locations were well above the 1999 average yields of about 750 lb/a for these species. Total dry matter accumulation and harvest index (Table 3) were not affected by increased nitrogen rates. Components of yield that reflect general increases in seed yield at the Sherman site were an increase in fertile tillers (Table 4) and more florets per spikelet (also at the Taylor site, Table 5). Other factors (seed size and spikelet number) did not give as strong an indication of higher potential yield. Plant height and spike length were increased by higher rates of nitrogen (Table 6). The longer stems and higher yield at the Sherman site also increased lodging (data not presented). This may have had a detrimental affect on seed yield as reflected by the decreased seed yield in the higher rates at the Sherman location.

Table 2. Seed yield (lb/a) of fine fescue following varied rates of spring applied N, 1999.

Spring N rate (lb/a)	Sherman Farm	Taylor Farm	2-site average
0	1211 c*	1497	1354
30	1683 b	1530	1607
50	1848 a	1484	1666
70	1831 a	1509	1670
90	1792 ab	1479	1636
110	1728 ab	1494	1611
140	1662 b	1445	1554
LSD 0.05	140	NS	---

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values (P=0.05).

Soil NO_3-N

Soil samples were taken in the fall (mid November). Samples taken post-harvest were obtained from three treatments: 0, 70, 140 lb N/a and at three depths: 0-1, 1-2, 2-3 ft. Results are detailed in Tables 7 and 8. At both sites the highest nitrogen rate (about 2 times normal N rates used) generally increased NO_3-N in the 0-12 in. zone (Tables 7 and 8). The same results were apparent in the 13-24 in. zone but at much lower concentrations. Even though there are higher NO_3-N concentration

Table 1. Site information for the fine fescue locations.

Location	County	Variety	Soil type	Fertilizer application	Windrow	Combine
Chuck Sherman Farm						
Chewings fine fescue	Marion	Brittany	Jory silty clay loam	3/19	7/5	7/23
Denny Taylor Farm						
Creeping red fescue	Marion	Shademark	Nekia silty clay loam	3/22	7/22	8/10

levels due to the higher nitrogen rates, the actual residual concentrations are all low (<10 ppm) to medium (10 to 20 ppm) according to OSU guidelines[2] with no high (20-30 ppm) or excessive (>30 ppm) levels. These data show efficient soluble nitrogen removal by the fibrous root systems of these perennial grass seed crops during crop growth and development for seed production. At the Taylor Farm site, there was a slight increase in NO_3-N at the 25-36 in zone. This may indicate a buildup of mineralized N occuring during the summer that the plant was unable to scavenge or movement of soluble N may be past the effective root zone for the crop. At a typical grower rate 70 lb N/a the overall averages of the whole profile (0-36 in) were low concentrations of 2.8 ppm and 4.0 ppm (Sherman and Taylor Farms respectively) as shown in Table 8. Use of recommended N rates will result in low levels of leachable NO_3-N being available in the soil after harvest.

Table 7. Soil NO_3-N concentrations (ppm) taken early fall at three soil depths of fine fescue following varied rates of spring applied N, 1999.

Spring N rate (lb/a)	Post havest sample depth 0-12 in.	13-24 in.	25-36 in
(ppm)			
Sherman Farm			
0	2.8	1.0	1.3
70	5.1	1.5	1.9
140	10.2	3.9	2.9
LSD 0.05	3.4	1.5	NS
Taylor Farm.			
0	3.8	1.4	3.3
70	6.0	2.7	3.4
140	10.8	4.6	5.6
LSD 0.05 (0.10)	5.4	2.2	(1.6)
P-value	0.050	0.035	0.060
2-site average			
0	3.3	1.2	2.3
70	5.6	2.1	2.7
140	10.6	4.3	4.6

Table 8. Soil NO_3-N concentrations (ppm) taken early fall from spring N fertilizer rate and depth of sampling on fine fescue, 1999.

Sherman Treatment	Taylor Farm	2-site Farm	average
	(ppm)		
Spring N rate (lb/a)			
0	1.7	2.8	2.3
70	2.8	4.0	3.4
140	5.7	7.0	6.4
LSD 0.05	*1	1.6	---
Soil sample depth			
0-1 ft	6.0	6.9	6.5
1-2 ft	2.1	2.9	2.5
2-3 ft	2.0	4.1	3.1
LSD 0.05	*1	1.6	---

*1 Interaction of rate x depth significant at $P \leq 0.05$ (see Table 7)

Summary

Optimum levels of spring applied N for fine fescue seed production were 50-70 lb N/a at these sites. Applying more than the optimum rates did not ensure increased yield. It must be noted that these results are from first-year seed crops, and only by continuing these trials for 2-3 years will we be able to provide data over the life of these stands. Seed yields for all locations, as indicated in Table 2, were well above Willamette Valley average yields for 1999. Soil test results show efficient use of applied N and little potential for leaching losses at recommended use rates. These sites are being continued for a second year (and possibly a third year) to determine the long-term economic and agronomic effects of these treatments.

[2]Marx, E.S., J.Hart and R.G. Stevens. 1996. Soil Test Interpretation Guide. Table 1. Oregon State University Extension Service, EC 1478.

Table 3. Harvest index and total biomass at maturity of fine fescue following varied rates of spring applied N, 1999.

Spring N rate (lb/a)	Harvest index			Total biomass		
	Sherman Farm	Taylor Farm	2-site average	Sherman Farm	Taylor Farm	2-site average
	(%)			(ton/a)		
0	27.2	11.8	19.5	2.4	6.4	4.4
30	21.2	11.1	16.2	4.0	6.9	5.5
50	21.7	13.1	17.4	4.4	5.7	5.1
70	15.1	11.5	13.3	6.1	6.7	6.4
90	19.5	10.5	15.0	4.7	7.0	5.9
110	19.8	11.9	15.9	4.8	6.4	5.6
140	14.6	10.6	12.6	6.1	6.9	6.5
LSD 0.05	NS	NS	---	NS	NS	---

Table 4. Fertile tiller density and spikelets per tiller in fine fescue following varied rates of spring applied N, 1999.

Spring N rate (lb/a)	Fertile tiller density			Spikelets		
	Sherman Farm	Taylor Farm	2-site average	Sherman Farm	Taylor Farm	2-site average
	(no./sq. ft.)			(no. per tiller)		
0	198 b	314	256	33.6 bc	37.2	35.4
30	271 ab	337	304	33.3 bc	32.8	33.1
50	272 ab	291	282	26.5 d	44.2	35.4
70	346 a	249	298	37.7 ab	31.5	34.6
90	330 a	330	330	31.0 cd	33.6	32.2
110	333 a	288	311	41.7 a	35.0	38.4
140	340 a	318	329	38.8 ab	40.2	39.5
LSD 0.05	85	NS	---	6.6	NS	---

Table 5. Floret number and 1000 seed weight of fine fescue following varied rates of spring applied N, 1999.

Spring N rate (lb/a)	Floret number			1000 seed weight		
	Sherman Farm	Taylor Farm	2-site average	Sherman Farm	Taylor Farm	2-site average
	------------ (avg. no. per spikelet) ------------			---------------------- (g) ----------------------		
0	4.5	5.3	4.9	1.12	1.16	1.14
30	5.3	5.6	5.5	1.08	1.16	1.12
50	5.5	5.9	5.7	1.05	1.19	1.12
70	5.6	5.4	5.5	1.08	1.21	1.15
90	5.5	5.4	5.5	1.07	1.16	1.12
110	5.3	5.5	5.4	1.11	1.22	1.16
140	6.5	5.9	3.2	1.11	1.20	1.16
LSD 0.05(0.10)	(0.9)	(0.4)	---	0.04	NS	---
P value	0.106	0.090		0.022		

Table 6. Plant height and inflorescence length at maturity in fine fescue following varied rates of spring applied N, 1999.

Spring N rate (lb/a)	Plant height			Inflorescence length		
	Sherman Farm	Taylor Farm	2-site average	Sherman Farm	Taylor Farm	2-site average
	-------------------- (cm) --------------------			-------------------- (cm) --------------------		
0	63.9	74.6	69.3	10.9	13.0	12.0
30	70.1	78.9	74.5	11.1	13.6	12.4
50	77.5	77.8	77.7	11.2	14.5	12.9
70	77.8	77.8	77.8	12.0	14.4	13.2
90	75.3	75.8	75.6	11.3	14.4	12.9
110	76.2	71.4	73.8	13.1	14.0	13.6
140	79.1	75.4	77.3	13.2	15.8	14.5
LSD 0.05	8.7	NS	---	1.5	NS	---

RELATIONSHIP BETWEEN GROWING DEGREE DAYS, RYEGRASS DEVELOPMENT, AND NITROGEN TIMING

S.M. Griffith

The use of growing degree days (GDD) is becoming more widely accepted across the U.S. to compare genotypes and predict the rate of plant development. The technique is simple and does not require complicated plant development staging techniques.

Growing degree day accumulations involve the amount of accumulated heat required for plants to reach a certain stage of plant development. This relationship holds true for most organisms if their growth and development is regulated by temperature (e.g., weeds, insects, pathogens). Thus, management practices that are linked to plant growth stages, such as pesticide, herbicide, or fertilizer applications or even cultivation can be timed based on an accumulated GDD time scale. From year to year, this time scale is much more consistent in predicting plant development than using calendar date.

The determination of GDD is easy. GDD takes into account the average daily temperature accumulations that influence plant development above a certain predetermined base temperature threshold. For temperate grass, I have been using 0°C or 32°F.

For each day that the average temperature is one degree above the base temperature, one degree day has accumulated. Due to temperature differences, plant development may vary from year to year and among locations in any given year; basing a crop practice by a particular week on a calendar cannot take these variations into consideration. The calculations of the GDD for a 24-hour period require the following formula: Max. temp + Min. temp/2 -Base temp (0°C or 32°F)=GDD. For example: If on March 3 the maximum temperature is 60°F and the minimum temperature is 50°F the GDD for March 3 is 60°F +50°F /2 = 102/2 = 55°F and 55°F - 50°F = 5 GDD. If the average temperature is equal to or less than the base temperature, no degree days are accumulated. For this system to work, the maximum and minimum temperatures need to be taken every day from January 1. For western Oregon I start accumulating GDD beginning January 1 (Table 1). Early in the season the growing degree days will accumulate slowly; however, as temperatures rise they accumulate faster. Temperature data can be found from a number of sources. One source I often use is the Oregon Climatic Service (www.ocs.orst.edu).

One practical use for the GDD time scale is with timing of fertilizer N application. For western Oregon, one N application between late winter and mid-spring which equates to 400 to 900 GDD has been shown to be sufficient (Table 2). Split N applications in the spring has no seed yield advantage but may be necessary because of equipment constraints due to high fertilizer volumes. Multiple or split fertilizer applications increase energy use, add equipment costs, and increase potential for soil compaction. There is usually sufficient mineralized soil N present in the fall to meet fall crop N needs for maximum grass seed yields. Therefore, fall N fertilization is not necessary from a nutritional stand point. There is some indication that without fall applied N, canopy closure may be retarded and result in less weed suppression between rows.

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Table 1. The relationship between accumulated growing degree days (GDD) and perennial ryegrass. Data were collected from cultivars 'Boardwalk' and 'Elegence.' There were no apparent differences in the relationship between GDD and developmental stage in these two cultivars. Accumulated GDD corresponding with these calendar dates were calculated starting January 1 and using the centigrade temperature scale.

Accumulated Growing Degree Days	Plant Developmental Stage
673	Third-leaf fully expanded - Forth-leaf elongating
716	Forth- to fifth-leaf stage/stem elongation
1112	Full expanded flag leaf
1136	Boot emergence/post-emergence
1403	Mid-anthesis
1874 to 1932	Seed harvest

Table 2. Values represent mean first year final seed yield of perennial ryegrass as a function of N rate and N timing expressed as accumulated growing degree days (GDD). All plots received four N rates at either 475, 627, or 857 GDD. Means followed by the same letter (or no letter) were not significant at $P \leq 0.05$ by the Duncan's Multiple Comparison test. Accumulated GDD corresponding with these calendar dates were calculated starting January 1 and using the centigrade temperature scale

	Timing of applied N (GDD)			Mean seed yield across N timing treatment
Total N applied	475	627	857	
0	743	769	769	761 a
40	895	844	1003	914 ab
80	962	1087	1050	1033 bc
120	1185	1207	1205	1199 c

THE EFFECT OF BORON FERTILIZER ON SOIL AND PLANT TISSUE LEVELS IN GRASS SEED FIELDS

M.E. Mellbye and G.A. Gingrich

Introduction. Boron (B) deficiency is the most widespread of all micronutrient deficiencies in the Pacific Northwest. Analysis of over 300 Willamette Valley soil samples in the 1950's showed 80% tested low in B, or less than 0.5 ppm of hot water extractable B. Field trials conducted at that time by T.L. Jackson showed dramatic yield responses in clover and sugar beets, but did not show any response in cereal or grass seed crops (T.L. Jackson, 1956 and 1957).

Crops vary widely in their B needs. In general, dicotyledons (broadleaf plants) have a greater requirement than monocotyledons (grasses). Legume and brassica crops are the most sensitive of the dicots to insufficient B. Crops with a high B requirement need more than 0.5 ppm soil test B. Some agronomists suggest 0.3 ppm B be used as a sufficiency guideline for crops with a low B requirement. OSU fertilizer guides do not use this guideline and do not recommend B fertilization of wheat or grass seed crops in Oregon. In the Willamette Valley, most grass seed fields that do not have a history of B fertilizer application test below 0.3 ppm B. The fertilizer industry was interested in evaluating B applications on these types of fields. Therefore, a preliminary investigation was conducted in 1999 to determine if B fertilizer applications in the spring could increase B soil test levels and B uptake by grass seed plants.

Methods. Boron fertilizer field trials were conducted at six farm locations. In one set of trials, granular B (Borate 48) was applied with the second application of dry urea nitrogen (N) fertilizer in late March or early April at a rate of 1.25 lb/a B. Total spring N application was 135 lb/a. This treatment was added to four existing N fertilizer trials on perennial ryegrass and tall fescue on farmer's fields in the southern Willamette Valley. The treatment was compared to the 135 lb/a N rate with no B in the established trial. The B treatment was added along the border of the trials and was not randomized at these locations, although it was replicated three times along with the rest of the N treatments.

In the second set of trials, liquid B fertilizer (Solubor) was applied to two fields of perennial ryegrass at 0.5 lb/a B on May 10, 1999. The check plot and B treatment in this trial were arranged in a randomized block design with three replications. In both granular and liquid B tests, soil samples and flag leaf samples were taken in May during late boot to early head emergence stage of growth. Both trials used grower equipment and an OSU weigh wagon at harvest as described in the preceding article – Defining optimum nitrogen fertilization practices for perennial ryegrass and tall fescue seed production systems in the Willamette Valley.

Results. Boron fertilizer increased the soil test and flag leaf tissue concentrations at each of the four locations that received granular B fertilizer (Table 1). At these locations, the soil test level was increased from less than 0.2 ppm to an average of 0.8 ppm B. Flag leaf concentration of B was increased from an average of 16 ppm to 31 ppm. Application of granular B with the dry fertilizer in the spring in these preliminary trials appeared to be an effective and easy method of applying B on grass seed fields.

At the two locations where foliar B was applied, no effect on soil test levels was measured (Table 2). Only one site showed an increase in B concentration in the tissues. The two sites located on well-drained soils had been in rotation with crops that received B in the past. Both soil and plant tissue tests on the check plots where foliar B was applied were higher than that measured on the four grass seed fields that received granular B.

Good seed yields were obtained from all fields in these trials. Out of six locations, only one showed an increase in seed yield from the B application. This location was one of the perennial ryegrass sites that received granular B. Because the B fertilizer treatment was not randomized at this location, no statistical analysis was made. However, each replication of the B treatment showed a 300 to 400 lb increase over the same rate of N without B, suggesting this site may have been responsive. The fact that the other three sites showed no response indicates that B was probably not a significant limiting factor on those grass seed fields despite their testing below 0.3 ppm B. Again, these are preliminary observations. Additional trials are planned to evaluate the effect of B on seed yield where grass seed crops are grown on soils that test low in B.

Acknowledgement: Appreciation is extended to Neil Christensen, OSU soil fertility research scientist, and John Hart, OSU Extension soils specialist, for their help on this project.

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Table 1. The effect of granular boron fertilizer on soil test values, flag leaf tissue concentrations, and seed yields on perennial ryegrass and tall fescue seed fields, 1999.

Boron[1] fertilizer rate (granular)	Crop (Variety)	Soil type	Boron samples (5/19)[2] Soil (0-4 inch.)	Flag leaf (heading)	Clean seed yield[3]
(lb/a)			------------- (ppm)	-------------	(lb/a)
0	Perennial ryegrass	Dayton	0.1	16a	1400
1.25	(SR4200)	silt loam	0.6	38b	1810
0	Perennial ryegrass	Concord	0.1	21a	1460
1.25	(DLF-1)	silt loam	0.8	32b	1490
0	Tall Fescue	Malabon	0.2	15	1510
1.25	(Duster)	silty clay loam	1.1	30	1530
0	Tall Fescue	Bashaw	0.2	12a	1360
1.25	(Kittyhawk SST)	silty clay	0.7	22b	1220

[1]Boron applied as dry granular boron mixed with urea nitrogen fertilizer, applied with the 2nd fertilizer application (3/25/99 to 4/6/99). Total N application in the spring of 135 lb/a.

[2]Boron samples:
(a) Soil samples taken from each rep and bulked for analysis. No statistics performed.
(b) Flag leaf samples taken form each rep and analyzed separately. Statistical analysis conducted on each site independently. Paired means in the column followed by different letters are significantly different (p=0.10).

[3]Seed yield is the mean of three replications. The Boron treatment was not randomized in the trial and so no statistical analysis is provided.

Table 2. The effect of foliar boron fertilizer on soil test values, flag leaf tissue concentrations, and seed yields on perennial ryegrass seed fields, 1999.

Boron[1] fertilizer rate (liquid)	Crop (Variety)	Soil type	Boron samples (5/19)[2] Soil (0-4 inch.)	Flag leaf (heading)	Clean seed yield[3]
(lb/a)			------------- (ppm)	-------------	(lb/a)
0	Perennial ryegrass	Willamette	0.5	22a	1827
0.5	(Cutter)	silt loam	0.6	35b	1883
0	Perennial ryegrass	Malabon/	0.5	30	1744
0.5	(Charger II)	Newburg loams	0.6	32	1840

[1]Boron applied as solubor liquid spray in 20 gpa during early head emergence (5/10/99). Total N application in the spring of 135 lb/a.

[2]Boron samples:
(a) Soil samples taken from each rep and bulked for analysis. No statistics performed.
(b) Flag leaf samples taken form each rep and analyzed separately. Statistical analysis conducted on each site independently. Paired means in the column followed by different letters are significantly different (p=0.10).

[3]Seed yield is the mean of three replications. There were no statistical differences in yield.

MANAGEMENT OPTIONS FOR VOLUNTEER ESTABLISHED ANNUAL RYEGRASS SEED CROPS

T.B. Silberstein, M.E. Mellbye and W.C. Young III

Introduction

Few studies have focused on the improvement of nonthermal cropping systems for annual ryegrass seed production and with reductions in open field buring allowances, other economic alternatives to managing low value crops such as annual ryegrass seed production are needed. Alternatives to conventional plow-drill establishment include use of no-till establishment systems and reliance of seed lost in the harvesting operations to provide a volunteer established crop.

A major obstacle with volunteer established annual ryegrass seed crops is the very high plant density resulting from the typically several hundred pounds of seed from swathing and combining losses. The effect of these high density stands is a resultant decrease is seed yield due to plant competition. Previous studies determining the impact of high densities have been conducted by OSU personnel (see previous articles in the 1995-1997 editions of Seed Production Research).

Stand densities can be reduced by spraying out rows and leaving a portion of the stand unsprayed to form "rows." This method has been tried with some success using different herbicides such as Roundup, Gramoxone, or Diuron. These methods are effective at reducing the population and can improve yields over the straight volunteer stand but do not always result in seed yields as high as drilled stands. Another way growers reduce plant density is winter grazing with sheep. This practice works well to reduce volunteer annual ryegrass stands and provide pasture for the livestock. The actual benefit is not well documented but growers report it has helped increase yields from volunteer stands. However, many of the volunteer established fields are not capable of being grazed so the option spraying out a portion of the volunteer seedlings to improve yield conditions could be a viable alternative.

This study was established to measure the effects of both grazing and row spraying under actual field conditions to determine if row spraying is comparable to grazing and help increase seed yields in annual ryegrass.

Procedure

A volunteer annual ryegrass trial was located in a grower's field that would be grazed during the winter. An annual ryegrass seed crop had been drilled in the fall of 1997. This planting was harvested in 1998 and provided the volunteer seedling population for the 1999 crop. Plots were established in the field using electric fencing to exclude sheep grazing from selected plots. Individual plot size was 22 ft x 300 ft. The experiment was a split-plot design with grazing duration as the main plot and row spraying as the subplot. There were four main plot treatments: 1) grazing all season, 2) grazing during the first part of the season, 3) grazing during the later part of the season and 4) no grazing. Within each main plot half was row-sprayed and half was left unsprayed. These eight treatments were replicated three times in the field. The total plot area is about five acres. Fencing was shifted once to change exclusion areas in order to control the duration for each treatment. A shielded row sprayer was used to spray out a nine inche wide band on twelve inch centers thus leaving three inch wide 'rows." Sheep were introduced into the field and grazed until early March and were then removed for a period of time. Plots to be row-sprayed were done at this time using Gramoxone at 2 pt/a. Fences were also shifted at this time to expose the late grazing plots and exclude the early grazing plots. Sheep reintroduced in late March and were left until mid-April at which time all grazing ceased, fences removed and the field was fertilized by the grower. The field was fertilized April 16 with 250 lb/a 32-0-11-5 and on April 27 with 12.5 gal/a of Solution 32.

Plots were sampled for yield components at early bloom. Swathing and combining were done by the grower on July 7 and July 22 respectively. Each plot was combined and augered into a weigh wagon to measure yields. Subsamples were then taken for cleanout and seed weight measurements.

Results

Grazing duration. Seed yield was increased by grazing (Table 1). The yields reported for the different grazing durations are the averages of both the sprayed and unsprayed sub-plots in each main grazed plot. Both the early and the full duration graze benefited yield compared with either the late or ungrazed treatments. The early graze (late December to early March) was of much longer duration than the late graze (late March to mid-April). The extra 3-4 weeks of grazing in the full duration did benefit yield by 221 lb/a seed over the early graze (a significant effect) indicating the importance of grazing especially later in the season. Yield component data were not significant, but the individual fertile tillers in the grazed treatment were 25% heavier (data not shown) indicating larger fertile tillers. Also, 1000 seed weight tended to be greater in the two higher yielding treatments. Improved seed set and seed fill were probably the main contributors to increased seed yield.

Row spraying. In addition to the grazing benefit, there was a significant response to the row spraying. Seed yield was increase by almost 10 percent with the row spray treatment. The yields for the row spray treatment are the average of all graze treatments that received the row spray treatment, and the same regarding the no spray treatment. Yield components affected by row spraying were decreased biomass (fewer plants) and decreased fertile tiller number.

In addition to the main factors having a significant effect, there was a slight, but important graze X row spray interaction between the two factors (P value = 0.105). The effect of this interaction is shown in Table 2 where each treatment combination is shown. As can be seen, in the absence of heavy grazing (full season and early) the row spray treatment increased yields, but when there was grazing pressure, there was little impact from the row spray treatment. This gives good evidence that chemically thinning the stand can be a moderate substitute for grazing. This study has shown the improvement in seed yield from grazing management and its benefits, and also the potential for useful adaptation of row spraying. This study is being continued for a second year on another volunteer annual ryegrass field.

Table 1. Seed yield and harvest components of annual ryegrass under graze and row spray treatments, 1999.

Main factors	Seed yield	1000 seed weight	Above-ground biomass	Harvest index	Fertile tillers
	(lb/a)	(g)	(tn/a)	(%)	(no/sq ft)
Grazing duration					
None	1934 c*	2.67	2.9	34	111
Early	2252 b	2.74	3.2	38	119
Late	1991 c	2.69	3.2	38	139
Full season	2473 a	2.73	3.6	35	116
Row-spray					
None	2071	2.71	3.7 a	29 b	143 a
Spray	2254	2.70	2.8 b	43 a	99 b

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values (p=0.05).

Table 2. Grazing X Row-spray seed yield intermeans, 1999.

	Grazing duration			
	None*	Early	Late	Full
Row-spray	(lb/a)			
None	1806	2231	1798	2449
Spray	2062	2274	2183	2497

* Table is to be read in the column format to compare each graze factor individually with or without rowspraying.

ROOT PRODUCTIVITY AND SEED PRODUCTION IN GRASS SEED CROPS

T.G. Chastain, W.C. Young III, C.J. Garbacik and T.B. Silberstein

Introduction

Little is known about the role of root systems in the persistence and long-term productivity of grass seed production fields. The influence of management practices, environment, and plant stand density on these vital plant organs remains to be discovered.

The objectives of our work were to: (i) determine the contribution of root system development to seed yield in cool-season grasses, (ii) learn how stand density and stand age impact root system development of bunch-type and creeping-type grass seed crops, and (iii) determine how burning promotes seed yields in grass seed crops with a creeping-type growth habit. This article reports the second-year progress of a three-year study.

Methods

Field trials were conducted with perennial ryegrass (*Lolium perenne*) cv. Cutter, tall fescue (*Festuca arundinacea*) cv. Velocity, Chewings fescue (*F. rubra* var. *commutata*) cv. SR5100, slender red fescue (*F. rubra* var. *litoralis*) cv. Seabreeze, and creeping red fescue (*F. rubra* var. *rubra*) cv. Shademaster and Hector. Crops were sown in 6-, 12-, 18-, and 24-inch rows at a constant within-row seeding rate. Three stubble treatments were used to differentiate root, rhizome, shoot, and seed yield responses in Shademaster creeping red fescue and Seabreeze slender red fescue: (i) no stubble removal, (ii) complete mechanical removal of stubble, and (iii) removal of stubble by burning.

Roots were excavated with a golf course cup cutter from the soil surface to a 12-inch depth and from under the crop rows to the center of inter-row areas. Roots were washed free of soil and dry weight was determined. Seed yield was measured by harvesting crops with a small plot swather and combine.

Results

The crop density gradient created by the four row spacings resulted in marked plasticity in root biomass density (Table 1). Root biomass in first-year stands was affected by row spacing in Cutter perennial ryegrass but not in second-year stands, although the trends remained similar in the second year. Root biomass in Velocity tall fescue was affected by row spacing in both years. Root biomass was not affected by row spacing in both years in Shademaster creeping red fescue and in SR5100 Chewings fescue. Root biomass density was generally greater when crops were sown in narrow row spacings than in wider row spacings. Averaged over row spacings, increases in root biomass as stands aged from first to second year were: 146% in perennial ryegrass, 386% in tall fescue, 321% in Chewings fescue, and 427% in strong creeping red fescue.

Root biomass was most affected by row spacing in the shallow portion of the soil profile in slender red fescue, creeping red fescue, Chewings fescue, and tall fescue (Fig 1). Narrow rows produced greater root biomass than wide rows in the shallow portion of the soil profile in the 1st year. Smaller effects of row spacing were noted at moderate soil depth in the 2nd year. Root biomass was essentially unchanged from the 1st year to the 2nd year in the deep portion of the soil.

Perennial ryegrass exhibited a unique pattern of root exploration as the stands aged (Fig. 1). Root biomass was increased by narrow rows over wide rows in the shallow and moderate depths in the 1st year. However, root biomass only increased modestly from the 1st year to the 2nd year compared to other species, and root biomass actually declined in the moderate depths in the 2nd year. Seed growers have observed more stand loss as stands age in perennial ryegrass than in other grass seed crop species, and it is possible that a decline in the productivity of the root system may play a role in this phenomenon.

Seed yield in perennial ryegrass, Chewings fescue, and slender red fescue was generally greater in 6- and 12-inch rows in 1st-year stands (Table 2). Greatest seed yield in creeping red fescue was observed in 12-inch rows in 1st -year stands. Seed yield was not affected by row spacing in 2nd-year stands. Row spacing had no effect on tall fescue seed yield in either year.

Shallow root biomass density was related to seed yield in creeping red fescue, Chewings fescue, and perennial ryegrass, but not in slender red fescue and tall fescue (Fig. 2). This relationship is best expressed by a Weibul function; increases in root biomass are accompanied by increased seed yield until a maximum is attained. Greater levels of root biomass beyond this point do not result in higher seed yields.

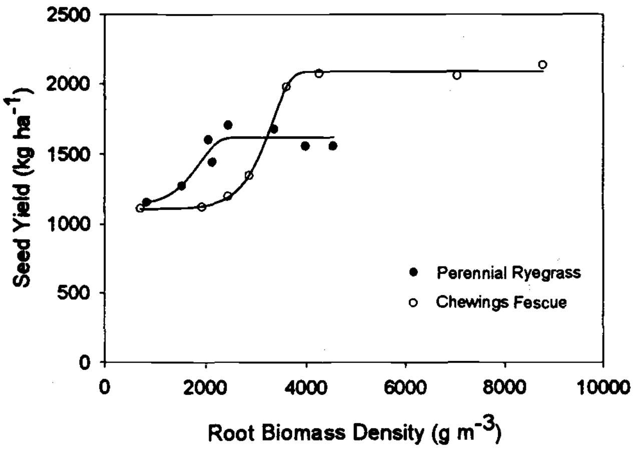

Figure 2. Relationship of shallow root biomass density on seed yield in Cutter perennial ryegrass and SR5100 Chewings fescue.

Autumn root biomass was not statistically different among stubble treatments after the first year of residue management. Clean seeds yields in 1999 were similar regardless of stubble treatment in Shademaster creeping red fescue (Table 3). Stubble removal by burning or mechanical means reduced seed yield in Seabreeze slender red fescue.

Table 3. Seed yield responses to residue management in root trials.

Residue management	Creeping red fescue	Slender red fescue
	(lb/a)	
Burn	1410	992 a†
Stubble removed	1428	1047 b
No stubble removed	1385	1080 c

† Means in column followed by the same letter are not different.

These root studies will be continued for one more growing season. New trials to determine the impact of Palisade plant growth regulator on root development of grass seed crops are underway.

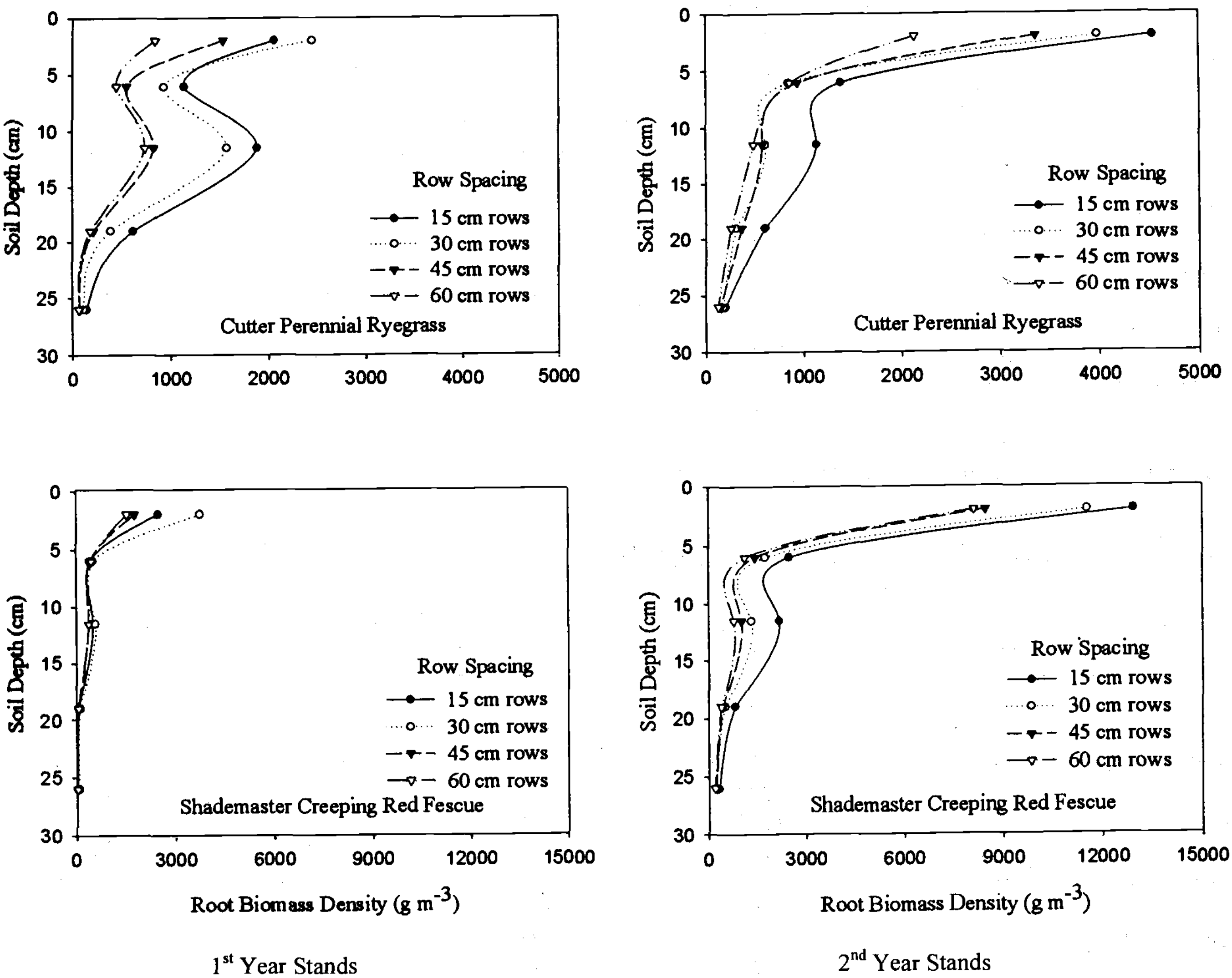

Figure 1. Influence of stand age, row spacing, and soil depth on root biomass density in Shademaster creeping red fescue and Cutter perennial ryegrass.

Table 1. Effect of row spacing and stand age on root biomass density in grass seed crops. Root biomass densities are averaged over soil depths and sampling distance from crop row.

Grass seed crop	Year	Row spacing (inch) 6	12	18	24
		(g/m^3)			
Perennial ryegrass	1st	1166 b†	1090 b	636 a	452 a
	2nd	1573	1188	1079	774
Tall fescue	1st	359 c	296 bc	210 ab	156 a
	2nd	1676 b	952 ab	701 a	659 a
Chewings fescue	1st	837	837	497	246
	2nd	2645	2031	1391	1084
Creeping red fescue	1st	702	1005	532	491
	2nd	3752	3071	2318	2122

† Means in rows followed by the same letter are not different

Table 2. Effect of stand age and row spacing on seed yield cool-season grass seed crops.

Grass seed crop	Year	Row spacing (inch) 6	12	18	24
		(lb/a)			
Perennial ryegrass	1st	1434 b†	1523 b	1143 a	1037 a
	2nd	1390	1392	1499	1291
Tall fescue	1st	1212	1461	1176	1504
	2nd	1710	1710	1690	1583
Chewings fescue	1st	1074 ab	1205 b	996 a	1007 a
	2nd	1907	1837	1853	1767
Creeping red fescue	1st	712 ab	823 c	755 b	693 a
	2nd	1363	1421	1425	1421
Slender red fescue	1st	637 b	664 b	546 a	570 a
	2nd	1025	1025	1069	1040

† Means in rows followed by the same letter are not different

GLUFOSINATE IN PERENNIAL GRASSES

C.A. Mallory-Smith, P.E. Hendrickson, B.D. Brewster and B.D. Hanson

Glufosinate (Rely) is a foliar-applied herbicide that is fairly effective in controlling herbicide-resistant annual bluegrass and roughstalk bluegrass in the Willamette Valley. The ryegrass and fescues are less susceptible to glufosinate than are the bluegrass species, but this tolerance is only relative, and the window of safety is rather small. Perennial ryegrass is probably more tolerant than the fescues, but stage of growth and weather conditions are important factors for all species. Sufficient time must be allowed for the crop to recover from glufosinate injury before onset of the reproductive stage. Glufosinate application is nearly always followed by a period of suspended crop growth accompanied by chlorosis. Additional stresses due to weather, disease, or herbicides can increase crop injury. Although low rates in early fall in combination with other herbicides have appeared useful, the most effective time of application is after threat of hard freezing weather is over and active crop growth has begun, but before nodes are detectable above the soil surface. This period is often between mid-February and mid-March in western Oregon.

Applications after the initiation of jointing may reduce crop seed yield. Since glufosinate is poorly translocated, good spray coverage is important. Delayed applications may allow the crop to partially canopy over the bluegrass and reduce glufosinate contact. Table 1 contains data on annual bluegrass control in two trials near Tangent during 1998. The level of annual bluegrass control is typical of what we have seen with glufosinate in other trials. Table 2 lists visual ratings of perennial ryegrass injury in the two trials. Considerable injury was present 3 weeks after application, and some stunting was still visible after initiation of jointing in early April—especially at the higher rate of glufosinate application. Ryegrass seed yield from the treatments in these two trials is presented in Table 3. The increase in seed yield compared to the untreated control at the Steve Glaser location was somewhat unexpected considering the degree of visible injury. Because the annual bluegrass stand density was very high, and since annual bluegrass is very efficient at harvesting nitrogen, glufosinate treatment prior to the spring fertilizer application undoubtedly allowed the ryegrass to absorb more nitrogen in the glufosinate-treated plots.

Figures 1 through 4 represent grass seed yields from trials on 4 species at Hyslop Farm in 1999. These weed-free tolerance trials were conducted on 4-year-old stands. Although perennial ryegrass seed yields were not reduced by the 0.375 lb a.i../a rate of glufosinate at any application date, significant reductions in yield occurred at all but the February timing with the 2X rate of application. Injury ratings in April for the 0.375 lb a.i./a treatments ranged from a high of 60 percent for the December application to a low of 8 percent for the February application. For the 0.75 lb a.i./a treatments, the ratings were 96 and 13 percent, respectively, for those two dates.

Tall fescue seed yields were reduced by glufosinate applications at 0.375 lb a.i./a in December and January, and the 2X rate reduced yields at all dates of application. Injury ratings for the tall fescue were lower than those for the ryegrass in the winter months, but yields tended to be reduced more. The two fine fescue cultivars were injured more in the January timing than on the three other dates. The 2X application of glufosinate nearly eliminated seed production in these two cultivars at the January application.

Table 1. Annual bluegrass control on April 9, 1998, at two farms near Tangent, OR, following application of glufosinate on February 27.

Treatment	Rate	Annual bluegrass control: Dennis Glaser	Steve Glaser
	(lb a.i./a)	(%)	
Glufosinate	0.375	88	74
Glufosinate	0.75	97	86
Check	0	0	0

Table 2. Visual evaluation of perennial ryegrass injury on two dates following glufosinate application at two farms near Tangent, OR, on February 27, 1998.

Treatment	Rate	Annual bluegrass control: Dennis Glaser 3/17/98	Dennis Glaser 4/9/98	Steve Glaser 3/17/98	Steve Glaser 4/9/98
	(lb a.i./a)	(%)			
Glufosinate	0.375	15	10	15	3
Glufosinate	0.75	25	25	43	25
Check	0	0	0	0	0

Table 3. Perennial ryegrass seed yield at two farms near Tangent, OR, following applications of glufosinate on February 27, 1998.

Treatment	Rate	Ryegrass seed yield: Dennis Glaser	Steve Glaser
	(lb a.i./a)	(lb/a)	
Glufosinate	0.375	1460	1140
Glufosinate	0.75	1440	1210
Check	0	1250	870
LSD 0.05		NS	240

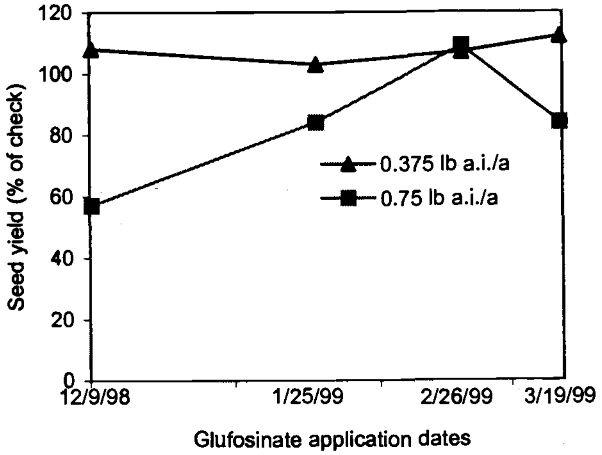

Figure 1. 'Affinity' perennial ryegrass seed yield following glufosinate applications at two rates on four dates at Hyslop Farm, Corvallis, OR.

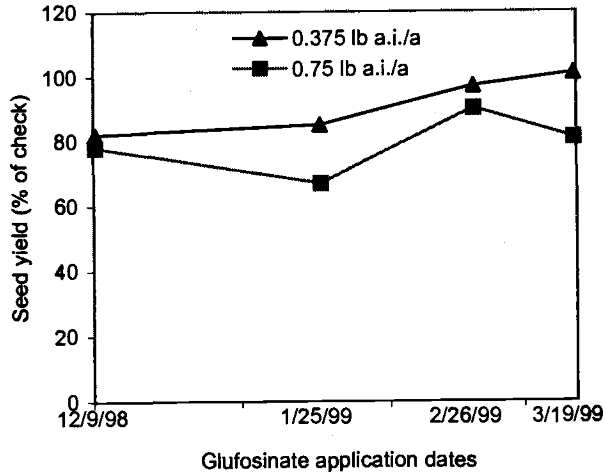

Figure 2. 'Rebel II' tall fescue seed yield following glufosinate applications at two rates on four dates at Hyslop Farm, Corvallis, OR.

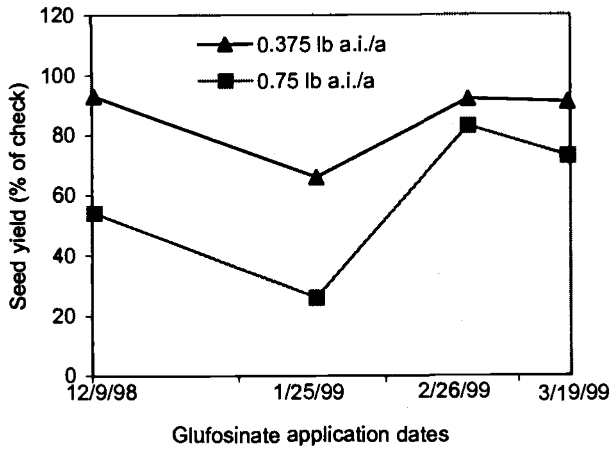

Figure 3. 'Seabreeze' creeping red fescue seed yield following glufosinate applications at two rates on four dates at Hyslop Farm, Corvallis, OR.

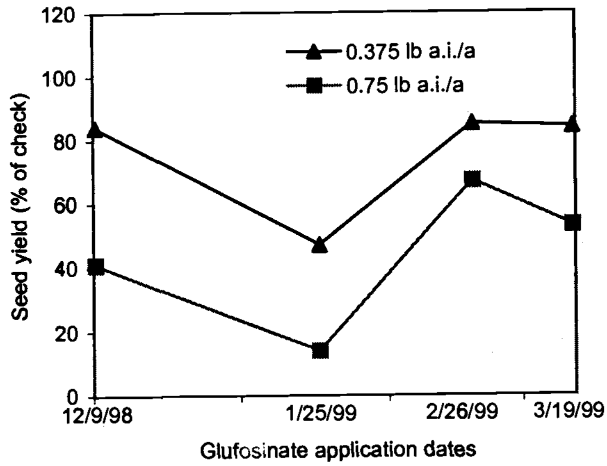

Figure 4. 'SR5100' chewings fescue seed yield following glufosinate applications at two rates on four dates at Hyslop Farm, Corvallis, OR.

PERENNIAL RYEGRASS TOLERANCE TO SPRING-APPLIED RELY

G.W. Mueller-Warrant

The recent registration of low rates of Rely (glufosinate) for suppression of annual weeds in perennial grasses grown for seed offers growers a valuable new tool in their ongoing struggles with weeds such as annual bluegrass, roughstalk bluegrass, California brome, and downy brome. However, the indemnification procedure associated with this registration clearly warns users of the potential for serious crop damage. Perennial ryegrass possesses the best tolerance to Rely of all major grasses grown for seed in the Pacific Northwest, but even it can suffer serious yield loss if herbicide rates are too high or application dates are too late. Research in the 1996-97 growing season showed that seed yield in a late-planted, first-year perennial ryegrass crop was reduced by mid-May applications of Rely at rates of 0.175 lb/a and beyond, with 50% yield loss at 0.23 lb/a, while annual bluegrass control improved with herbicide rate up to 0.3 lb/a. Research in the 1997-98 growing season showed that perennial ryegrass seed yield was reduced by mid-April applications of Rely at all rates tested, even the lowest (0.25 lb/a), with 50% yield loss occurring at 0.47 lb/a. However, mid-April timing of Rely in 1998 caused less damage than mid-May timing had in 1997. Late March applications in 1998 of 0.3 lb/a Rely increased perennial ryegrass seed yield at a site heavily infested with annual bluegrass, and had no effect on yield at two sites without significant annual bluegrass pressure. However, yield loss from mid-April application at the nearly weed-free site exceeded yield benefit from late March application at the weedy site. Hence, there was a clear need for further research focusing on the optimum timing and rate of spring-applied Rely. Studies involving Rely in the 1998-99 growing season focused on the late March to late April time period, and used rates of 0.3, 0.375, and 0.5 lb/a. This is the same period that was found to be critical as a cut-off date for application of Horizon (fenoxaprop), and corresponds to the beginning of rapid tiller elongation and elevation of the growing point above the soil surface.

Rely treatment in 1999 damaged exposed perennial ryegrass leaves at all rates and application dates, with higher rates causing more severe damage. Leaves emerging after treatment were generally healthy, and most injury symptoms were outgrown in three weeks. Some stunting from higher rates of the later application dates lingered through harvest. However, the critical question was whether or not the leaf damage translated into lower seed yield. When applied on March 25, Rely was safe on perennial ryegrass at all three rates, even 0.5 lb/a (Table 1). Indeed, there was a small increase in yield over the untreated check at the two higher rates. When Rely was applied 12 days later (April 6), there was a modest decrease in yield as rate of the herbicide increased (112 lb/a less seed per 0.2 lb/a more herbicide), but yield was unaffected at the 0.3 lb/a rate. Delaying application until April 16 reduced seed yield by an average of 181 lb/a compared to April 6. Delaying application until April 29 reduced seed yield another 96 lb/a beyond the damage done by April 16 application. The impact on seed yield of increasing herbicide rate was more serious for April 16 and April 29 applications than it had been for April 6 application (avg. 202 lb/a less seed per 0.2 lb/a more herbicide). Extrapolating beyond the highest rate used in this test provides an estimate of 50% yield loss at 0.77 lb/a of Rely applied April 29.

While reasons for differences in perennial ryegrass sensitivity to Rely between years are not fully known, one possible cause is the weather. Rainfall was above normal from November 1998 through April 1999, and flooding may have delayed the physiological development of the crop compared to earlier years. The abundant soil moisture may have also aided the crop's recovery from leaf burn by Rely. Position of the growing point (apical meristem) provided a good indicator of sensitivity of perennial ryegrass seed yield to Rely. The growing point was only 0.25 inches above the soil on April 6, but reached four times that height by April 16, when Rely caused severe yield loss. When the perennial ryegrass growing point reaches 1 inch above the soil surface, growers should limit their treatments to the lower rates of Rely. When the growing point has elevated to 3 to 4 inches, growers should probably not apply Rely at any rate unless the weed infestations are severe. Roughstalk bluegrass was present in great abundance at another test site in 1999. Application of 0.3 lb/a Rely in late March at this site provided 90% control of the roughstalk bluegrass, killing both seedlings and well established plants. Indeed, Rely controlled roughstalk bluegrass was more fully effectively than it controlled annual bluegrass. Because Rely causes substantial damage to the crop canopy only 2 to 3 months before harvest, numerous factors may interact in determining whether this foliar damage leads to any yield loss. Growers should exercise caution when combining applications of Rely in the spring with other factors that also change crop growth and development, such as growth regulators, other herbicides, altered seeding rates, row spacings, irrigation practices, and introduction of new varieties.

Table 1. Perennial ryegrass seed yield response to rate and application timing of Rely in 1999 under nearly weed-free conditions.

Application date	Growing point elevation	Spring herbicide treatment 0.3 lb/a Rely	0.375 lb/a Rely	0.5 lb/a Rely	Average
	(inch above soil)	(lb/a clean seed)			
March 25	0.16	1428 ab*	1449 a	1436 a	
April 6	0.25	1408 ab	1373 abc	1296 cd	1359 X*
April 16	1.0	1263 de	1222 de	1049 f	1178 Y
April 29	3.4	1185 e	1064 f	996 f	1082 Z
April 6, 16, 29 avg.		1286 A*	1220 B	1114 C	

*Means followed by the same letter within a group of letters do not differ at the $P = 0.05$ level. Interaction of rate by application timing was non-significant for the three April dates, but was significant when March 25 yields were included. Seed yield of untreated check = 1320 lb/a, seed yield of March 25 application of 0.25 lb/a Rely + 1.0 lb/a Avenge (difenzoquat) = 1383 lb/a.

HERBICIDE SCREENING IN CARBON-SEEDED PERENNIAL RYEGRASS

B.D. Hanson, B.D. Brewster and C.A. Mallory-Smith

Diuron has been used to control weeds and volunteer ryegrass in carbon-seeded perennial ryegrass fields in western Oregon for many years. Annual bluegrass has developed resistance to diuron through repeated use of this herbicide in new seedings and established stands. This resistance has greatly reduced the quality of seed produced in infested fields and underlines the need for alternative herbicide programs in both new seedings and established stands of perennial ryegrass. Two studies were established in carbon-seeded perennial ryegrass at the Hyslop Research Farm near Corvallis, OR to evaluate crop tolerance and annual bluegrass control with several herbicides.

Experimental design in both experiments was a randomized strip plot with four replications. Individual plots were 8 by 24 ft in the fall-seeded trial (8 ft seeded without carbon and 16 ft seeded with carbon) and 8 by 32 ft in the spring-seeded trial (8 ft seeded without carbon and 24 ft seeded with carbon). 'Delaware Dwarf' perennial ryegrass was seeded at 8 lb/a in 12-inch rows in both experiments. Activated carbon was applied at 300 lb/a in a one-inch band over the seedrow at planting. Herbicides were applied preemergence with a single-wheel, compressed-air, plot sprayer calibrated to deliver 20 gpa at 19 psi and 3 mph (Table 1). The spring-seeded trial was sprinkler-irrigated to simulate fall growing conditions and increase the probability of crop injury. Seed yield in the fall-seeded trial was determined by swathing a 6 by 14 ft area from the carbon-seeded rows on July 10, allowing the grass to dry in the windrow, and threshing the seed on July 22, 1999 with a small plot combine. Seed yield was not obtained from the spring-seeded trial.

Table 1. Application data.

Seeding date	September 30, 1998	March 15, 1999
Application date	September 30, 1998	March 16, 1999
Air temp (F)	77	38
Soil temp (F)	68	40
RH (%)	39	98
Soil texture	Silt loam	Silt loam
Organic member (%)	2.4	2.4
pH	5.3	5.2

Annual bluegrass control in the fall-carbon-seeding experiment was at least 89% with all treatments (Table 2). Perennial ryegrass injury ranged from 20 to 81% in the absence of carbon and from 0 to 25% when carbon-seeded. Seed yield of perennial ryegrass was not different among treatments. Carbon-seeded perennial ryegrass was adequately protected from injury with all treatments in this experiment.

Spring-seeded perennial ryegrass was injured 33 to 100% by in the absence of carbon and 0 to 95% when carbon-seeded (Table 3). Diuron, sulfentrazone (Spartan), and norflurazon (Solicam) were safe to the crop when carbon-seeded; low rates of azafenidin (Milestone) also were marginally safe. Carbon seeding did not prevent significant perennial ryegrass injury from pendimethalin (Prowl) and flufenacet-metribuzin (Axiom).

Table 2. Annual bluegrass control and crop injury and seed yield in fall carbon-seeded perennial ryegrass.

Treatment	Rate	Annual bluegrass control	Perennial ryegrass injury[1] no carbon	Perennial ryegrass injury[1] carbon-seeded	Perennial ryegrass seed yield
	(lb a.i./a)	(%)	(%)	(%)	(lb/a)
Untreated check	--	0	0	0	2094
Diuron	1.6	100	81	25	2172
Clomazone	0.25	100	30	3	2338
Norflurazon	0.25	89	20	0	2556
Sulfentrazone	0.125	97	55	3	2547
Diuron + clomazone	0.8 + 0.25	100	65	10	2520
Diuron + norflurazon	0.8 + 0.25	100	60	10	2558
Diuron + sulfentrazone	0.8 + 0.125	100	73	10	2355
LSD (0.05)	--	3	13	4	NS

[1] February 15 rating

Table 3. Crop injury from herbicides in spring-seeded perennial ryegrass on June 9, 1999.

Treatment	Rate	Perennial ryegrass injury no carbon	Perennial ryegrass injury carbon-seeded
	(lb a.i./a)	(%)	(%)
Untreated check	--	0	0
Diuron	2.4	100	9
Sulfentrazone	0.125	33	0
Sulfentrazone	0.25	58	8
Sulfentrazone	0.375	80	3
Norflurazon	0.5	70	0
Norflurazon	1.0	96	9
Norflurazon	1.5	100	13
Pendimethalin	1.5	99	60
Pendimethalin	3.0	100	90
Pendimethalin	4.5	100	95
Azafenidin	0.125	100	15
Azafenidin	0.25	100	24
Azafenidin	0.375	100	30
Flufenacet-metribuzin	0.42	100	53
Flufenacet-metribuzin	0.63	100	68
Flufenacet-metribuzin	0.84	100	85
LSD (0.05)		17	16

TALL FESCUE TOLERANCE TO S-DIMETHENAMID

B.D. Hanson, B.D. Brewster, P.Hendrickson and C.A. Mallory-Smith

Dimethenamid (Frontier) is registered for use in grasses grown for seed. S-dimethenamid is a new formulation that soon will replace dimethenamid. A study was established in a tall fescue field at the Hyslop Research Farm near Corvallis, OR to determine the effects of s-dimethenamid applied alone and in combinations on tall fescue growth and yield, and on control of seedling volunteer tall fescue.

Individual plots were 8 by 25 ft arranged in a randomized complete block with four replications. Herbicide treatments were applied with a single-wheel, compressed-air, plot sprayer calibrated to deliver 20 gpa at 19 psi and 3 mph (Table 1). A 6 by 14 ft area was swathed in each plot in early July, allowed to dry in the windrow, and harvested with a small plot combine.

Table 1. Application data and crop growth stage.

Application date	October 6, 1998	October 16, 1998
Timing	PRE	POST
Air temp (F)	72	67
Soil temp (F)	68	60
RH (%)	66	74
Cloud cover (%)	5	5
Growth stage		
Tall fescue	4 - 6 in	4 - 6 in
Volunteer tall fescue	Pre - 1 leaf	1 - 2 leaf
Soil texture	Silt loam	
Organic matter (%)	2.8	
pH	5.9	

Seedling volunteer tall fescue was controlled at least 83% by all treatments on November 30, 1998 (Table 2). Metolachlor at 6.0 lb a.i./a, and s-dimethenamid at 1.3 and 2.6 lb a.i./a controlled volunteer tall fescue as well as s-dimethenamid or metolachlor (Dual) followed by oxyfluorfen (Goal) plus diuron. Volunteer tall fescue control followed a similar trend at later ratings but was not statistically different among treatments. Tall fescue was injured 3 to 5% by all PRE treatments and 30% with all combination treatments at the October 30, 1998 evaluations but injury symptoms were not apparent at later ratings. Tall fescue seed yield did not differ from the untreated control with any of the herbicide treatments.

Table 2. Control of seedling volunteer tall fescue and tall fescue crop safety with s-dimethenamid.

Treatment	Rate	Application timing	Vol. tall fescue control[1]	Tall fescue	
				Injury[2]	Seed yield
	(lb a.i./a)		--------- (%)	-----------	(lb/a)
Untreated check	--	--	0	0	1645
Metolachlor	6.0	PRE	96	5	1693
Dimethenamid	1.17	PRE	83	3	1484
S-dimethenamid	0.65	PRE	90	5	1700
S-dimethenamid	0.82	PRE	89	5	1541
S-dimethenamid	1.3	PRE	91	4	1710
S-dimethenamid	2.6	PRE	95	5	1711
S-dimethenamid / oxyfluorfen + diuron	0.65 / 0.25+1.2	PRE/ POST	98	30	1767
S-dimethenamid / oxyfluorfen + diuron	0.82 / 0.25+1.2	PRE/ POST	99	30	1883
Metolachlor / oxyfluorfen + diuron	1.5 / 0.25+1.2	PRE/ POST	98	30	1622
LSD (0.05)			7	2	NS

[1]November 30, 1998 rating
[2]October 30, 1998 rating

FUNGICIDE OPTIONS FOR RUST CONTROL IN GRASS SEED FIELDS

M.E. Mellbye, G.A. Gingrich and R.J. Burr

There are a number of good fungicides for disease control in grass seed crops. Between 1992 and 1999, we conducted over 50 small plot trials on perennial ryegrass, tall fescue, orchardgrass, and fine fescue to evaluate the efficacy of new fungicide materials. In addition, several larger scale Emergency Use Permit (EUP) trials were harvested using grower equipment to establish crop safety and yield data of promising new fungicides. This work contributed to the registration of Quadris, Folicur, Laredo, and several contact materials like Sulforix. The purpose of this article is to summarize the work that we have done comparing these products over the past eight years, and provide some recommendations on the use of these products to control stem rust in Willamette Valley grass seed fields.

Field trials were conducted at sites in Marion, Clackamas, Linn, Benton, and Lane Counties. All trials were randomized block designs with 3-4 replications, and spray applications were made at 30-40 psi using XR 8003 nozzles with a spray volume of 20 gpa. Use of surfactant varied among the trials. Disease severity (% rust infection of entire plants) was evaluated 3 to 4 times starting in April or May each year and ending just before swathing in late June or early July. The determination of % rust infection was based on methods recommended by plant pathologists Ron Welty (USDA retired) and Paul Koepsell (OSU Extension Service retired). Please check the references at the end of this article for reports of data from individual years.

Oils and sulfur products

We began plot work in 1992 to evaluate and register contact fungicides that could be used with Tilt. At that time, Tilt was the only systemic fungicide available for use in grass seed crops. While no stem rust resistance toTilt in grass seed crops had been confirmed, there was concern in the industry about the potential of resistance developing due to the heavy reliance on Tilt for rust control. Products such as Stylet Oil and Sul forix were found to provide a moderate level of rust control by themselves (about 30%), and appeared to provide some additional control when tank mixed with Tilt in a resistance management program. We investigated how to use these products with Tilt, based on general principles of resistance management, even though rust resistance has never been confirmed in Willamette Valley grass seed fields.

With the registration of Quadris and the removal of feeding restrictions on Bravo in 1998, the situation changed. These products have a completely different mode of action than Tilt and are more effective fungicides on stem rust than oils and sulfur products. Therefore they are better choices to use in a resistance management program. Registration of Folicur and Laredo also provide some additional choices to use in place of oils or sulfur materials, although like Tilt, they are sterol inhibitor fungicides, and may not play a significant role in resistance management with Tilt.

Bravo (chlorothalonil)
Bravo is an excellent protectant fungicide. Bravo's strength is on the leafspot organisms that develop in cool wet conditions. It has never been as effective on rust as sterol inhibitor fungicides like Tilt.

However, tank-mixes of Bravo with Tilt or Folicur were shown to contribute to rust control early in the season. On seedling perennial ryegrass and turf-type tall fescue fields prone to rust early, this application makes sense not only to optimize control in susceptible fields, but also as a resistance management strategy.

If rust is present, early head emergence is the optimum time to apply a Tilt or Folicur plus Bravo fungicide mixture. For most varieties, this will occur between early and mid-May. To maximize the effectiveness of this tank mix, it should be applied as a preventative spray prior to flowering of the grass seed crop.

For many years, the inability to feed Bravo treated straw and seed screenings prevented the widespread use of this product on perennial ryegrass and tall fescue. This issue was resolved in 1998. The current Oregon 24c label allows feeding of straw and seed screenings.

Tilt (propiconazole)
After 19 years of use on grass seed in the valley, Tilt continues to provide excellent rust control. To date, there are no cases of confirmed resistance. Tilt is a sterol inhibitor fungicide. It is locally systemic in the plant, which means it does not move far from where it is taken up by the plant, so good coverage is still important in the use of this material. Under heavy rust pressure later in the season, Tilt has been less effective for stem rust control than Quadris, but has provided control equal to other sterol inhibitor fungicides discussed in this article.

Tank mixing and alternating Tilt with other fungicides, especially Bravo and Quadris, should help preserve Tilt as a valuable tool for rust control in seed crops. Tilt should be applied with adequate water to insure good coverage. High pressure is not required to do this; in fact, excessive pressure can result in loss of material by evaporation, and does not improve uniformity of application. Use of a surfactant with Tilt, an EC formulation, is not required, but is an acceptable practice. Tilt should be used at a rate of 4-6 oz/acre. The lower rate can provide satisfactory control under moderate disease pressure. A rate of 5-6 oz/acre can provide somewhat longer control and is more effective under severe disease pressure. Straw and seed screenings can be fed. Tilt has a 20 day pre-harvest interval (PHI).

Folicur (tebuconazole)
A full Federal label was approved in 1999 for use of this fungicide in grass seed crops. Folicur is a sterol inhibitor fungicide like Tilt and Laredo. All three are excellent fungicides for stem rust control under moderate disease pressure conditions.

Under heavy rust pressure later in the season, Quadris has provided better control than Folicur. Sometimes Tilt appears to be a little more consistent than Folicur under severe rust pressure on perennial ryegrass later in the season.

A tank-mix of Folicur with Bravo, similar to Tilt plus Bravo, has also provided excellent rust control in our trials on tall fescue and perennial ryegrass early in the season. These tank mixes are as good or better than Quadris during cool wet weather in May for early season leafspot and rust control. There do appear to be some differences in the sterol inhibitor fungicides, but on average they provide comparable rust control.

In contrast to reports from New Zealand and Australia, Folicur does not provide longer rust control than Tilt on Willamette Valley grass seed crops. Folicur should be used with a good surfactant and used at a rate of 6 oz/acre. Folicur has a 4 day PHI.

Laredo (myclobutanil)
Laredo is another sterol inhibitor fungicide, which means it has a mode of action like Tilt and Folicur. In our 1998 and 1999 trials, this product was reported under the name Systhane. Laredo received a 24c label for use on grass seed in Oregon in February 2000. It appears to be somewhat more effective for control of powdery mildew in Kentucky bluegrass, but does not offer any advantage over the other sterol inhibitor fungicides with respect to stem rust control in the Willamette Valley.

A use rate of 8 to 12 oz/acre is allowed. Under conditions of high rust pressure, 8 oz/ac has not provided good control. Ten ounces, which is a rate of active ingredient similar to 6 oz/ac of Tilt or Folicur, has provided control similar to these fungicides. We have not tested mixtures of Laredo with Bravo, but would not anticipate much difference from the Tilt and Folicur tank mixes.

Laredo is an EC formulation with a danger signal word on the product label, so you will want to take suitable precautions handling this material. Laredo has a 1-year grazing restriction, similar to several other materials registered with 24c labels during 1999 and 2000. There are no restrictions on feeding of straw and seed screenings. The manufacturer recommends that Laredo be used with a non-ionic surfactant.

Quadris (azoxystrobin)
The fungicide Quadris received a 24c or Special Local Needs (SLN) registration in 1998. This is an excellent rust control fungicide with a completely different mode of action than the sterol inhibitor fungicides. It is one of a number of new fungicides called strobilurins. At the use rate of 9-12 oz/acre, Quadris usually has somewhat better curative ability and longer residual activity than Tilt or Folicur. Quadris can provide excellent rust control throughout the season. Early in the season, it sometimes does not suppress rust as well as the sterol inhibitor fungicides, but later in the season, it provides superior control when rust pressure is high. Under moderate rust pressure, a use rate of 6 oz/acre provides excellent control. A surfactant (non-ionic, crop oil, etc.) should be added to the spray mixture for best rust control, especially under severe rust pressure.

A potential weakness of Quadris is that it is more prone to develop resistance problems than Tilt, and therefore it should be alternated with other fungicides. Quadris does not appear to be as effective as Bravo on some the leafspot diseases, including Rhycosporium head blight in orchardgrass.

Tank mixes of Quadris with Bravo do not provide added control of leafspots or rust in grasses and are not recommended. In some trials, control of rust was reduced when Bravo was mixed with Quadris.

Summary
Tilt, Folicur, Laredo, and Quadris are all effective rust fungicides. None can eradicate a rust infection that has gotten out of control. Even Quadris at the highest use rate with surfactant, or Quadris + Tilt tank mixes, cannot eradicate a severe epidemic. Regardless of which one you choose, the timing and coverage of your applications remains critical to the overall level of control achieved and to the number of sprays applied.

In a multiple spray program for rust, there continues to be some debate about which fungicide to use first. Based on our field trials, we recommend that Quadris be used second or third. It has good "kickback" and a bit more residual activity, and therefore seems a better choice for when rust pressure is severe late in the season. Tilt, Folicur, or Laredo are equally effective early on, so use them first in a fungicide rotation.

Another reason to use Quadris later is that we do not recommend Bravo tank-mixes with Quadris at this time. If rainy weather occurs in May, a Bravo tank mix with one of the other sterol inhibitor fungicides (Tilt, Folicur, or Laredo) should be the spray of choice prior to flowering.

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USDA webpage http://www.usda.gov

USING DEGREE DAYS TO MONITOR GENERATION TIME IN STEM RUST

W.F. Pfender

Introduction
When stem rust in a grass seed field "blows up", or becomes severe throughout the field, we are seeing the end result of many generations of rust fungus population growth. In fact, the reason rust epidemics can be so damaging is that the pathogen has the capability of rapid reproduction. Therefore a key factor in whether a particular rust epidemic becomes severe is the number of generations the rust fungus can produce during a season. For example, consider an epidemic that starts with a single rust pustule per square foot of field. If the rust increases by about 1.7 times in each generation (a realistic number), it will reach a severity of 3% (slight yield reduction) in 18 generations, but will reach 30% (very substantial damage) in just 5 more generations. And because a shorter generation time is the same thing as more generations per season, we can estimate how quickly a rust epidemic is progressing by monitoring the generation time.

Generation time (or "latent period" in the vocabulary of plant disease) is affected primarily by temperature. At warmer temperatures (up to a limit) the latent period is shorter than at colder temperatures. To determine exactly what the relationship is between temperature and latent period, experiments were done in the greenhouse and checked against observations from field experiments.

Procedures
Plants of perennial ryegrass and tall fescue grown in the greenhouse were sprayed with stem rust spores. After inoculation, and incubation overnight under conditions favorable for infection, plants were kept in one of several growth chambers maintained at different constant temperatures. Plants were examined daily, and time of pustule emergence was noted. These constant-temperature data were combined, and an equation relating temperature to latent period (generation time) was fit to the data.

To field-test the latent period equations for perennial ryegrass and tall fescue, an experiment was conducted for two years at Hyslop Farm. On 5-6 different dates during the growing season of each year, inoculated plants from the greenhouse were set out in the field. The plants were observed frequently, and the date of the emergence of the first few pustules per plant was noted. An automated weather station recorded the temperature every 30 minutes near the plants. These temperature readings were used to calculate the fraction of a latent period that passed every 30 minutes (based on the equations from the constant-temperature experiments), and the fractions were added until the estimates indicated that a complete latent period was achieved. A comparison could then be made between the actual (observed) latent period and the calculated one.

Results
Data obtained from controlled-temperature experiments showed a hyperbolic decrease in latent period as temperature increased from a minimum to the optimum, followed by a sharp increase in latent period with temperatures above the optimum (Figure 1). Converting these data from latent period duration to fraction of latent period obtained per half-hour (that is, the rate of completing a full latent period) showed that there is a nearly linear increase in rate with temperature up to the maximum rate, followed by a sharp decline in rate at higher temperatures. When the rate equation was used with 30-minute temperature data, the calculated latent period was usually within 1.5 days of the actual latent period observed on the plants in the field.

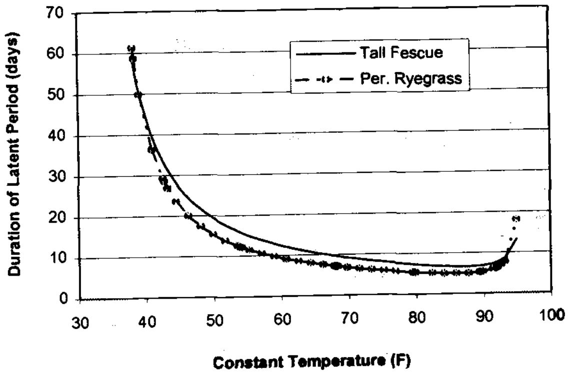

Figure 1. Latent period (generation time) for stem rust is 60 days long at 40F, but only 7 days at 70F, for perennial ryegrass.

For the more commonly available temperature data, in which 30-minute readings are not available, a degree-day calculation can be used based on daily maximum / minimum temperatures. The results approximate closely those achieved with the more detailed equation, at least over temperature conditions common to most of the spring and summer. For the degree-day calculation, one should set the low threshold temperature at 1C, the upper threshold at 30C and use the double sine calculation method. With this calculation, latent period duration is 145 degree-days for perennial ryegrass and 180 degree-days for tall fescue. To use temperatures in Fahrenheit degrees, the low threshold is 34 F, the upper threshold is 86 F, and latent periods are 260 and 325 degree days for perennial ryegrass and tall fescue, respectively.

Figure 2 illustrates comparisons of actual latent periods with those calculated as degree-days from daily max/min temperatures. If the calculated latent periods were exactly the same as the observed ones, all the points would lie on the line of perfect fit. In fact, although the calculated and observed latent periods are not exactly the same, they are within a day or two in almost all cases.

Discussion
By knowing the duration of perennial ryegrass and tall fescue latent periods in degree-days, we can estimate the number of generations of the rust pathogen that could occur as the season progresses. A season with more generations will be a more severe rust season than one with fewer generations.

However, there are several other very important factors that determine the severity of a rust epidemic. The amount of rust inoculum that survives through the winter to begin the epidemic in spring is critical. Also, inoculum (spores) must be dispersed from existing rust pustules to the sites of new infections. And for each latent period (generation) to begin, environmental conditions must be favorable for infection to start. In other words, the latent period is very important for determining epidemic development but it acts in conjunction with several other important determinants. Understanding the effect of weather on latent period is one important step toward being able to predict rust development.

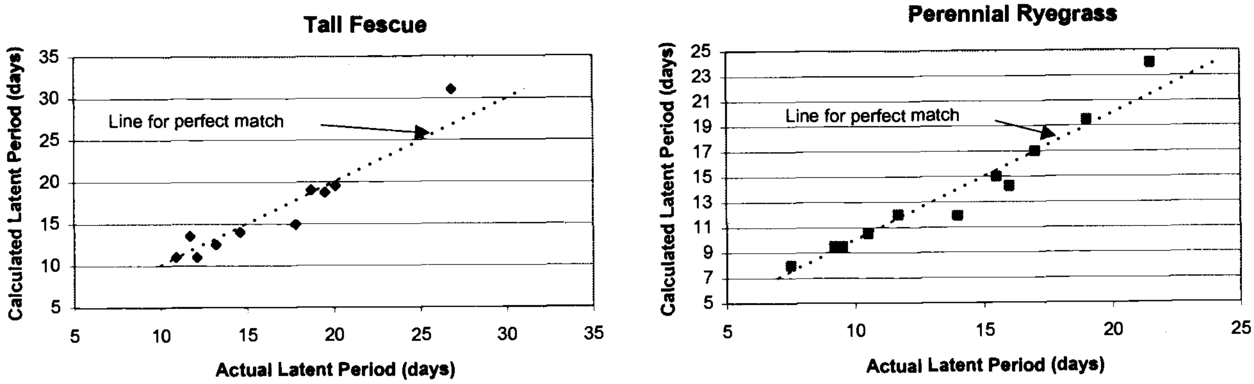

Figure 2. Comparisons of actual latent periods for tall fescue (left) and perennial ryegrass (right), measured in the field, with latent periods calculated from heat units. The dotted line on each graph shows where the points would be if the calculated and observed periods were exactly the same.

SUSCEPTIBILITY OF ANNUAL RYEGRASS TO STEM RUST

W.F. Pfender and R.E. Barker

Although stem rust has generally been a problem primarily on perennial ryegrass and tall fescue, there are reports of stem rust in annual ryegrass as well. Research reported here was done in order to understand the relationship between the stem rust pathogen on annual ryegrass and that on the other grasses, and to learn something about the range of variability among annual ryegrass lines for susceptibility to stem rust.

Procedures

Rust spores (urediniospores) were collected in summer and fall from perennial ryegrass, tall fescue and annual ryegrass separately. Inoculum from each source was applied to healthy, 12-week-old plants of perennial ryegrass, tall fescue and annual ryegrass grown in the greenhouse. Ten plants were used for each combination of test species and inoculum source. Inoculated plants were subjected to standard infection conditions overnight, then placed in the greenhouse for observation. Two weeks later, each plant was examined and the number of pustules was recorded. The experiment was repeated one month later with new plants.

Twenty cultivars or breeding lines of annual ryegrass were chosen to represent a range of older and newer cultivars and germplasm. Plants were grown under greenhouse conditions to an age of 12 weeks. Twelve replicates, with 10 plants per cultivar per replicate, were inoculated with rust urediniospores and subjected to standard infection conditions overnight. After 14 days, each plant was scored for pustule number (on a 0 - 3 scale, where 3 is > 30 pustules per plant) and pustule type (standard 0 - 4 scale, where 4 is most susceptible reaction). After scoring, the plants were trimmed severely to remove rusted leaves, then grown for two more weeks. The inoculation and scoring procedure was then repeated on the same plants.

Results and Discussion

In two separate tests, rust spores collected from annual ryegrass caused infection on perennial ryegrass and annual ryegrass, but not on tall fescue. Rust from perennial ryegrass likewise infected annual and perennial ryegrass but not tall fescue. Rust spores collected from tall fescue could infect all three grass species, but at a much lower rate (fewer pustules per plant) than ryegrass rust inoculum applied to ryegrasses. Because it is often difficult to get severe infection of tall fescue under greenhouse conditions, we cannot say conclusively that stem rust from ryegrasses cannot infect tall fescue. In fact, we have data from a larger study indicating that such infection, although infrequent, can occur. It is clear, however, that annual and perennial ryegrass each can be infected by the same strain of the rust fungus that infects the other.

Among 20 lines of annual ryegrass inoculated in the greenhouse, all were susceptible to stem rust, at least to some degree. Although there were some statistically significant differences among lines with respect to the number of pustules produced by the inoculation, the differences were not dramatic. There is clearly variance for rust susceptibility/resistance in many lines. The least susceptible line had 60% resistant plants (no pustules), and the most susceptible had 7% resistant plants. There was not a consistent difference among lines with respect to pustule type produced by the rust fungus.

These results of greenhouse experiments demonstrate that annual ryegrass is susceptible to the same fungus that causes stem rust on perennial ryegrass. The study also indicates that stem rust susceptibility is common among annual ryegrass lines, and that there is probably exploitable genetic resistance available.

STEM RUST RESISTANCE IN TALL FESCUE IMPROVES SEED YIELD WITHOUT USE OF FUNGICIDES

R.E. Barker, W.F. Pfender and R.E. Welty

Abstract

Cultivars with resistance to stem rust (caused by *Puccinia graminis* Pers. subsp. *graminicola* Urban) would be beneficial in tall fescue (*Festuca arundinacea* Schreb.) grown for seed in the Pacific Northwest. Two cycles of polycross (PX) selection on progenies from 34 parent plants (14 forage-types and 20 turf-types) were developed using a 2-stage greenhouse screening process. Direct selection response was determined in the greenhouse from composite half-sib progenies from each cycle and seed yield response from the same plants grown for four years at the Hyslop field station on a Malabon soil. Number of plants with resistant reaction based on pustule type increased from 5 to 54% in the PX forage-type population and from 6 to 50% in the PX turf-types. Direct selection response indicated that rapid progress from selection in the greenhouse is possible, but most of the additive genetic variance was used after one cycle of PX selection. Seed yields were larger in populations selected for stem rust resistance than in base populations. Cycle 1, however, had larger seed yields than for cycle 2 in both forage-type and turf-type populations indicating possible inbreeding depression. Reverse selection for stem rust susceptibility resulted in smaller seed yields. These results indicate that genetic resistance to stem rust can improve seed yields in tall fescue and reduce the need for pesticides.

Introduction

Tall fescue is an important grass grown for forage and turf in the southeast and midwest regions of the USA and for turf in the mid-Atlantic and west regions of the USA and southern areas of Australia. It ranks third among grasses in number of acres grown for seed in the Willamette Valley of Oregon. Stem rust, first reported on the seed crop in 1987 (Welty and Mellbye, 1989), has increased in economic impact in seed production fields in recent years with fungicides commonly used to control the disease (Pscheidt, 1996). Genetic resistance, however, would provide a more environmentally sound approach to control the disease.

Welty and Barker (1993) surveyed 20 cultivars of tall fescue for resistance to stem rust. None of the cultivars were judged resistant, but there were differences among cultivars for number of plants with a resistant response when inoculated with stem rust. Resistant plants were saved from the survey. This study reports direct selection response results from two cycles of recurrent selection in controlled environment screening and indirect response on seed yield over four years.

Materials and Methods

Source plants for this study were selected from among 1,400 plants in a nursery established in 1990 containing 70 plants from each of 20 cultivars (Welty and Barker, 1993). Selection criterion, using procedures described by Welty and Barker (1993), was freedom of any stem rust symptoms during two inoculations on seedlings in a greenhouse and two scoring periods in 1990 after plants were transplanted to the field. Thirty-four plants had resistant reactions in both greenhouse inoculations and in field scoring. Plants with resistant reaction were divided into two populations based on the intended use of the cultivar from which they came. Twenty plants were placed in a turf-type population with plants coming from the cultivars Arid (6 plants), Mesa (6 plants), Thoroughbred (4 plants), Finelawn I (2 plants), Finelawn 5GL (1 plant), and Adventure (1 plant), and fourteen plants in a forage-type population coming from the cultivars Kentucky 31 (10 plants), Forager (3 plants), and Johnstone (1 plant).

Population Development

Both populations were developed simultaneously through two selection cycles in the same way as described by Barker and Welty (1996). Ten vegetative cuttings (ramets) were collected from each selected plant and established in isolated polycross (PX) blocks. Open pollinated (OP) seed from the resistant plants in the original nursery was also harvested. This seed could have been pollinated with pollen from either resistant of susceptible plants so selection was only on the maternal side. OP selection is often practiced by commercial breeders because onset of stem rust in the field is often delayed until after pollination. Two cycles of PX selection were compared to one cycle of OP selection followed by one cycle of among and within family PX bi-directional selection for susceptibility or resistance.

Following an establishment year, seed was harvested from each plant and composited by maternal line. Sixty seedlings from each maternal line were screened through two inoculations with stem rust spores in the greenhouse (Welty and Barker, 1993). Maternal family lines with the lowest average infection type score were selected and individual plants within families chosen based on freedom of any stem rust symptoms in both inoculations. Three plants were saved from each of seven lines for the turf-type population and from five lines for the forage-type. The second cycle of OP selection included reverse selection for susceptibility to stem rust. Selected plants for all populations were divided into ten ramets each and established in isolated crossing blocks in the field.

Direct Selection Response

Equal quantities of seed from each plant in the isolated crossing block were composited to form the populations used to determine response from selection. Selection progress was measured on ten plants in each of twelve replications and was tested by the two-stage inoculation procedure in the greenhouse. Disease infection type was scored by classes as described by Welty and Barker (1993) with 0 = no macroscopic sign of infection and 4 = large uredinia and abundant sporulation. Average infection type (AIT) was computed for each entry (not all data presented) and the frequency (%) of individual plants with a zero score in both inoculations was determined. Realized gain was calculated as the difference in frequency of plants with resistant reaction between two successive selection cycles, for example, $\Delta G = C1 - C0$.

Indirect Selection Response on Seed Yield

Identity of individual plants was maintained as they were transplanted to a field near Corvallis, OR to measure seed production. Plants were arranged in four replications of 20 plants each, with 10 plants spaced 30 cm apart in each of two rows spaced on 0.5 m centers and plots spaced 1 m apart. The soil type was a Malabon (fine, mixed, mesic Pachic Ultic Argixeroll).

Seed was harvested on a plot basis by maturity of each entry when influorescences were at about 43% moisture. Biomass was air dried, then threshed on a belt thresher and cleaned on a M2B cleaner. Seed yield data were collected in 1996, 1997, 1998, and 1999.

Stem rust was scored after anthesis on a plant basis and averaged for each plot. A severity score (0 to 4=worst) was based on the Cobb scale (an estimated percentage pustule coverage of leaves) modified by pustule type and incidence was the percent of the plants in a plot infected with rust.

Results and Discussion

Direct Selection Response

Number of plants with resistant reaction in both inoculations based on pustule type increased from 5 (AIT = 3.3) to 54% (AIT = 1.1) in the PX forage-type population and from 6 (AIT = 3.1) to 50% (AIT = 1.2) in the PX turf-types. The first cycle of PX selection produced 73 and 89% of the realized gain in the two populations, respectively (Barker and Welty, 1996). Overall response from initial OP selection was similar to PX selection, but 78 and 50% of the realized gain, respectively, was made in the PX cycle. Reverse selection for susceptibility caused all resistant plants to be lost in only one cycle of selection. This demonstrates how rapidly genetic gains could be lost when utilizing natural field populations of rust for screening in a year with low stem rust pressure.

Among check cultivars included in the direct response test, frequency of plants with resistant reaction in both inoculations ranged from 0 to 11% and AIT from 2.9 to 3.7 (Table 1). All cultivars tested in this and other studies using this inoculation procedure were classified as susceptible and had less than 11% plants that were judged resistant (data not shown).

Table 1. Frequency (%) of individual tall fescue check cultivar plants with stem rust resistant reaction in both of two inoculations.

Cultivar	Resistant plants	Average infection type
	(%)	(Score[1])
Kentucky 31	11	2.9
Arid	8	3.1
Mesa	5	3.0
Thoroughbred	4	3.3
Bonanza	2	3.3
Forager	2	3.4
AU Triumph	0	3.7
LSD (0.05)		0.3

[1]Severity score (0 to 4 = worst) based on modified Cobb scale.

Seed Yield Response

Data were analyzed over years as a split plot in time. There were highly significant differences ($p<0.0001$) for entries (Table 2), years (Table 3), and entry X years (Table 4) for both seed yield and reaction to stem rust infection.

Seed yield over four years followed closely the response pattern of number of resistant plants from the greenhouse selection studies (Table 2). Seed yields in the C1 polycrosses were higher than those in the other selection cycles, and they also had low susceptibility to stem rust. Seed yields may be lower in the C2 cycles because of inbreeding depression from the narrowing of the genetic base as selection progresses. Seed yield in the OP populations was higher in the C2 cycle selected for resistance than in C1 cycle, or in the C2 selected for susceptibility. Inbreeding in the OP populations would not be apparent in the C2 because that was the first cycle that both male and female parents were limited.

Table 2. Seed yield and average stem rust reaction of tall fescue populations averaged over four years of seed production.

Cultivar	Seed yield	Rust severity	Rust incidence
	(lb/a)	(Score[1])	(%)
Forage-types			
Polycross (PX)			
C0	1865	1.9	62
C1	2180	1.4	49
C2	1832	1.3	46
Open pollination (OP C1)	1988	1.9	61
"Resistant" (OPr C2)	2004	1.0	38
"Susceptible" (OPs C2)	1863	2.0	62
Turf-types			
Polycross (PX)			
C0	1981	1.8	63
C1	2237	1.1	45
C2	2074	1.0	39
Open pollination (OP C1)	2144	1.6	57
"Resistant" (OPr C2)	1978	1.0	38
"Susceptible" (OPs C2)	1823	2.0	63
"Super susceptible" check	1545	2.3	65
Check cultivars:			
Kentucky 31	2031	1.6	55
Arid	1815	1.8	62
Mesa	2100	1.6	60
Thoroughbred	1906	2.1	64
Bonanza	2173	2.2	66
Forager	1959	2.3	64
LSD (0.05)	203	0.3	7

[1]Severity score (0 to 4 = worst) based on modified Cobb scale.

It was an unusual circumstance, but there was essentially no stem rust pressure in 1999, and seed yield was highest in that year (Table 3). Stem rust was present the other three years and a reduction in seed yield was observed. Stem rust data collected in 1996 were not reported here because they were on a different scoring scale than the other three years.

Table 3. Seed yield and average stem rust reaction of tall fescue populations and check cultivars in each of four years of seed production.

Year	Seed yield	Rust severity	Rust incidence
	(lb/a)	(Score[1])	(%)
1996	1935	--	--
1997	1890	2.3	77
1998	1984	2.7	90
1999	2086	0	0
LSD (0.05)	93	0.1	3

[1]Severity score (0 to 4 = worst) based on modified Cobb scale.

The entry X year interaction is easily seen by comparing populations and cultivars in 1998, a heavy rust year, with 1999, a low or no rust year (Table 4). Seed yields in 1998 followed closely the direct selection response pattern and the four year yields, but yield patterns in 1999 were much different. In the absence of pressure from stem rust, cultivars that were bred for high seed yield had the highest seed yields. The populations in the selection cycles had similar performance patterns to the cultivars. Even the "super susceptible" check that was bred specifically, and came from the same base populations, had higher seed yields than some of the selection cycles, and was higher than in 1998 when it had high rust infection.

Table 4. Seed yield and average stem rust reaction of tall fescue populations in 1998 and 1999 seed production years.

Cultivar	Seed yield		Rust incidence	
	1998	1999	1998	1999
	------------ (lb/a) -------------		------------- (%) ------------	
Forage-types				
Polycross (PX)				
C0	1974	2124	96	0
C1	2543	2170	82	0
C2	2040	1644	82	0
Open pollination (OP C1)	2019	2173	94	0
"Resistant" (OPr C2)	2203	1926	72	0
"Susceptible" (OPs C2)	1784	1940	99	0
Turf-types				
Polycross (PX)				
C0	1709	1985	99	0
C1	2516	2191	76	0
C2	2378	1990	68	0
Open pollination (OP C1)	2301	2043	94	0
"Resistant" (OPr C2)	2331	1833	70	0
"Susceptible" (OPs C2)	1218	2097	99	0
"Super susceptible" check	1535	2025	100	0
Check cultivars:				
Kentucky 31	2005	2342	90	0
Arid	1685	1956	96	0
Mesa	1991	2097	98	0
Thoroughbred	1681	1794	96	0
Bonanza	1940	2976	99	0
Forager	1848	2320	100	0
LSD (0.05)	566	432	14	0

Conclusions

Results indicated that rapid progress from selection in the greenhouse for stem rust resistance in tall fescue is possible, but most of the additive genetic variance was used after one cycle of PX selection and genetic improvement will be slower in future cycles. Resistance may be easily lost if control of the pollen parent is not restricted to resistant plants. Welty and Barker (1993) demonstrated that resistance detected in the greenhouse is maintained under field conditions. Hence, it is more important to control the pollen parent by selecting at the seedling growth stage under controlled conditions than to select mature plants in the field.

Seed yields were higher in populations that had a higher resistance to stem rust. Genetic resistance to stem rust will increase seed yield and lower the need for pesticides to control the disease.

The PX cycle 2 resistant populations provided sources of resistance to stem rust that will be useful in developing improved cultivars. These germplasms were designated ORTFRR-T94 for the turf-type population and ORTFRR-F94 for the forage-type. Seed will be stored by the USDA-ARS National Forage Seed Production Research Center and limited quantities of each germplasm made available upon written request.

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A LEAF SPOT DISEASE IN HARD FESCUE: SENSITIVITY OF THE PATHOGEN TO FUNGICIDES

W.F. Pfender, S.G. Seguin, C.M. Ocamb, B.A. Dankert, J.K. Stone, M.E. Mellbye and G.A. Gingrich

A hard fescue disease problem that has been present for a number of years in and near Marion County is characterized by leaf lesions and, sometimes, crown die-back. The disease occurs in small patches in a field, but can become more widespread with time. Its effect on seed yield is unknown. The pathogen or pathogens that may be involved in the disease syndrome are likewise unknown. One component of the problem may be a pathogen causing a leaf spot. This report describes our study of a fungus that can cause a leaf spot on hard fescue.

Procedures

Isolations were made from diseased hard fescue leaves collected in commercial fields in the Sublimity/Silverton area. The isolated fungi were sorted into about 15 groups based on similarity in appearance, then several representatives from each group were inoculated onto four different cultivars of hard fescue grown in the greenhouse. Fungi from two of the groups caused lesions on the leaves. These fungi were re-isolated and studied in more detail. Finally, we focused our efforts on the more aggressive of the two.

To determine whether several fungicides, labeled for use on grasses, have any beneficial effect against the leaf spot disease, we conducted greenhouse experiments. One-year-old plants of two cultivars were inoculated with spores of the fungus that we collected from agar cultures. To favor infection, plants sprayed with the spores were incubated overnight in a mist chamber for two nights in a row. In the intervening day, and for the next three weeks, plants were maintained on a bench in the greenhouse. To compare fungicide treatments, some plants were sprayed with fungicide 36 hours before the spores were applied. Other plants were sprayed with fungicide 2.5 days after the inoculation. Plants in the check treatment were not treated with fungicide. Fungicides were applied using a spray booth to achieve coverage similar to a field application. Bravo was applied at a rate of 20 oz/acre, Quadris was applied at 9 oz/acre, and Tilt was applied at 6 oz/acre. Each was applied in 20 gallons per acre at 30 psi. Plants were rated for leaf spot severity (% of leaf area diseased) 10 days after inoculation, and again 10 days later.

Results and Discussion

The two fungi found to be pathogenic on hard fescue were *Spermospora subulata* and an as-yet unidentified species of *Stagonospora*. *Spermospora* has been reported previously as a pathogen on hard fescue. However, our isolates caused only a small amount of disease on the inoculated plants; most of these plants showed no symptoms, and there were only a few leaf spots on the plants that did become diseased. Each of the several isolates of *Stagonospora* we used caused numerous leaf spots on almost all plants. The lesions ranged in size from 1/8 inch to an inch or more in length, and were generally similar in appearance to leaf spot symptoms observed on field-grown plants.

Plants in the check treatment (no fungicide) had about 2% of their leaf area diseased by 10 days after infection, and almost 10% diseased leaf area by three weeks after infection (Figure 1). None of the fungicides we tested caused a significant decrease in disease if they were applied 21/2 days after infection. If fungicides were applied before infection, however, they were able to reduce disease significantly. Although the differences among fungicides applied before infection were not statistically significant, the average disease scores were lower for Quadris and Bravo than for Tilt.

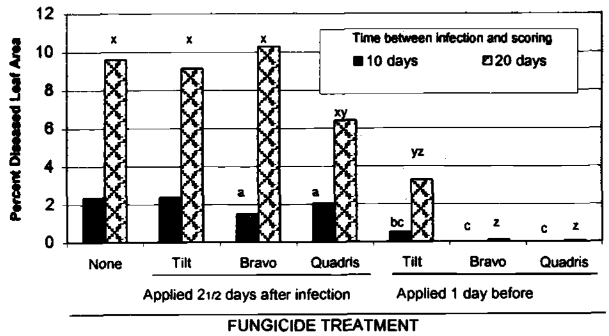

Figure 1. Effect of fungicides on hard fescue leafspot, 1999.

We are currently working to identify the species of the *Stagonospora* pathogen. From our observations and experiments, it appears to be a significant leaf spot pathogen on hard fescue in the Willamette Valley. Its relative importance in the disease syndrome is not yet known, and we continue researching the possible role of root and/or crown pathogens in the problem. Management of the leaf spot with fungicides does not appear very promising at present. Our results suggest that fungicide must be applied before infection occurs. Although we do not know what conditions are favorable for infection, it is likely that infections can occur during a prolonged time span. Field trials conducted by Mark Mellbye and Gale Gingrich showed a decrease in leaf spot symptoms only in plots that were sprayed repeatedly during the winter and spring.

CONTROL OF THE GREY GARDEN SLUG WITH BAITS

J.T. DeFrancesco and G.C. Fisher

Two trials were established in commercial fields of perennial ryegrass near Corvallis, Oregon, to determine the effectiveness of molluscidal baits in controlling the gray garden slug (*Deroceras reticulatum*, Mueller). Bait treatments consisted of Mesurol (2% methiocarb) and Deadline Mini-pellets (4% metaldehyde).

Field Trial #1:
Treatments included Mesurol bait at three different rates: 5.0 lb/a, 7.5 lb/a and 10.0 lb/a, and Deadline Mini-pellets at 10.0 lb/a. Treatments were arranged in a randomized complete block design with four replications; each plot measured 75 x 75 ft. Treatments were applied with a hand-held dispenser on December 16, 1998 and January 15, 1999. An untreated control was included for comparison.

Treatments were evaluated on December 19 and 27, 1998, and January 12, 19 and 26, 1999. Slug populations were determined using open bait stations consisting of three metaldehyde bait pellets per station, with five bait stations within each treatment in each replicate. Number of slugs visiting each bait station was recorded 24 hours after each baiting episode. Due to unfavorable weather conditions (very wet or freezing temperatures) reliable slug population data could be collected only on January 12 and 26, 1999, which corresponds to 27 days after first treatment and 11 days after second treatment, respectively.

At 27 days after initial treatment application, all molluscide treatments had statistically significant fewer slugs when compared to the untreated control (Table 1). All rates of Mesurol Bait provided a comparable amount of control. A similar trend was observed on January 26, 1999, 11 days after the second application of the molluscide treatments.

Field Trial #2:
Treatments included Mesurol bait at 10.0 lb/a and Deadline Mini-pellets at 10.0 lb/a. Treatments were arranged in a randomized complete block design with four replications; each plot measured 100 x 100 ft. Treatments were applied with a hand-held dispenser on December 17, 1998. An untreated control was included for comparison.

Treatments were evaluated on December 19 and 27, 1998, and January 12, 19 and 26, 1999. Slug populations were determined using open bait stations consisting of three metaldehyde bait pellets per station, with five bait stations within each treatment in each replicate. Number of slugs visiting each bait station was recorded 24 hours after each baiting episode. Due to unfavorable weather conditions (very wet or freezing temperatures) reliable slug population data could be collected only on January 12, 1999 and January 26, 1999, which corresponds to 26 and 40 days after treatment, respectively.

At 26 days after initial treatment application, both Mesurol and Deadline Mini-pellet plots had statistically significant fewer slugs when compared to the untreated control (Table 2). At 40 days after treatment, only the Mesurol-treated plots had statistically significant fewer slugs than the untreated control.

Table 1. Effect of baits and rates on slug mortality, Field Trial #1, perennial ryegrass, Corvallis, 1999.

	January 12, 1999 (27 days after treatment)		January 26, 1999 (11 days after treatment)	
Treatment	No. of slugs	Control	No. of slugs	Control
	(per bait station)	(%)	(per bait station)	(%)
Mesurol @ 5 lb/a	10.4 a *	63.4	2.8 a *	83.7
Mesurol @ 7.5 lb/a	11.8 a	58.4	4.0 a	76.7
Mesurol @ 10 lb/a	9.1 a	68.0	3.9 a	77.3
Deadline Mini-pellets @ 10 lb/a	14.1 a	50.4	5.6 a	67.4
Untreated Control	28.4 b	---	17.2 b	---

* Means followed by the same letter within a column do not differ significantly at $P \leq 0.05$

Table 2. Effect of baits on slug mortality, Field Trial #2, perennial ryegrass, Corvallis, 1999.

Treatment	January 12, 1999 (26 days after treatment) No. of slugs	Control	January 26, 1999 (40 days after treatment) No. of slugs	Control
	(per bait station)	(%)	(per bait station)	(%)
Mesurol @ 10 lb/a	0.8 a	99.3	0.9 a	80.4
Deadline Mini-pellets @ 10 lb/a	2.3 a	80.5	2.7 ab	41.3
Untreated Control	11.8 b	---	4.6 b	---

* Means followed by the same letter within a column do not differ significantly at $P \leq 0.05$

RESPONSE OF COOL SEASON GRASSES TO FOLIAR APPLICATIONS OF PALISADE® (TRINEXAPAC-ETHYL) PLANT GROWTH REGULATOR, 1999

T.B. Silberstein, W.C. Young III, T.G. Chastain and C.J. Garbacik

Introduction

Perennial ryegrass grown for seed is prone to lodging at the high fertility rates used to maximize seed production. Lodging of the crop can result in increased problems from disease and can reduce the efficacy of pollination. Use of manufactured plant growth regulators (PGRs) to control stem elongation and optimize seed production in cool season grasses had some success in the mid 1980s. Research developed during this period was based on the use of a residual, soil applied PGR in the triazole family (paclobutrazol) that gave reliable control of lodging and was able to improve seed yields. However, due to the longevity of this chemical in the soil, and difficulties in funding registration of chemicals for use on minor crops, use of this family of chemicals is not allowed.

Recent development of new foliar applied PGR type chemicals that readily breakdown in the environment and are effective at controlling rapid stem elongation are being studied to assess their potential for use in grass seed production systems. Initial trials using Palisade (trinexapac-ethyl), a foliar applied PGR manufactured by Novartis on perennial ryegrass grown for seed production conducted on older perennial ryegrass stands in 1997 and 1998. The trials resulted in substantial yield improvement (see 1998 report). How well this compound works on new stands of perennial ryegrass as well as other cool season grasses (tall fescue and fine fescues) grown for seed in the Willamette Valley is not known. The trials summarized in this report expand the PGR research to newly established stands of perennial ryegrass, tall fescue, creeping red fescue and Chewings fescue.

Procedure

Established stands entering the first seed crop year were used for this experiment. Cutter perennial ryegrass was carbon seeded in the fall 1998 at Hyslop Crop Science Research Farm. The trials for the other species were established in grower fields: tall fescue var. Stetson at Tom Bernard's farm, McMinnville; creeping red fescue var. Silverlawn at Ioka Farms, Sublimity; and Chewings fescue var. Brittany at Joe Schumacher's farm, Sublimity. A factorial design with rate and date as main factors was used. PGR treatments were applied at walking speed using a bicycle-type 10-foot wide boom sprayer with nozzles at 18 inch spacing. The sprayer operated at 20 psi with XR TEEJET 8003VS nozzles (approx. 30 gal/a water). Treatments at all sites were applied at three rates rates of trinexepac-ethyl (200, 400, and 600 g a.i./ha) applied as a single treatment or split treatment on two dates. Treatment dates were selected to coincide with defined plant growth stages. The first date was at the onset of internode expansion with an average of 2 nodes palpable in the stem and the second date was at flag leaf emergence/early heading (see Table 1 for actual data). Plot size was 10 ft x 50 ft (10 ft X 30 ft for PR). Elongation and nodal development was assessed using a weighted average of tiller size and internode expansion from plant samples taken the day of or day prior to treatments.

Plots were sampled at early bloom for fertile tiller counts, length measurements, and above ground biomass weights. Inflorescences were also randomly sampled for yield component analysis and spike or panicle length measurements. Harvesting was done using a 6 ft wide swather for windrowing and a Hege 180 small plot combine for harvest (see Table 1 for actual data). Combined harvested seed samples were cleaned using an M2-B clipper cleaner for final cleanout; subsamples of clean seed were taken for 1000 seed weights.

Table 1. Calendar dates for PGR application, swathing, and combining, 1999.

Crop species	Application 1st	Application 2nd	Swath	Combine
Perennial ryegrass	5/5	5/19	7/15	7/27
Tall fescue	4/30	5/10	7/16	7/23
Creeping red fescue	4/29	5/10	7/23	8/2
Chewings fescue	4/29	5/10	7/13	7/19

Results

Perennial Ryegrass

Seed yield increases from the PGR treated plots averaged 30 percent above the untreated check (Table 2). A rate X time interaction with seed yield is presented in Table 3. This interaction shows an increasing yield response to the 1st application date and a decreasing yield response to the second application date. The split yield response to the application was similar to the 1st treatment date. The best results were obtained using a single application on the 1st date treatments. There was no improvement by splitting the application. The reductions in yield with the higher rates on the 2nd date indicate the optimum timing for application was past. Further evidence of yield reductions from later applications is presented in Table 4 where a third date at the 400 g a.i./ha was applied on June 1 (at about 100% head appearance). This resulted in yields not much above the untreated check. The evidence here and in the previous two years indicate the best timing for yield enhancement would be during early internode expansion and prior to flag and head emergence. This was especially important if using the higher rates, but at the lowest rate (200 g a.i./ha) yield was about equal at both timings.

Table 3. Table of significant rate X date interactions for seed yield from foliar applied Palisade in Cutter perennial ryegrass, 1999.

Rate	1st date (5/5)	2nd date (5/19)	Split (5/5 + 5/19)
(g a.i./ha)	-----------	(lb/a)	-----------
200	2742 b	2741 a	2585 b
400	2869 ab	2708 a	2810 ab
600	3032 a	2497 b	3021 a

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05.

Table 4. Response of seed yield (lb/a) to different application dates of foliar applied Palisade (400 g a.i./ha) in Cutter perennial ryegrass, 1999.

Treatment	Seed yield
Check	2142 b
Date of application	
May 5	2869 a
May 19	2708 a
June 1	2366 b
Split (5/5 + 5/19)	2810 a

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05.

Fertile tiller densities and total biomass were not affected by any treatments. Harvest index (a ratio of seed yield to total biomass) was increased by the applications of Palisade. This is to be expected as the seed yield improved with no changes in total biomass. Seed size (1000 seed weight) was not affected by any treatments. Culm length was reduced an average of 23% with progressively shorter stems as the rate increased. Lodging was effectively controlled compared to the untreated crop. A lodging score of four or higher indicated the heads and plant structures are in contact with the ground. Early season lodging was prevented at all rates of application (data not presented). Seed moisture was within 3 percent of the untreated plots at maturity. All plots were swathed at the same time. At harvest the treated plots were still off the ground, which allowed for easy windrowing. In the highest PGR treated plots, the windrows were smaller and had less crop residue to combine.

Tall fescue

Tall fescue was less responsive to PGR applications than perennial ryegrass. Using a contrast to compare the check treatment to all treated plots seed yield was increased by 21 percent (P value = 0.097) over the check (Table 5). There were no PGR treatment differences in yield. Other factors affected by PGR applications were harvest index, plant height, and lodging. Harvest index was improved by PGRs as well as higher application rates increasing the harvest index. Culm height was reduced an average of 30 percent and reflected a stepwise response to increasing rates of Palisade. Lodging was effectively controlled with almost no (or little) lodging occurring at all treatment rates. Continued research will be needed to determine if tall fescue will be consistantly responsive to Palisade.

Creeping red fescue

Seed yield in the Silverlawn creeping red fescue showed good yield responses to applications of Palisade. Seed yield averaged a 31 percent increase over the check as shown in Table 6. There was also some response to the higher rates of Palisade. The 400 g a.i./ha rate and 600 g a.i./ha rate being about the same, but yielding more than the 200 g a.i./ha rate. Timing of the applications at the growth stages observed had equal effect. Even later applications at heading (May 19) as in Table 7 yielded the same as the earlier treatments. Splitting the application was no different than a single application. Above ground biomass was reduced by the increased rates of Palisade. Fertile tiller densities were not affected by treatments. Seed size (1000 seed weight) was improved in a contrast analysis with the untreated check, but this does not account for the levels of yield increases. Harvest index was improved as is reflected by the increased seed yield. Plant height was reduced an average of 26 percent with the highest treatment rate (600 g a.i./ha) reducing plant height by 39 percent. Lodging was well controlled with all treatments keeping the crop from laying flat on the ground as fine fescue is prone to do. The 2nd date and split applications gave the best lodging control as well as increased rates of application. The results from this year indicate that creeping red fescues may be a good crop species to use Palisade on.

Table 7. Response of seed yield (lb/a) to different application dates of foliar applied Palisade (400 g a.i./ha) in Silverlawn creeping red fescue, 1999.

Treatment	Seed yield
Check	1295 b
Date of application	
April 29	1794 a
May 10	1808 a
May 19	1804 a
Split (April 29, May 10)	1710 a

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05.

Chewings fescue

The seed yield results for this Chewings type fescue were even more dramatic than the creeping red fescue. Treated yield averaged 43 percent greater than the untreated check, about 670 lb/a yield improvement as shown in Table 8. In this trial there was no statistical effect by the rate or timing of the PGR application indicating this crop may respond to lower rates of Palisade than were used. Fertile tiller density was not affected by Palisade applications at this site. 1000 seed weight and harvest index showed trends (P value <0.10) to increase using a contrast comparison between the treated and the check plots. Lodging was well controlled by this compound and even at harvest the crop was easy to swath in the treated plots. The 2nd date of application gave the best lodging control with the highest rate (600 g a.i./ha) most effective.

Summary

All four species treated this year were responsive to Palisade applications. The perennial ryegrass and Chewings fescue species were the most responsive in seed yield. Creeping red fescue was a little less responsive and tall fescue the least affected. This compound is effective at controlling lodging and increasing yield. The cause of the yield increase has not been fully accounted for, but from other data collected this season (not presented here), improved seed set, reduced lodging and improvements in yield components are all adding to the increased yield.

The most important part of using this compound will be knowing the optimum stage of development to apply Palisade for maximize effect. The timing appears to have different windows in the different crop species, some are more sensitive to timing than others. Perennial ryegrass does not respond as well to later applications as the fine fescues do. The best timing and rate for tall fescue is yet to be identified. Fine fescues were responsive merely to the application (though the creeper seemed to increase a little with higher applications) so a lower rate may be quite effective. Each year is unique, but the responses observed in perennial ryegrass yield and lodging control were very similar to those reported in the previous two years on older stands. In these four trials, every PGR treatment yielded higher than the untreated check. This product looks to be a useful and effective tool in helping improve and realize the yield potential of these grass seed crops.

Acknowledgments: This research was supported in part through funds from Novartis Crop Protection, Inc.

Table 2. Main factor effects of foliar applied Palisade (trinexapac-ethyl) on seed yield, harvest components, and tiller length in Cutter perennial ryegrass, 1999.

Main factor treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Culm reduction	Lodging score
	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	------- (%) -------		(1-5)[1]
Check vs Treated								
Check	2142 b*	100	5.3	301	1.98	20 b	0 a	5.0 b
Treated (all)	2778 a	130	5.2	291	2.00	27 a	23 b	3.3 a
Rate of application (g a.i./ha)								
200[3]	2690 [2]	126	5.5	300	2.01	25 b	14 a	4.0 b
400	2796	131	5.1	286	1.99	28 ab	23 b	3.2 ab
600	2850	133	5.0	286	2.00	29 a	31 c	2.8 a
Date of application								
1st date	2881 [2]	135	5.0	281	1.99	30 a	20	3.2 ab
2nd date	2645	124	5.3	288	2.02	25 b	24	3.8 b
Split	2805	131	5.3	304	1.98	27 ab	24	2.9 a

*Within each main factor, means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05. No letters = no significant differences
[1] Lodging score at harvest 1-5: 1 = vertical; 5 = horizontal
[2] Significant rate X date interaction
[3] The pint/acre rate for the 1 lb a.i./gal EC formulation is 1.4 pt/a (200 g a.i./ha), 2.9 pt/a (400 g a.i./ha), and 4.3 pt/a (600 g a.i./ha)

Table 5. Main factor effects of foliar applied Palisade (trinexapac-ethyl) on seed yield, harvest components, and tiller length in Stetson tall fescue, 1999.

Main factor treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Culm reduction	Lodging score
	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	------- (%) -------		(1-5)[1]
Check vs Treated								
Check	1467 [2]	100	7.4	85	2.30	10 b*	0 b	3.8 b
Treated (all)	1770	121	6.5	85	2.29	14 a	30 a	1.7 a
Rate of application (g a.i./ha)								
200	1757	120	7.2	84	2.28	12 b	13 c	2.3 b
400	1672	114	6.1	84	2.32	14 a	33 b	1.6 a
600	1881	128	6.2	89	2.27	15 a	45 a	1.3 a
Date of application								
1st date	1776	121	6.3	83	2.27	14	33	1.8
2nd date	1808	123	6.6	89	2.29	14	32	1.6
Split	1726	118	6.5	83	2.31	13	26	1.9

*Within each main factor, means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05. No letters = no significant differences
[1] Lodging score at harvest 1-5: 1 = vertical; 5 = horizontal
[2] P-value between 0.05 and 0.10

Table 6. Main factor effects of foliar applied Palisade (trinexapac-ethyl) on seed yield, harvest components, and tiller length in Silverlawn creeping red fescue, 1999.

Main factor Treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Culm reduction	Lodging score
	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	------- (%) -------		(1-5)[1]
Check vs Treated								
Check	1295 b*	100 3.7		258	1.09 b	17 b	0 b	4.1 b
Treated (all)	1690 a	131 3.8		275	1.14 a	23 a	26 a	2.9 a
Rate of application (g ai/ha)								
200	1504 b	116 4.1	a	285	1.13	19 b	13 c	3.5 c
400	1771 a	137 3.7	b	279	1.14	24 a	26 b	3.0 b
600	1796 a	139 3.5	b	263	1.16	26 a	39 a	2.2 a
Date of application								
1st date	1712	132 3.7		253	1.15	24	27	3.2 b
2nd date	1712	132 3.8		277	1.13	23	27	2.7 a
Split	1647	127 3.8		226	1.14	22	25	2.8 a

*Within each main factor, means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05. No letters = no significant differences

[1] Lodging score at harvest 1-5: 1 = vertical; 5 = horizontal

Table 8. Main factor effects of foliar applied Palisade (trinexapac-ethyl) on seed yield, harvest components, and tiller length in Britanny Chewings fescue, 1999.

Main factor Treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Lodging score
	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	(%)	(1-5)[1]
Check vs Treated							
Check	1555 b*	100	5.1	188	1.00 [2]	13 [2]	4.2 b
Treated (all)	2227 a	143	5.3	208	1.04	18	2.7 a
Rate of application (g ai/ha)							
200	2119	136	5.8 [2]	218	1.03	16	3.5 b
400	2212	142	5.7	207	1.05	17	2.4 a
600	2351	151	4.5	197	1.05	21	2.1 a
Date of application							
1st date	2254	145	5.3	206	1.04	19	2.7 ab
2nd date	2326	150	5.4	211	1.05	19	2.4 a
Split	2102	135	5.4	205	1.03	17	2.9 b

*Within each main factor, means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05. No letters = no significant differences

[1] Lodging score at harvest 1-5: 1 = vertical; 5 = horizontal

[2] P-value between 0.05 and 0.10

RESPONSE OF COOL SEASON GRASSES TO FOLIAR APPLICATIONS OF APOGEE® (PROHEXADIONE-CALCIUM) PLANT GROWTH REGULATOR, 1999

T.B. Silberstein, W.C. Young III, T.G. Chastain and C.J. Garbacik

Introduction

Perennial ryegrass grown for seed is prone to lodging at the high fertility rates used to maximize seed production. Lodging of the crop can result in increased problems from disease and can reduce the efficacy of pollination. Use of manufactured plant growth regulators (PGRs) to control stem elongation and optimize seed production in cool season grasses had some success in the mid 1980s. Research developed during this period was based on the use of a residual, soil applied PGR in the triazole family (paclobutrazol) that gave reliable control of lodging and was able to improve seed yields. However, due to the longevity of this chemical in the soil, and difficulties in funding registration of chemicals for use on minor crops, use of this family of chemicals is not allowed.

Recent development of new foliar applied PGR type chemicals that readily breakdown in the environment and are effective at controlling rapid stem elongation are being studied to assess their potential for use in grass seed production systems. This experiment was conducted to examine the effect of Apogee (prohexadione-calcium), a foliar applied PGR manufactured by BASF Corporation.

Procedure

Established stands entering the first seed crop year were used for this experiment. Cutter perennial ryegrass was carbon seeded in the fall 1998 at Hyslop Crop Science Research Farm. The trials for the other species were established in grower fields: tall fescue var. Stetson at Tom Bernard's farm, McMinnville; creeping red fescue var. Silverlawn at Ioka Farms, Sublimity; and Chewings fescue var. Brittany at Joe Schumacher's farm, Sublimity. A factorial design with rate and date as main factors was used. PGR treatments were applied at walking speed using a bicycle-type 10-foot wide boom sprayer with nozzles at 18 inch spacing. The sprayer operated at 20 psi with XR TEEJET 8003VS nozzles (approx. 30 gal/a water). Treatments at all sites were applied at three rates rates of prohexadione-calcium (1/4, 3/8, 1/2 lb a.i./a) applied as a single treatment or split treatment on two dates. In addition, a third date was used at the low rate in the perennial ryegrass and creeping red fescue sites. Treatment dates were selected to coincide with defined plant growth stages. The first date was at the onset of internode expansion with an average of 2 nodes palpable in the stem, and the second date was at flag leaf emergence/early heading (see Table 1 for actual dates). Plot size was 10 ft x 50 ft (10 ft x 30 ft for PR). Elongation and nodal development was assessed using a weighted average of tiller size and internode expansion from plant samples taken the day of or day prior to treatments.

Plots were sampled at early bloom for fertile tiller counts, culm length measurements, and above ground biomass weights. Harvesting was done using a 6 ft wide swather for windrowing and a Hege 180 small plot combine for harvest (see Table 1 for actual dates). Combined harvested seed samples were cleaned using an M2-B clipper cleaner for final cleanout; subsamples of clean seed were taken for 1000 seed weights.

Table 1. Calendar dates for PGR application, swathing, and combining, 1999.

Crop species	Application 1st	Application 2nd	Swath	Combine
Perennial ryegrass	5/5	5/19	7/15	7/27
Tall fescue	4/30	5/10	7/16	7/23
Creeping red fescue	4/29	5/10	7/23	8/2
Chewings fescue	4/29	5/10	7/13	7/19

Results

Perennial Ryegrass

Apogee applications to perennial ryegrass increased seed yield over the untreated check by an average of 690 lb/a (32 percent) as shown in Table 2. Split applications resulted in the highest yield responses with a 791 lb/a increase over the check. Seed size (1000 seed weight) was also improved by the 2nd date and split application, indicating that the later applications (May 19) may be responsible for increasing seed size. The rate of applied Apogee was less important than the timing. Making an application at any of the rates resulted in substantial seed yield increases. However, applications at full heading (June1) were too late in the season and caused yield to decrease over the earlier treatments (Table 3). Fertile tiller density and above ground biomass were the same across all treatments. Crop lodging was controlled best by the higher rates and by split applications of Apogee. Culm length was reduced an average of 22 percent with the greatest reduction (26 percent) from the split treatment. Improved seed yield without increased biomass resulted in an increase in the harvest index, a good measure of increased plant efficiency.

Table 3. Response of seed yield (lb/a) to different application dates of foliar applied Apogee (1/4 lb a.i./a) in Cutter perennial ryegrass, 1999.

Treatment	Seed yield
Check	2142 b*
Date of application	
May 5	2719 a
May 19	2747 a
June 1	2263 b
Split (May 5, May 19)	2911 a

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05.

Tall fescue

Tall fescue was less responsive to applications of Apogee than the perennial ryegrass. Seed yield (Table 4) was shown to be improved using a contrast analysis of check vs all treatments (significance P-value = 0.10). This resulted in an average seed yield increase of about 200 lb/a. Fertile tiller density was not affected by the PGR applications, nor was above ground biomass and seed size (1000 seed weight). Harvest index increase by 4 percent and was the result of somewhat higher biomass and lower seed yield in the untreated check. Culm height reduction was greatest from the early application and the split application (probably because of the 1st date treatment). The average reduction in height was 31 percent and the effect on lodging is shown in Table 4. Very little lodging occurred in any of the treatments except the untreated check. The higher application rates and 1st application dates gave the best lodging control.

Creeping red fescue

The Silverlawn creeping red fescue site was similar in seed yield response to the tall fescue previously discussed. Yield comparisons (Table 5) using a contrast of check vs treated plots was significant at a 0.10 level with an average seed yield increase of 266 lb/a. However, in the trial with a third treatement date, yields were significantly increased (Table 6) at the 1/4 lb a.i./a rate. The May 19 treatment yielded an average of 491 lb/a of seed over the check. The first date and split application also show an increase in seed yield. Above ground biomass and harvest index responded differently to the timing and rates of Apogee applications. This interaction data is shown in Table 7. Above ground biomass decreased as the application rate increases on the first treatment date and split application, but the biomass increase with increasing Apogee rates on the second application date. The converse was true for the harvest index as it is inversely linked to biomass.

Table 6. Response of seed yield to different application dates of foliar applied Apogee (1/4 lb a.i./a) in Silverlawn creeping red fescue, 1999.

Treatment	Seed yield (lb/a)
Check	1295 c
Date of application	
April 29	1595 ba
May 10	1442 bc
May 19	1786 a
Split (April 29, May 10)	1576 ba

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05.

Table 7. Table of significant rate X date interactions from foliar applied Apogee in Silverlawn creeping red fescue, 1999.

Rate	1st date (4/29)	2nd date (5/10)	Split (5/5 + 5/15)
(lb a.i./a)	------ Above ground biomass (tn/a)---------		
1/4	3.6 a*	3.6 b	3.8 a
3/8	3.5 a	3.4 b	3.9 a
1/2	2.8 b	4.3 a	2.9 b
	------------- Harvest index (%) --------------		
1/4	22 b	20 ab	21 b
3/8	21 b	23 a	21 b
1/2	31 a	16 b	30 a

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05.

Chewings fescue

Seed yield in Brittany Chewings fescue was greatly improved by the applications of Apogee PGR. The seed yield increase averaged 561 lb/a as seen in the check vs treated data in Table 8. This site was responsive to both the increased rates and the split applications of Apogee as shown in the table. Above ground biomass was not affected by the PGR applications and the increase in seed yield subsequently increased the harvest index. Fertile tiller densities remained constant. Seed size (1000 seed weight) was somewhat diminished by split application but was rather small in the effect. Crop lodging was decreased the most by the higher rates and the first application dates.

Summary

The perennial ryegrass and Chewing fescue sites were the most responsive to Apogee applications. The tall fescue and creeping red fescue sites were similar in response and much less pronounced than the perennial ryegrass or Chewing fescue. This compound appears to work best in a split application. Waiting until full heading in perennial ryegrass decreased the yield over the earlier treatments, however, in the creeping red fescue yield increased with the later treatment. This indicates that each species may be different in how it responds to Apogee. The date of application was more important than the rate of application on the perennial ryegrass, tall fescue and creeping red fescue site. At the Chewing fescue site, both the date and the rate of application affected the seed yield. However, at all sites the split treatment generally performed better than the single application. It should be noted also that no treatment by the PGR was less than the untreated check. The overall cause of the yield increase appears to be from several factors: less lodging, better seed set, and improved canopy architecture. This compound performs well, and with more research the best treatment timing and rates will be established to improve the potential and actual yields in these crops. This product is not yet registered for use on these crops.

Acknowledgments: This research was supported in part through funds from BASF Corporation.

Table 2. Main factor effects of foliar applied Apogee (prohexadione-calcium) on seed yield, harvest components, and tiller length in Cutter perennial ryegrass, 1999.

Main factor treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Culm reduction	Lodging score
	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	------- (%)	-------	(1-5)[1]
<u>Check vs Treated</u>								
Check	2142 b*	100	5.3	301	1.98	20 b	0 b	5.0 b
Treated (all)	2832 a	132	5.7	304	1.97	25 a	22 a	3.2 a
<u>Rate of application</u> (lb ai/a)								
1/4	2792	130	5.6	300	1.97	26	21	3.8 b
3/8	2901	135	6.0	312	1.96	25	20	3.0 a
1/2	2803	131	5.7	301	1.97	25	24	2.8 a
<u>Date of application</u>								
1st date	2770 b	129	5.8	311	1.93 b	24 [2]	18 b	3.7 b
2nd date	2793 b	130	5.9	300	1.98 a	24	21 ab	3.8 b
Split	2933 a	137	5.5	301	1.99 a	28	26 a	2.1 a

*Within each main factor, means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05. No letters = no significant differences

[1] Lodging score at harvest 1-5: 1 = vertical; 5 = horizontal

[2] P-value between 0.05 and 0.10

Table 4. Main factor effects of foliar applied Apogee (prohexadione-calcium) on seed yield, harvest components, and tiller length in Stetson tall fescue, 1999.

Main factor treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Culm reduction	Lodging score
	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	------- (%) -------		(1-5)[1]
Check vs Treated								
Check	1467 [2]	100	7.4	85	2.30	10 b*	0 b	3.8 b
Treated (all)	1756	120	6.4	84	2.30	14 a	31 a	1.7 a
Rate of application (lb ai/a)								
1/4	1737	118	6.4	83	2.31	14	27 [2]	2.1 b
3/8	1783	122	6.6	89	2.30	14	33	1.5 a
1/2	1747	119	6.3	79	2.31	14	32	1.5 a
Date of application								
1st date	1860	127	6.8	91	2.27	14	37 a	1.3 a
2nd date	1639	112	6.4	81	2.34	13	20 b	2.2 b
Split	1769	121	6.0	79	2.30	15	35 a	1.5 a

*Within each main factor, means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05. No letters = no significant differences

[1] Lodging score at harvest 1-5: 1 = vertical; 5 = horizontal

[2] P-value between 0.05 and 0.10

Table 5. Main factor effects of foliar applied Apogee (prohexadione-calcium) on seed yield, harvest components, and tiller length in Silverlawn creeping red fescue, 1999.

Main factor treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Culm reduction	Lodging score
	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	------- (%) -------		(1-5)[1]
Check vs Treated								
Check	1295 [2]	100	3.7	258	1.09	17 b*	0 b	4.1
Treated (all)	1561	121	3.5	267	1.11	23 a	19 a	3.6
Rate of application (lb ai/a)								
1/4	1538	119	3.7 [3]	263	1.10	21 [3]	15 b	3.8
3/8	1562	121	3.6	269	1.10	22	19 ab	3.6
1/2	1582	122	3.3	270	1.12	26	23 a	3.3
Date of application								
1st date	1591	123	3.3 [3]	250	1.12	25 [3]	19	3.6
2nd date	1455	112	3.8	271	1.10	20	17	3.8
Split	1636	126	3.5	281	1.10	24	21	3.4

*Within each main factor, means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05. No letters = no significant differences

[1] Lodging score at harvest 1-5: 1 = vertical; 5 = horizontal

[2] P-value between 0.05 and 0.10

[3] Significant rate X date interaction

Table 8. Main factor effects of foliar applied Apogee (prohexadione-calcium) on seed yield, harvest components, and tiller length in Brittany Chewings fescue, 1999.

Main factor treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Lodging score
	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	(%)	(1-5)[1]
Check vs Treated							
Check	1555 b*	100	5.1	188	1.00	14	4.2 [2]
Treated (all)	2116 a	136	6.1	219	1.02	15	3.7
Rate of application (lb a.i./a)							
1/4	1933 b	124	6.4	221	1.01	13 b	4.0 b
3/8	2167 a	139	6.2	225	1.03	16 ab	3.7 ab
1/2	2248 a	145	5.6	211	1.01	17 a	3.4 a
Date of application							
1st date	2061 b	133	6.5	226	1.03 a	14 [2]	3.4 [2]
2nd date	2057 b	132	6.3	219	1.02 ab	15	3.9
Split	2230 a	143	5.4	212	1.00 b	17	3.8

*Within each main factor, means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05. No letters = no significant differences

[1] Lodging score at harvest 1-5: 1 = vertical; 5 = horizontal

[2] P-value between 0.05 and 0.10

RESPONSE OF TALL FESCUE AND PERENNIAL RYEGRASS TO PROHEXADIONE-CALCIUM (APOGEE®) PLANT GROWTH REGULATOR

B.D. Hanson, B.D. Brewster, P.E. Hendrickson and C.A. Mallory-Smith

Two experiments were performed in established stands of tall fescue and perennial ryegrass near Tangent, OR to determine the effects of prohexadione-calcium (Apogee), a plant growth regulator, on the growth and yield of the grass seed crop. Single (Experiment 1) and split application (Experiment 2) treatments of prohexadione were included in these experiments along with a standard treatment of trinexapac (Palisade) and an untreated control.

Plots were 8 by 25 ft arranged in a randomized complete block design with four replications. Growth regulator treatments were applied with a single-wheel, compressed-air, plot sprayer calibrated to deliver 20 gpa at 19 psi and 3 mph (Table 1). R-11, a nonionic surfactant, was added to all treatments at 0.5% v/v. A 5 by 21 ft area was swathed in each plot in early July, allowed to dry for 1 to 2 weeks, and harvested with a small plot combine.

Tall fescue did not lodge in either experiment in treated or untreated plots. Tall fescue height reduction ranged from 17 to 38% with all single application treatments, however, seed yield was variable and not statistically different among treatments (Table 2). Lodging of perennial ryegrass was reduced 25 to 57% with all treatments; height was reduced in all treated plots but there were no differences among treatments. Perennial ryegrass seed yield increased when treated with prohexadione at 0.125 lb a.i./a at the 2 node, 0.5 lb a.i./a at 3 node, and 0.25 lb a.i./a at early heading; while trinexapac increased yield at the 2 node timing.

Split applications of prohexadione reduced tall fescue height 22 to 40% (Table 3); height reductions were similar at all timings, although higher rates tended to have the greatest reductions. Tall fescue seed yield was not significantly increased by prohexadione rate or timing. Lodging of perennial ryegrass was less than the control in all treatments; the lowest lodging occurred with higher rates and later timings of prohexadione. Although perennial ryegrass height was reduced by all treatments, the greatest reductions occurred when an application at early heading was included in the treatment. Perennial ryegrass seed yield increased by up to 731 lb/a when treated with prohexadione.

Table 1. Application data.

	Experiment 1		Experiment 2	
	Tall fescue	P. ryegrass	Tall fescue	P. ryegrass
2 node application	April 29, 1999	May 5, 1999	May 5, 1999	April 23, 1999
Air temp (F)	45	54	45	55
Relative humidity (%)	71	69	77	69
Cloud cover (%)	0	10	10	0
3 node application	May 5, 1999	May 16, 1999	May 16, 1999	May 5, 1999
Air temp (F)	52	61	59	54
Relative humidity (%)	67	89	89	55
Cloud cover (%)	10	100	100	10
Early heading application	May 10, 1999	May 24, 1999	May 19, 1999	May 21, 1999
Air temp (F)	56	54	57	50
Relative humidity (%)	73	76	68	73
Cloud cover (%)	100	0	20	10

Table 2. Effects of prohexadione rate and timing on tall fescue and perennial ryegrass (Experiment 1).

		Tall fescue		Perennial ryegrass		
Treatment	Rate	Height	Seed yield	Lodging	Height	Seed yield
	(lb a.i./a)	(in.)	(lb/a)	(%)	(in.)	(lb/a)
Untreated	--	52	2035	63	39	1724
2 node						
Prohexadione	0.125	43	2480	38	32	2278
Prohexadione	0.25	41	2697	38	30	2106
Prohexadione	0.38	38	2529	15	29	2110
Prohexadione	0.5	36	2633	9	30	2155
Trinexapac	0.25	38	2591	19	30	2199
3 node						
Prohexadione	0.125	42	2705	50	32	1649
Prohexadione	0.25	38	2658	21	32	1823
Prohexadione	0.38	34	2668	33	33	2157
Prohexadione	0.5	32	2524	25	30	2266
Trinexapac	0.25	35	2780	30	32	1990
Early heading						
Prohexadione	0.125	42	2704	16	31	1897
Prohexadione	0.25	40	2843	13	31	2233
Prohexadione	0.38	34	2660	6	31	2136
Prohexadione	0.5	34	2668	8	32	1714
Trinexapac	0.25	39	2583	10	32	1787
LSD (0.05)		4	ns	11	2	433

Table 3. Effects of prohexadione split-applications on tall fescue and perennial ryegrass (Experiment 2).

Treatment	Rate	Tall fescue		Perennial ryegrass		
		Height	Seed yield	Lodging	Height	Seed yield
	(lb a.i./a)	(in.)	(lb/a)	(%)	(in.)	(lb/a)
Untreated	--	50	825	68	36	1318
2 node / 3 node						
Prohexadione	0.125 / 0.125	39	921	14	28	1743
Prohexadione	0.18 / 0.18	34	735	18	28	1782
Prohexadione	0.25 / 0.25	30	748	0	27	1829
Trinexapac	0.125 / 0.125	36	858	16	29	1733
3 node / E. head						
Prohexadione	0.125 / 0.125	35	651	4	26	2017
Prohexadione	0.18 / 0.18	36	791	0	22	1818
Prohexadione	0.25 / 0.25	37	898	0	22	2049
Trinexapac	0.125 / 0.125	38	771	19	27	1732
2 node / 3 node / E. head						
Prohexadione	0.08 / 0.08 / 0.08	33	798	6	26	1998
Prohexadione	0.125 / 0.125 / 0.125	30	838	0	24	1967
LSD (0.05)		5	ns	9	2	299

THE EFFECT OF PLANT GROWTH REGULATOR APPLICATIONS ON YIELDS OF GRASS SEED CROPS

G.A. Gingrich and M.E. Mellbye

Introduction. The application of synthetic plant growth regulators (PGRs) has been a commercial production practice used by growers on various field crops for many years. They are most widely used on cereal grain crops to reduce lodging and increase grain yields. In the early 1980s research on grass seed crops in western Oregon with a group of soil active PGRs in the triazole family (paclobutrazol) resulted in the registration of Parlay for commercial use on grass seed fields. However, due to the chemical's soil residual characteristics, certain crops that were planted following the treated grass fields were adversely affected by the carryover of Parlay. By the late 1980s this registration was cancelled and the commercial use of any PGR in grass seed production was essentially discontinued.

In 1997 OSU seed researchers Dr. William C. Young III and Tom Silberstein conducted experiments using a new group of foliar active PGRs. These products quickly break down after application and do not have the soil residual characteristics as the previously registered products. Their application to stands of perennial ryegrass effectively controlled rapid stem elongation, reduced plant height and reduced crop lodging. They also gave significantly greater seed yields. Additional information collected from these trials included fertile tiller numbers and above ground biomass production (Silbertein and Young, 1998; Silberstein et al. 1998). This early work was conducted at the OSU Hyslop Field Station on small, replicated plots.

In the spring of 1999 Novartis Crop Protection Inc., the manufacturer of trinexapac-ethyl (Palisade), applied for a registration to use Palisade 1EC on perennial ryegrass seed fields in western Oregon. In anticipation of getting a label Novartis asked that several larger, on-farm yield trials be established. In addition BASF Corp. had a similar PGR, Apogee 27.5 DF, they were attempting to have labeled and wanted it included in this study. Palisade was granted a registration for use on up to 15,000 acres of perennial ryegrass in 1999. Apogee has not yet received a registration for use on grass seed crops.

Methods. Trials were established on six commercial grass seed fields in the Willamette Valley. They included one tall fescue, two perennial ryegrass and three fields of fine fescue. Plots were set up to accommodate grower equipment for swathing and seed harvest. A weigh wagon was used to determine harvested seed yields. A sub-sample of the harvested seed was collected to determine percent clean out and calculate clean seed yield. Each treatment was replicated three times and individual plot size ranged from 20 ft. wide by 200 to 400 ft. long depending on the particular field configuration. The PGRs were applied using an ATV mounted, boom sprayer. The sprayer was equipped with TeeJet 11002 VS nozzles and operated at 30 psi applying a spray volume of 14 gpa. The surfactant Preference @ 0.25% by volume was added to all Apogee treatments. No surfactant was used with Palisade. There were two application dates at each location. The first was Apogee at 1.38 lb/a and at 0.69 lb/a (the first of a two application split treatment). Approximately 10 days to two weeks later the Palisade, the second part of the split Apogee treatment and the other 1.38 lb/a Apogee treatments were made. Specific application dates and plant growth stages at treatment are listed along with the seed yield data in Tables 1 & 2. Palisade was applied at 1.5, 2.5 and 4 pts/a. At the Shademark red fescue location there was no late Apogee or high rate Palisade applications. The Cutter perennial ryegrass was the only field that received supplemental irrigation during the growing season. It also had the highest overall seed yield of the two perennial ryegrasses sites.

Results. At least one of the treatments of a PGR significantly increased seed yields when compared to the untreated check plots on all sites except tall fescue (Tables 1 & 2). At no location did the high rate of Palisade significantly increase seed yields over the best yield of the two lower rate Palisade treatments. Although there was no significant yield difference between any of the treatments on the tall fescue site the high rate Palisade plot produced less seed than any other treatment, including the untreated check. When comparing the best Palisade treatment with the highest yielding Apogee at each location a common trend is observed. On each of the perennial ryegrass and tall fescue trials the best treatment was an application of Apogee. However on each of the fine fescue sites it was a Palisade treatment that produced the highest seed yield. At all locations except the Cutter perennial ryegrass there was no yield advantage to Palisade rates greater than 1.5 pt/a. On the Cutter, where irrigation was applied, the 2.5 pt/a rate of Palisade yielded significantly more seed than the 1.5 pt/a rate.

In addition to seed yield differences between treatments the amount of clean out was determined for seed harvested from each plot. There was no significant difference between treatments relative to the percent clean out. The average clean out for each treatment, across the three locations, is shown in the last column of Tables 1 & 2.

The results from these large, on-farm trials on perennial ryegrass support the results observed earlier on the small plots. Applications of PGRs can significantly increase seed yields of perennial ryegrass. PGR applications on fine fescue also increased seed production. In these trials tall fescue did not respond positively to PGR applications. Additional work should be done on both species of fescue.

Acknowledgement: Appreciation is expressed to Novartis Crop Protection, Inc. and BASF Corp. for their financial support of this project. Appreciation is also extended to the growers who allowed these trials to be conducted on their farms.

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Table 1. Effect of PGR applications on seed yield and percent clean-out in perennial ryegrass and tall fescue, 1999.

Treatment	Rate	Clean seed yield			Clean-out
		Charger II perennial ryegrass	Cutter perennial ryegrass	Veranda tall fescue	
	(Product/acre)	(lb/a)			(%)
Check	0	1744	1827	1255	10.2
Palisade	1.5 pt.	2059	2054	1387	10.7
Palisade	2.5 pt.	2050	2309	1237	10.9
Palisade	4.0 pt.	2078	2273	1163	10.7
Apogee	1.38 lb. (early)	2152	2335	1405	8.9
Apogee	0.69 lb. (2x,split)	2173	2391	1354	8.9
Apogee	1.38 lb. (late)	2134	2179	1341	9.6
LSD (0.05)		166	200	NS	

Application dates and stage of growth at treatment.

Apogee early and 1st of split treatments

April 28 (early jointing to 1-2 nodes on main tillers)

Palisade and Apogee late and 2nd of split treatments

May 5 – tall fescue (boot stage with flag leaves emerged, few heads out)

May 10 – perennial ryegrass (boot stage with flag leaves emerged, few heads out)

Table 2. Effect of PGR applications on seed yield and percent clean-out in Chewings and creeping red fescue, 1999.

Treatment	Rate	Clean seed yield			Clean-out
		Brittany chewings	Cindy creeping red	Shademark creeping red	
	(Product/acre)	(lb/a)			(%)
Check	0	1827	1324	1474	11.1
Palisade	1.5 pt.	2083	1490	1776	12.6
Palisade	2.5 pt.	2104	1399	1795	11.4
Palisade	4.0 pt.	2050	1495	----	11.9
Apogee	1.38 lb. (early)	2059	1381	1620	12.5
Apogee	0.69 lb. (2x,split)	2037	1371	1568	12.1
Apogee	1.38 lb. (late)	1974	1434	----	11.3
LSD (0.05)		100	74	157	

Application dates and stage of growth at treatment.

Apogee early and 1st of slit treatments

April 23 (boot stage, very early heading)

Palisade and Apogee late and 2nd of split treatments

April 29 – Brittany & Cindy (15-25% of tillers with heads emerged)

May 10 – Shademark (15 – 25% of tillers with heads emerged)

CONSERVATION PRACTICES THAT HELP REDUCE RUNOFF

J.J. Steiner, S.M. Griffith and M.E. Mellbye

By volume, sediment from soil erosion is the nation's largest single water pollutant. Stream sediment arises from numerous sources. On farms growers use a variety of methods to combat this problem. Practices such as conservation tillage, no-till planting, contour farming, and terracing are now common in many parts of the country.

Grass seed crops can play an important and increasing role in preventing the pollution of surface waters, particularly with regard to sediments. With its fibrous root system and ability to cover the soil, grass is especially effective at providing a buffer between cropland and water bodies, and Oregon grass seed is commonly used in filter strips, riparian buffers, and grass waterways worldwide for these reasons.

Currently, annual ryegrass seed from Linn County is being tested as a winter cover crop for no-till corn and soybeans in Illinois and surrounding states in the Midwest. Use of annual ryegrass in this fashion could make a major contribution to agriculture and water quality in the upper Mississippi watershed, and represent a significant new market outlet for Oregon seed. In California, the reintroduction of native perennial grasses to replace the introduced annual grasses offers many advantages over the invasive annual grasses.

What about grass seed fields here in the Willamette Valley? Research indicates that sediment, nutrient, and chemical runoff from established grass seed fields is not a significant problem during years following establishment (Griffith et al., 1997; Gohlke et al., 1999). Little runoff occurs. On the other hand, erosion and nitrate leaching from first-year established and fallow fields in the winter could be significant and result in elevated nutrient and sediment loss to ground and surface waters. This is being researched.

Soil erosion and herbicide runoff do occur to a measurable degree from sprayed drainage ways, roadsides, and "clean" field borders in areas prone to runoff. How significant this sort of erosion is from a biological viewpoint is a subject of much debate.

It is interesting to note that Oregon, compared to the rest of the U.S. is far behind in adopting conservation tillage practices. From 1989 to 1998, the increase in conservation acreage across the U.S. was +11.6%, compared to Oregon of only +1.3%, California +13.3%, and Washington, +6.2% (Tables 1 and 2) (Conservation Technology Information Center, http://www.ctic.purdue.edu/CTIC/CTIC.html). On an Oregon county basis, data show Benton County at –9.3%, Lane County –0.8%, Linn County –10.5% (compare Tables 1 and 2), Marion County 12.7%, Polk County 5.0%, and Yamhill County 2.8%. What is fortunate is that the Oregon counties showing a decline in conservation tillage acreage are those with a large number of acres in grass seed production. This results in fewer soil disturbance (e.g., plowing) years when considering the lifetime of an entire perennial grass seed crop rotation. It must be kept in mind that grass seed production systems are themselves high conservation systems compared to most conventional annual cropped systems.

What does the science say? The concentration of herbicides, the most commonly detected pesticides in the Willamette River, is at low levels. Still, practical efforts to reduce erosion and pesticide runoff make sense as part of a larger state effort to improve water quality in the Willamette River Basin. Here are some recommendations for south Willamette Valley grass seed producers:

- Use Science-based production practices. Employ good agronomic science and sound farming methods when choosing the amount and time to apply fertilizers and pesticides. For example, delay nitrogen fertilizer applications until later in the season when spring run-off does not occur. Being careful not to spray or apply fertilizer over waterways can greatly reduce the amounts of agricultural chemicals that escape the field.
- Maintain existing riparian vegetation. Current USDA-ARS research in Linn County has shown that very little fertilizer is lost from established seed fields under good management. Riparian buffers can soak up even more excess nitrogen, may lessen stream bank erosion, and capture sediment. Riparian zones along waterways can also help shield streams during fertilizer and pesticide applications.
- Don't till seasonal streambeds. Leave areas in fields that are too wet for production undisturbed. These unproductive areas can filter surface runoff from the surrounding field. Also, when seasonal streambeds are not tilled, sediment losses are greatly reduced in the crop establishment year and the standing vegetation can help filter water.
- Plant filter strips. Consider planting grass filter strips or forest riparian buffers along sensitive waterways. Cost sharing is available to implement these practices through Federal conservation assistance programs such as CRP and CREP on eligible streams.
- Chop the full straw load. It is well established that leaving crop residue on the soil surface after seed harvest reduces soil erosion and runoff, recycles nutrients such as potassium, sequesters soil carbon, and generally improves soil quality. Consider adopting this practice on perennial seed fields, near streams, or along the natural drainage areas of fields. This practice also appears to suppress the weed *Poa annua* and can lead to reduced herbicide use.
- Replace some clean borders. For decades, the OSU Extension Service has recommended clean borders as part of certified seed production. However, vegetation is a better conservation choice. Consider replacing clean borders with

grass in areas prone to erosion. However, keep in mind the certification needs (such as varietal and mechanical isolation) for you and your neighbors' farms. Check for specifics with Oregon Seed Certification.

For more information about this project and others, check out Jeff Steiner's web page at: http://pwa.ars.usda.gov/nfsprc/Steiner/Steinersustain.htm/ or the USDA-ARS National Forage Seed Production Research Center home page at http://pwa.ars.usda.gov/nfsprc/

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Table 1. This table represents the crop residue management acreage for Linn County, Oregon for 1989. Data were taken from the (Conservation Technology Information Center (http://www.ctic.purdue.edu/CTIC/CTIC.html).

Linn County, Oregon		Conservation Tillage			Conventional Tillage	1989
	Total Planted Acres	No-Till	Ridge-Till	Mulch-Till	15-30% Residue	0-15% Residue
Corn (FS)	5,000	0	0	0	0	5,000
Corn (DC)	60	0	0	0	0	60
Small Grain (SpSd)	4,000	200	0	0	0	3,800
Small Grain (FlSd)	12,000	200	0	0	0	11,800
Soybeans (FS)	0	0	0	0	0	0
Soybeans (DC)	0	0	0	0	0	0
Cotton	0	0	0	0	0	0
Grain Sorghum (FS)	0	0	0	0	0	0
Grain Sorghum (DC)	0	0	0	0	0	0
Forage Crops	1,750	0	xxxxxxxxx	0	0	1,750
Other Crops	193,500	50,000	0	0	0	143,500
TOTAL	216,310	50,400	0	0	0	165,910
Permanent Pasture	750	0	xxxxxxxxx	0	0	750
Fallow	700	0	xxxxxxxxx	0	0	700

Table 2. This table represents the crop residue management acreage for Linn County, Oregon for 1998. Data were taken from the Conservation Technology Information Center (http://www.ctic.purdue.edu/CTIC/CTIC.html).

Linn County, Oregon						1998
		Conservation Tillage			Conventional Tillage	
	Total Planted Acres	No-Till	Ridge-Till	Mulch-Till	15-30% Residue	0-15% Residue
Corn (FS)	4,900	190	0	200	500	4,010
Corn (DC)	0	0	0	0	0	0
Small Grain (SpSd)	3,000	0	0	700	0	2,300
Small Grain (FlSd)	3,600	0	0	350	0	3,250
Soybeans (FS)	0	0	0	0	0	0
Soybeans (DC)	0	0	0	0	0	0
Cotton	0	0	0	0	0	0
Grain Sorghum (FS)	0	0	0	0	0	0
Grain Sorghum (DC)	0	0	0	0	0	0
Forage Crops	3,500	0	xxxxxxxxx	0	0	3,500
Other Crops	230,000	30,000	0	0	0	200,000
TOTAL	245,000	30,190	0	1,250	500	213,060
Permanent Pasture	500	0	xxxxxxxxx	0	0	500
Fallow	0	0	xxxxxxxxx	0	0	0

RIPARIAN ZONES, GRASS SEED CROPS, AND WATER QUALITY

S.M. Griffith, J.J. Steiner and M.E. Mellbye

There is a lot of concern about water quality in the Pacific Northwest with respect to salmon and trout. The "Oregon Plan" for salmon recovery places a lot of emphasis on watershed restoration, which includes reducing the impact that urban-areas, industry, and agriculture may have on the quality of surface waters. With a large portion of the landscape in grass seed crops in western Oregon, attention has naturally focused on this crop.

In the south Willamette Valley, for example, there are about 400,000 acres of cropland in Linn, Benton, and Lane counties. About 277,000 acres of that, or about 77%, is devoted to seed production. Indeed, grass seed is the major crop along or near most streams on the valley floor.

In 1995, Steve Griffith and Jeff Steiner, research scientists with the USDA-Agricultural Research Service in Corvallis, initiated a water quality research project involving grass seed production. Scientists from Oregon State University and USEPA cooperated in the study. The goal was to better understand the changes in surface and shallow groundwater water quality in grass seed production landscapes during the growing season, and to find out to what degree riparian zones might influence water quality.

Study based in Linn County. The project had two locations on perennial ryegrass fields in Linn County: one on the upper reaches of Lake Creek near Seven-Mile Lane, and the other on the Calapooia River. The project focused on soluble nitrogen and phosphorus, and herbicide diuron (Karmex). These were, and still are, the most commonly applied chemicals in grass seed production. From the beginning, this project was done with the cooperation of the grass seed industry, and became know to grass seed farmers as the "riparian project."

Prior to the start of the project, little was known about how non-point source water pollution was related to agricultural practices on the poorly drained soils where grass seed was grown. The four-year study yielded very encouraging results for the seed industry. Essentially, this study showed that the two well-managed and established grass seed fields had minimal impact on water quality.

Both forested and grass riparian buffers adjacent to grass seed fields were included in the study. For several years, an extensive sampling effort was conducted using an elaborate system of wells that allowed samples to be pulled from shallow groundwater to depths of 1.5 to 6 feet. Samples were taken from several transects of points from the fields through the riparian zones to the water ways, that allowed the researchers to characterize the flow of water and chemicals through the soil. Stream and swale water samples were also tested. Soil bacteria and plant processes were also examined to help explain water quality changes.

Results positive for grass seed production. Throughout the course of the study, concentrations of nitrate-, ammonium-, nitrite-N, soluble phosphorus, and diuron in the sampling wells and surface waters were below established standards or recommendations establish by the Environmental Protection Agency. Averaged over the season, nitrogen concentrations in the riparian zones were low and mostly undetectable. Levels in the field averaged less than 4 ppm nitrate-nitrogen. Again, this is low relative to the drinking water standard of 10 ppm nitrate-nitrogen, and less than that typically found in other traditional cropping systems.

It appeared that plant and soil bacterial processes in the established grass seed crop and riparian zones were responsible for much of the nutrient retention that helped minimize nitrate leaching and runoff. The nitrogen in the grass seed crop itself accounted for much of the soil nitrogen available to the crop.

The riparian zone was effective in reducing shallow groundwater nitrate to low levels during months of low precipitation flow but during high flow periods much of the perched water bypassed the riparian sub-soil zones and hence less was reduced through soil and plant processes. This points out the importance of good land and crop management practices, such as those used on the fields in this study, to alleviate excess runoff.

Another important point to keep in mind, this study was designed to examine grass seed production systems already in their second year of production and longer. The impact on water quality during the establishment year was not examined but is presently underway. This is important because soil disturbance events such as plowing, disking, and harrowing have been shown to increase mineralization and facilitate the release of nitrate from the soil. This can contribute to greater soil erosion and nitrate loss to waterways.

The erosion issue. Grass seed farmers in the valley have long recognized that erosion on new plantings and fallow ground can be a problem, especially when unusually heavy rainfall occurs in the winter months, as it did in 1964 and again during the 1996 floods. The Linn Soil and Water Conservation District (SWCD) has for decades focused on conservation efforts to reduce erosion.

Improving field drainage through ditching, deepening drainage ways, and installing drain tiles were key conservation practices promoted by the SWCD and Soil Conservation Service to reduce surface runoff, in addition to improving crop production. These practices are still effective in this regard. Although drainage of "wetlands" is no longer recommended or permitted, improving drainage on most grass seed fields ("prior converted" cropland) is allowed.

Improving field drainage is only part of the solution. No-till or conservation tillage combined with full straw remaining in fields can substantially reduce erosion, as well as improve soil quality and in the long run, these management tools may also help to improve economic yield. USDA-ARS is actively addressing these issues with current cropping systems research.

For more information on this project and others, check out Steve Griffith's web page at http://pwa.ars.usda.gov/nfsprc/griffith/java/ or the USDA-ARS National Forage Seed Production Research Center's home page at http://pwa.ars.usda.gov/nfsprc/.

GRASS SEED VARIETY YIELD TRIALS FOR NORTHEASTERN OREGON

D. Singh, D.A. Ball, and J.P. McMorran

Grass seed acreage in northeastern Oregon has significantly increased in past few years. Various factors are contributing to this increase including favorable production (seed yield) of some grass species, fewer problems with annual bluegrass, less disease pressure and good fit of grass seed crops in the available crop rotations in the region. However, there is lack of standardized information regarding the yield potential of different varieties of various grass seed crops including fine fescue, Kentucky bluegrass, tall fescue and perennial ryegrass.

In 1997, a cooperative project was initiated at the Hermiston Agricultural Research and Extension Center in Northeastern Oregon to evaluate the yield potential of different varieties of various grass seed crops under growing conditions in the Lower Umatilla Basin. Studies were initiated under center pivot irrigation for fine fescue, Kentucky bluegrass, tall fescue, and perennial ryegrass. On August 28-29, 1997, eighteen fine fescue (FF) varieties, sixteen Kentucky bluegrass (KBG) varieties, seventeen tall fescue (TF) varieties, and nineteen perennial ryegrass (PRG) varieties were seeded in separate four studies. Each entry was seeded at 5 lb/a with a plot drill at 12-inch row spacing. The studies were in a randomized complete block design, with four replications, and each plot was 6 x 25 feet (actual crop area 4 x 25 feet). Data presented in this report are the clean seed yields from first (1997-98) and second (1998-99) crop years of the grass seed variety trials. During the 1997-98 and 1998-99 cropping seasons the study areas were treated with the pesticides listed in Table 1.

In 1997-98, fine fescue varieties were swathed with a plot swather at approximately 25-30% seed moisture and were harvested with a plot combine on June 30, 1998. In 1998-99, fine fescue varieties were swathed at approximately 35-40% seed moisture and harvested on various dates listed in Table 2. A major hail and windstorm on June 24, 1999 caused severe seed shattering in the hard fescue varieties that were swathed a week earlier. Clean seed yield data from the fine fescue variety seed yield trial are presented in Table 2.

Kentucky bluegrass varieties in both crop years were swathed with a plot swather at approximately 28% seed moisture. In the first year, Kentucky bluegrass varieties were harvested with a plot combine on June 29, 1998 and the second year on July 6, 1999. On June 24, 1999, a major hail and windstorm caused seed shattering in the swathed Kentucky bluegrass. Seed shattering was most severe in the varieties that were swathed early, since they were most dry. Clean seed yields from the Kentucky bluegrass varieties seed yield trial are presented in Table 3.

In both crop years, tall fescue varieties were swathed with a plot swather at approximately 43% seed moisture. In the first crop year 1997-98, the tall fescue varieties were harvested with a plot combine on July 1, 1998 and on July 9, 1999 in the second crop year. On June 24, 1999, a major hail and windstorm caused seed shattering in earliest swathed (forage) tall fescue varieties. Clean seed yields from the two crop years of the tall fescue variety seed yield trial is presented in Table 4.

In both crop years, perennial ryegrass varieties were swathed with a plot swather at approximately 35% seed moisture. In the first crop year (1997-98) all perennial ryegrass varieties were harvested with a plot combine on July 17, 1998 on July 28, 1999 the second crop year (1998-99). Clean seed yields of perennial ryegrass varieties from the two crop years are presented in Table 5.

Table 1. Pesticides applied in the management of all four grass seed crop variety yield studies.

Date of application	Grass Seed Crop	Pesticide Name	Rate
Jul. 25, 1997	All	Vapam	33% solution @ 60 GPA
Sep. 20, 1997	FF	Buctril + NIS	2 pt/a 1 qt/100 gal
Oct. 3, 1997	All	Buctril + Rhomene + NIS	1 qt/a+ 1 pt/A + 1 qt/100 gal
Mar. 3, 1998	All	Buctril + Goal	1.5 pt/a +2 oz/a
Mar. 3, 1998	FF	Fusilade DX + COC	0.25 lb ai/a + 1 qt/a
Apr. 29, 1998	All	Tilt + NIS	4 oz/a + 1 qt/100 gal
May 18	KBG	Tilt + NIS	4 oz/a + 1 qt/100 gal
Sep. 27, 1998	FF	Goal 2XL + Lexone 75 DF	4 oz/a + 4 oz/a
Sep. 27, 1998	KBG, TF, PRG	Goal 2XL + Lexone 75 DF	6 oz/a + 5 oz/aA
Oct. 8, 1998	All	Lorsban	0.108 lbs ai/a
Apr. 1, 1999	All	Goal 1.6 EC + Buctril	2 oz/a + 1.5 pt/a
Apr. 1, 1999	All	Tilt + NIS	4 oz/a + 1 qt/100 gal
May 19, 1999	All	Quadris + NIS	6 oz/a + 1 qt/100 gal

NIS: non-ionic surfactant (R-11)
COC: crop oil concentrate (Moract)

Table 2. Clean seed yield of fine fescue varieties at Hermiston, OR.

Variety	Type	Company	Swathing date 1998	Seed yield 1998	Swathing date 1999	Harvest date 1999	Seed yield 1999
				(lb/a)			(lb/a)
Shademark	Creeping Red	Lesco	June 16	1613	June 28	July 8	1273
FRC 4-92	Chewings	Pickseed	June 16	1217	June 24	July 8	1557
Brittany	Chewings	Lesco	June 16	1214	June 24	July 8	1571
Tmi 3CE	Chewings	Turf Merchants	June 16	997	June 24	July 8	1429
Sandpiper	Chewings	Royal Seed	June 16	934	June 24	July 8	1564
Bridgeport	Chewings	Barenbrug	June 16	891	June 24	July 8	1552
Quatro	Sheep	Cebeco	June 15	801	June 17	June 29	1081
Bargreen	Chewings	Barenbrug	June 16	713	June 24	July 8	959
Barnica	Chewings	Barenbrug	June 15	610	June 18	June 29	843
Jamestown II	Chewings	Lofts Great Western	June 16	592	June 24	July 8	1116
Reliant II	Hard	Lofts Great Western	June 15	584	June 17	June 29	1333
Baroxi	Chewings	Barenbrug	June 16	580	June 24	July 8	766
Defiant	Hard	Lesco	June 15	572	June 17	June 29	1113
Osprey	Hard	Royal Seed	June 15	493	June 17	June 29	1259
Barduar	Hard	Barenbrug	June 12	382	June 17	June 29	779
Eureka	Hard	Cebeco	June 12	342	June 17	June 29	924
Barok	Hard	Barenbrug	June 16	230	June 17	June 29	356
Attila	Hard	Turf Merchants	June 12	224	June 17	June 29	665
L.S.D. (0.05)				148			201

Table 3. Clean seed yield of Kentucky bluegrass varieties at Hermiston, OR.

Variety	Company	Swathing date 1998	Seed yield 1998	Swathing date 1999	Seed yield 1999
			(lb/a)		(lb/a)
Voyager	Turf-Seed	June 12	945	June 16	658
A7-245A	Turf-Seed	June 12	891	June 18	543
Sodnet	Turf Merchants	June 12	852	June 21	560
Baronie	Barenbrug	June 12	822	June 17	769
Preakness	Lofts Great Western	June 12	745	June 15	511
VB5649	Barenbrug	June 16	743	June 21	439
P154	Zajac Performance	June 12	604	June 21	252
Barcelona	Barenbrug	June 12	593	June 18	314
Bartitia	Barenbrug	June 16	585	June 21	275
Blackstone	Turf-Seed	June 16	550	June 24	380
VB233	Barenbrug	June 16	545	June 21	432
A7-60	Turf-Seed	June 12	468	June 17	457
Moonlight	Turf-Seed	June 16	445	June 24	304
Rita	Turf-Seed	June 16	432	June 24	350
P-105	Lofts Great Western	June 12	291	June 21	403
A91-706	Turf Merchants	June 12	253	June 18	179
L.S.D. (0.05)			123		148

Table 4. Clean seed yield of tall fescue varieties at Hermiston, OR.

Variety	Company	Swathing date 1998	Seed yield 1998	Swathing date 1999	Seed yield 1999
			(lb/a)		(lb/a)
Wolf Pack (5RTK)	Turf-Seed	June 19	2122	June 24	1839
Laramie	Lesco	June 19	1731	June 24	1749
TF3	Barenbrug	June 19	1685	June 24	1677
TF6F	Barenbrug	June 19	1671	June 24	1607
Millennium (Tmi-RBR)	Turf Merchants	June 19	1650	June 24	1798
Grande	Royal Seed	June 19	1645	June 24	1657
TF1	Barenbrug	June 19	1606	June 24	1844
Tar Heel	Turf-Seed	June 19	1575	June 24	1438
Barlexas	Barenbrug	June 19	1572	June 24	1873
Bonsai-2000	Turf Merchants	June 19	1522	June 24	1410
Crewcut	Royal Seed	June 19	1511	June 24	1528
Coronado Gold (5RT)	Turf-Seed	June 19	1501	June 24	1685
Equinox	Turf Merchants	June 19	1496	June 24	1456
989	Lofts Great Western	June 19	1486	June 24	1808
Martin II (Forage)	Cebeco	June 12	1408	June 18	1060
AU Triumph (Forage)	Cebeco	June 9	1251	June 16	1020
Quantum (Forage)	Cebeco	June 9	958	June 16	796
L.S.D. (0.05)			261		193

Table 5. Clean seed yield of perennial ryegrass varieties at Hermiston, OR.

Variety	Company	Swathing date 1998	Seed yield 1998	Swathing date 1999	Seed yield 1999
			(lb/a)		(lb/a)
Penguin	Royal Seed	July 1	1839	July 8	1514
Premier II	Barenbrug	July 1	1656	July 8	1578
A-7	Lofts Great Western	July 1	1646	July 8	1501
2HO w/vermiculite	Turf-Seed	July 1	1633	July 8	1470
Top Hat	Cebeco	July 1	1544	July 8	1650
Gator II	Cebeco	July 1	1543	July 8	1706
MBH	Cebeco	July 1	1536	July 8	1694
Laredo	Turf Merchants	July 1	1531	July 8	1731
LPEE-93	Pickseed	July 1	1500	July 8	1563
Atlantis	Olsen Fennell	July 1	1496	July 8	1341
Palmer III	Lofts Great Western	July 1	1478	July 8	1870
2HO	Turf-Seed	July 1	1444	July 8	1469
Catalina	Turf-Seed	July 1	1425	July 8	1692
Tmi-MML	Turf Merchants	July 1	1399	July 8	1625
LP102-92	Pickseed	July 1	1397	July 8	1364
Blackhawk	Turf Merchants	July 1	1314	July 8	1749
Barlatra	Barenbrug	July 1	1296	July 8	1216
Barlet	Barenbrug	July 1	1240	July 8	1229
Barpolo	Barenbrug	July 6	718	July 14	514
L.S.D. (0.05)			375		216

DOWNY BROME CONTROL AND SEEDLING PERENNIAL RYEGRASS CROP TOLERANCE WITH RELY

D. Singh and D.A. Ball

Currently there is no registered herbicide to effectively control downy brome in seedling perennial ryegrass grown for seed in northeastern Oregon. Perennial ryegrass seed contaminated with downy brome seed is difficult to clean and increases the seed cleaning costs. Rely (glufosinate) is a post-emergence nonselective herbicide which has shown some selectivity for controlling downy brome depending on application timing. Three trials were conducted to evaluate the effect of application rate and timing of Rely on downy brome control and crop tolerance in seedling perennial ryegrass. The first (1997-98) and second (1998-99) trials were conducted under center pivot irrigation at the Hermiston Agricultural Research & Extension Center on fall-seeded stands. Herbicide treatments were applied with a hand-held CO_2 backpack sprayer with 15 GPA water at 30 psi. These two trials primarily evaluated crop tolerance since very little (First trial, Table 3) or no (Second trial, Table 4) downy brome was present in the study area. The third trial (1998-99) was conducted on a first-year commercially established, pivot-irrigated field near Echo, OR. Herbicide treatments were applied with a hand-held CO_2 backpack sprayer with 17 GPA water at 30 psi. Soil characteristics for each experimental site are summarized in Table 1. Application timings and climatic conditions at time of application are summarized in Table 2. No surfactant was mixed with Rely.

Table 1. Soil characteristics of experiment sites

	First trial (1997-98)	Second trial (1998-99)	Third trial (1998-99)
Soil Texture	Sandy loam	Loamy sand	Silt loam
Organic Matter (%)	0.79	1.09	1.04
pH	6.5	6.6	5.7
CEC (meq/100 g)	9.6	10.3	8.2

In the first trial (var. Palmer III), early spring and late spring application of Rely at high rate of 3.0 pt/a provided good control of downy brome (Table 3). An early/mid spring split application at 2.0 pt/a (4 pt/a total) also provided effective downy brome control. Rely applications were not overly phytotoxic to perennial ryegrass.

In the second trial (var. Top Hat) no visible crop injury on perennial ryegrass was evident from Rely treatments throughout the cropping season. However, clean seed yields were significantly reduced by early spring Rely application at high rate of 3.0 pt/A (Table 4) and by the mid/late spring split application of Rely at 2.0 pt/A (4 pt/a total). Highest seed yield was obtained in the weed-free check plots, which were hand-weeded.

In the third trial (var. Brightstar) perennial ryegrass response to mid-spring application of Rely was most prominent (Table 5). All treatments applied on the March 17 produced visible perennial ryegrass injury, but provided the best control of downy brome. Split treatment of Rely at 3.0 pt/a + 3.0 pt/a in early spring and mid-spring provided effective downy brome control in this study and reduced downy brome seed contamination in the cleaned seed. The same treatment significantly increased the clean seed yield of perennial ryegrass. Clean seed yield in the untreated check plots was significantly reduced due to the high downy brome pressure.

These trials indicate that Rely application in mid-March can reduce downy brome infestation in fall-seeded perennial ryegrass with minimal crop injury. Further studies will be conducted to define the proper application timing of Rely for optimal efficacy. Use of Rely will also be investigated in established perennial ryegrass where fall applied grass herbicides are not consistently effective in controlling downy brome and a spring application of Rely to control the remaining downy brome could save labor costs.

Table 2. Crop growth characteristics and climatic conditions at time of Rely application.

		Perennial ryegrass	Downy brome	Air temperature	Relative humidity	Soil temperature (2")
				°F	%	°F
First trial						
	Feb 17, 98	4-6 tillers, 4.5" tall	-	60	-	54
	Feb 27, 98	5-9 tillers, 4.5"tall	-	56	70	50
	Mar 25, 98	Multiple tillers	-	54	85	52
Second trial						
	Feb 23, 99	Multiple tillers, 3" tall	-	54	74	50
	Mar 15, 99	Multiple tillers, 4-5" tall	-	46	70	52
	Apr 2, 99	Fully tillered, 5-6" tall	-	58	48	42
Third trial						
	Feb 26, 99	3-4" tall	Tillered, 2-3" tall	50	54	50
	Mar 17, 99	3-4" tall	Tillered, 3" tall	54	60	56
	Apr 2, 99	3-5" tall	Tillered, 6-8"tall	58	54	48

Table 3. First trial: Effect of Rely treatments in seedling perennial ryegrass (variety Palmer III), 1998.

Treatment	Rate	Timing	April 28, 1998 Crop injury	April 28, 1998 Downy brome control	Clean seed yield
	(pt/a)		(%)	(%)	(lb/a)
Rely	2.0	Feb 17	0	63	997
Rely	3.0	Feb 17	7	97	1331
Rely / Rely	2.0 / 2.0	Feb 17 / Feb 28	3	93	1110
Rely	2.0	Feb 28	0	60	1161
Rely	3.0	Feb 28	7	63	1151
Rely / Rely	2.0 / 2.0	Feb 28 / Mar 25	7	63	1103
Rely	2.0	Mar 25	3	67	1276
Rely	3.0	Mar 25	7	93	1251
Untreated			0	0	1175
L.S.D (0.05)			NS	53	NS

L.S.D (0.05): Least significant difference at 5% level
NS: Non-significant

Table 4. Second trial: Effect of Rely treatments in seedling perennial ryegrass (variety Top Hat), 1999.

Treatment	Rate	Timing	Clean seed yield
	(pt/a)		(lb/a)
Rely	2.0	Feb 23	1830
Rely	3.0	Feb 23	1555
Rely / Rely	2.0 / 2.0	Feb 23 / Mar 15	1674
Rely	2.0	Mar 15	1807
Rely	3.0	Mar 15	1862
Rely / Rely	2.0 / 2.0	Mar 15 / Apr 2	1608
Rely	2.0	Apr 2	1824
Rely	3.0	Apr 2	1896
Untreated			1897
Weed-free Check			2109
L.S.D (0.05)			253

L.S.D (0.05): Least significant difference at 5% level

Table 5. Third trial: Effect of Rely treatments in seedling perennial ryegrass (variety Brightstar).

Treatment	Rate	Timing	April 14		May 13		DB[c] seed yield	PRG[d] seed yield	Contamination[e]
			PRG[a]	DB[b]	PRG[a]	DB[b]			
	(pt/a)		(%)				(lb/a)	(lb/a)	(%)
Rely	2.0	Feb 26, 99	0	13	10	40	154	993	1.3
Rely	3.0	Feb 26, 99	0	22	18	52	150	1172	0.6
Rely / Rely	2.0 / 2.0	Feb 26 / Mar 17, 99	23	68	8	41	171	1051	0.9
Rely / Rely	3.0 / 3.0	Feb 26 / Mar 17, 99	22	99	15	92	118	1465	0.4
Rely	2.0	Mar 17, 99	12	57	5	60	172	1175	2.1
Rely	3.0	Mar 17, 99	32	73	8	75	134	1160	0.8
Rely / Rely	2.0 / 2.0	Mar 17 / Apr 2, 99	22	68	10	73	129	1131	0.7
Rely	2.0	Apr 2, 99	3	20	0	22	188	1011	1.6
Rely	3.0	Apr 2, 99	5	23	0	7	157	759	2.3
Untreated			0	0	0	0	184	878	1.0
L.S.D (0.05)			11	19	NS	39	NS	375	NS

PRG[a]: Perennial ryegrass injury
DB[b]: Downy brome control
DB[c]: Downy brome seed separated during the clean process.
PRG[d]: Perennial ryegrass clean seed yield
Contamination[e]: Percent downy brome contamination by weight in cleaned perennial ryegrass seed.
L.S.D (0.05): Least significant difference at 5% level
NS: Non-significant

EVOLUTION OF RESISTANCE TO BEACON IN DOWNY BROME

G.W. Mueller-Warrant, C.A. Mallory-Smith and K.W. Park

Because herbicide resistance is generally recognized only after it has developed into a field-scale problem, specific details of its evolution are usually unknown. These unknown details may include the initial population size, the initial frequency of resistance genes within that population, and how resistance develops and spreads within the population in response to management practices. Knowledge of these details is vital in determining whether proposed resistance management plans are likely to work or are merely instances of wishful thinking. Long-term post-harvest residue management by herbicide treatment studies in Kentucky bluegrass grown for seed in Madras and LaGrande have provided the opportunity to observe critical details of the early stages of evolution of resistance to Beacon (primisulfuron, an ALS inhibitor) in downy brome. Grass seed stands sown in 1992 were harvested for five years. Herbicides treatments were generally applied to the same plots each year, but some treatments were modified after several years. Downy brome population density increased exponentially over time (approximately 10-fold per year) in untreated checks and in some of the 14 herbicide treatments. Excellent control was achieved by combinations of Beacon plus Sinbar (terbacil) in 1994 and 1995, but plot to plot variability in effectiveness of this treatment increased greatly by 1996. Archived seed samples from the 1994 through 1996 harvests of a selected group of treatments (50 to 55 plots total each year) were tested for tolerance to 0.56 oz ai/a (1X rate) of Beacon applied at the 2-leaf growth stage. Average downy brome survival was 5.9% for seed harvested in 1994, increasing to 7.7% in 1995 and 19.7% in 1996. Dose response curves have now been developed for seedlings of 21 accessions, including susceptible, intermediate, and resistant field plots, and survivors of Beacon treatment in earlier greenhouse tests. Questions we wished to answer with these dose-response curves included (a) what were the best combinations of herbicide rate and seedling growth stage for separating resistant from susceptible plants, (b) whether these downy brome populations have exhausted their potential to increase in resistance, and (c) what, if anything, can be inferred about the genetics and evolution of resistance.

Our specific objective was to measure changes in the frequency of resistance to Beacon in downy brome in response to selection pressure from the herbicide, both in the field and in the greenhouse. This was done by developing dose response curves to characterize the survival of 21 separate downy brome accessions over 12 rates of Beacon. Nine of the accessions derived from a single physical location (Madras plot 237) harvested in 1994, 1995, and 1996 after one, two, or three consecutive years of field treatment with Beacon, further subdivided on the basis of whether the seed was (a) produced in the field, (b) in the greenhouse on plants grown from seed from the field source but surviving treatment in the greenhouse with a 1X rate of Beacon, or (c) in the greenhouse on plants receiving no additional Beacon treatment. Three of the accessions were derived from the 1996 harvest of a nearby (minimum distance 54 ft, average distance 87 ft) plot (Madras plot 344), and included field grown seed, greenhouse 1X survivor seed, and a composite of greenhouse high rate (3X to 8X, 10 plants total) survivor seed. Four of the accessions were derived from a single physical location (LaGrande 340) in a second field test. These included 1995 field harvest seed, greenhouse 1X survivor seed (16 plants) from 1996 field source, and greenhouse untreated seed from both 1995 and 1996 field sources. The other five accessions were field harvest seed from three other plots at Madras and two at LaGrande. The logistic equation ($Y=100*10^{(A+B*X)}/(1+10^{(A+B*X)})$) was used to describe the dose response relationship between seedling survival and herbicide rate. Exponents were calculated by regression of transformed survival ($Y' = \text{Log}(0.01*Y/(1-0.01*Y))$) versus herbicide rate. Visual inspection of the raw data and preliminary regression analysis divided the 21 accessions into three categories: resistant (7 accessions), susceptible (9 accessions), and intermediate (5 accessions). Problems with uniformity of initial watering procedures lead to staggered emergence and a range in seedling growth stages when Beacon was applied. We recorded growth stages to the nearest 0.5 leaf for all 11,944 emerged seedlings at time of herbicide application. Most seedlings fell into the 2.5 to 3.0 or 3.5 to 4.0 leaf size groups, but those that were in the 0.5 to 2.0 leaf size group were much more sensitive to Beacon, while the largest ones were somewhat more tolerant than average size seedlings. The frequency of seedlings falling into each of the four leaf size groups varied among the 21 accessions and the 12 rates. Separate dose response curves for seedlings in the 0.5 to 2.0, 2.5 to 3.0, 3.5 to 4.0, and 4.0 to 8.0 leaf growth stages were calculated for the pooled resistant and susceptible groups. A logarithmic transformation procedure was then developed to adjust herbicide rates to correct for differences in leaf size using a single regression pooled over the leaf size groups (Figure 1). This transformation procedure did a reasonably good job of correcting for differences in tolerance to Beacon in the seedling size groups, although somewhat better adjustments could have been obtained by developing separate transformation procedures for the resistant and susceptible groups. However, applying separate transformation procedures to resistant and susceptible groups would have raised the difficult question of which procedure to use with any individual accession, and hence a single transformation procedure was used on all data. Data values of 0% or 100% survival were adjusted to 0.5% or 99.5% survival to enable their use in logistic regression. Data points were dropped from regression analysis in three general cases: (a) high rates with no survival when somewhat lower rates were already achieving complete kill, (b) low rates with 100% survival when complete survival was also occurring at somewhat higher rates, (c) points representing very small numbers of seedlings where the difference between measured percent survival and either 0 or 100% survival was based on the survival or death of only one or two seedlings. Such cases were generally handled by regrouping the data with neighboring points.

Relative to the average response of seedlings in the 2.5 to 3.0 and 3.5 to 4.0 leaf growth stages, seedlings in the 0.5 to 2.0 leaf growth stage were 4 times more sensitive to Beacon, while those in the 3.5 to 8.0 leaf growth stage were 1.8 times more tolerant (Figures 1). Doses required to kill half of the seedlings ($LD_{50\%}$) for the seven resistant accessions were 4 to 5 times larger than for the nine susceptible accessions (Figures 1 and 2). For both types of response, 2-fold increases in herbicide rate above the $LD_{50\%}$ decreased survival to under 3%, while 2-fold decreases in rate increased survival to around 84%. The 2X treatment was the best single rate to classify individual plants at the 2.5 to 3.0 leaf growth stage as either almost certainly resistant (survivors) or probably susceptible (seedlings that died). Lower rates greatly increased the chance of truly susceptible individuals surviving treatment (escapes), while higher rates increased the chance of resistant individuals dying anyway. High rate survivors (3X to 8X) of a resistant accession in an earlier greenhouse test were no more resistant than the field plot seed source itself (Figure 3). Failure of these plants to exhibit any further increases resistance to Beacon (beyond the 5X resistance they already possessed) is good news, implying that their genetic variation for this trait may have been exhausted. The 1X survivors of several partially resistant accessions did increase in resistance over their original seed sources. This occurred in greenhouse 1X survivors for the 1994 harvest of Madras plot 237 (Figure 4) and for the 1996 harvest of LaGrande plot 340 (data not shown). In the Madras plot, this increase was similar to that occurring in the field itself between 1994 and 1995.

Dose response relationships of these 21 accessions provided ambiguous hints regarding the genetics of resistance. The possibility that results for all 21 accessions could be explained by their seed being physical mixtures of only two phenotypes (R and S) suggests that the genetics might be as simple as that for a single, dominant gene. However, the quantitative, continuous nature of these dose response functions implies the existence of multiple minor factors working together to determine the fate of individual seedlings. If the mechanism of resistance is indeed metabolic detoxification, as indicated by previous research, then the maximum degree of resistance may be set by a single genetic factor (such as the affinity of an enzyme for Beacon), with many other factors potentially reducing the rate at which the herbicide is metabolized and increasing the probability of death.

Several additional steps are currently being taken to improve our understanding of the evolution of resistance to Beacon in these downy brome populations. We are now screening 1997 harvest downy brome seed from all 180 plots at each site for frequency of resistance, defined as survival when treated with a 2X rate at a 3-leaf growth stage. When this screening is completed, we will map the spatial distribution of resistance at both test sites, and correlate this with plot herbicide treatment history, seed dispersal patterns during swathing and combining, resistance frequency measurements on selected plots (55 out of 360) from 1994 to 1996, and downy brome density per plot from 1994 through 1997. We then hope to develop a computer model that will describe the observed spread of resistance, and predict the impact of alternative scenarios of management history, such as broadcast application over the field of single treatments (e.g., highly effective applications of Beacon plus Sinbar, moderately effective applications of Beacon alone, or moderately effective treatments without Beacon), alternating use of highly effective and ineffective treatments from year to year, or side-by-side placement of effective and ineffective treatments. This computer model will subsequently be used to develop and evaluate potential resistance management strategies. In addition to other field sites where downy brome might develop metabolically based resistance to ALS inhibitors, these strategies should also be applicable to other cases in which predominantly self-pollinated weeds develop moderate levels of resistance to herbicides.

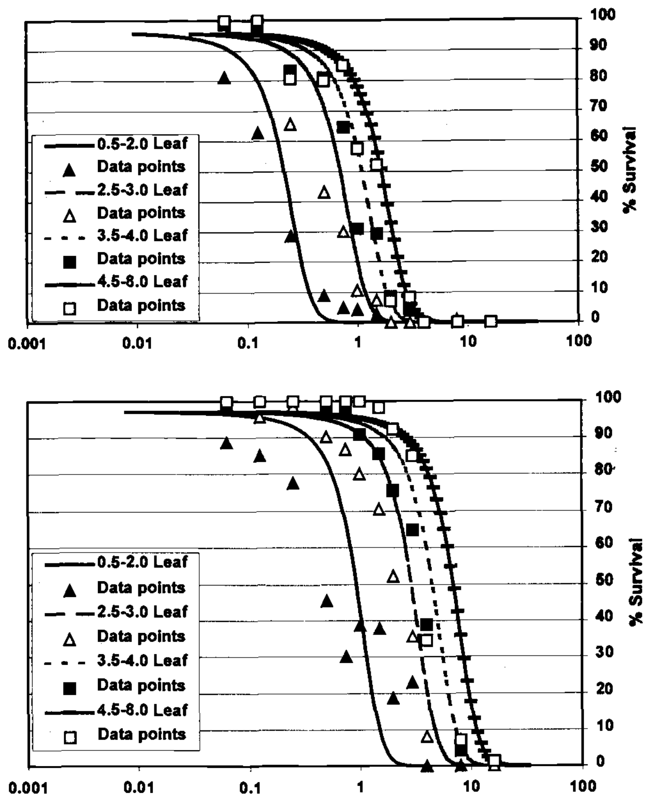

Figure 1. Impact of leaf growth stage at time of treatment on dose response curves for pooled data from 9 susceptible (above) and 7 resistant accessions (below). Logistic regressions based on adjusting Beacon rate by the square of the ratio of the logarithm of the number of leaves in each leaf stage group to the logarithm of the average number of leaves.

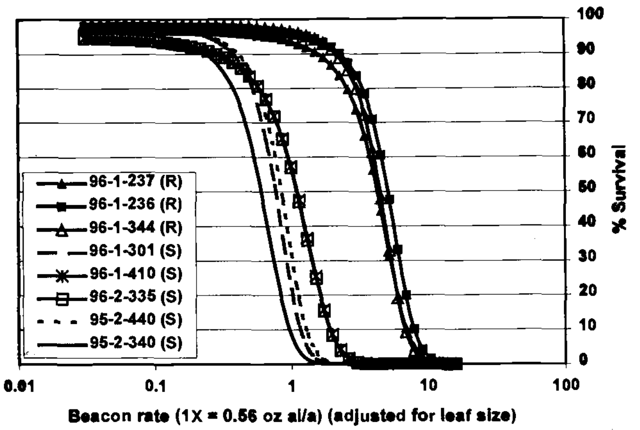

Figure 2. Dose response curves for all field plot seed sources. Note grouping into 3 resistant (R) types and 5 susceptible (S) types.

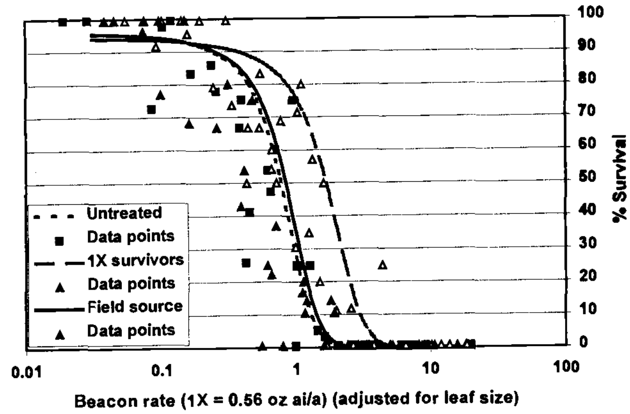

Figure 4. Dose response curves for field harvest, greenhouse 1X survivor, and greenhouse untreated for 1994 harvest of plot 237 at Madras, OR. Increase in resistance from greenhouse 1X selection was similar to increase in field from 1994 to 1995.

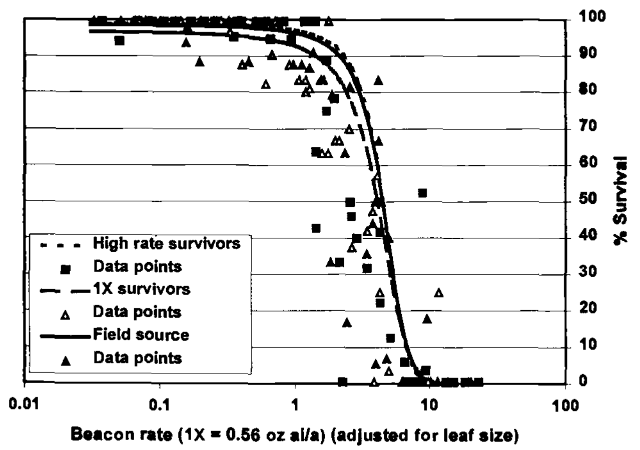

Figure 3. Dose response curves for field harvest, greenhouse 1X survivor, and greenhouse high rate survivors for 1996 harvest of Madras plot 344. Note similarity of all curves, indicating absence of further gain from selection pressure.

EVALUATION OF HERBICIDES FOR CONTROL OF CHEATGRASS AND RATTAIL FESCUE IN ROUGH BLUEGRASS, 1998-99

M.D. Butler and N.A. Farris

Central Oregon is the major rough bluegrass (*Poa trivialis*) seed production area in the United States. Rough bluegrass is used for overseeding warm season grasses in the south when they go dormant during the cool season. The object of our research was to do an initial screening of herbicides for use on rough bluegrass to control cheatgrass (*Bromus tectorum*) and rattail fescue (*Vulpia myuros*). Rough bluegrass is generally more sensitive to herbicides than Kentucky bluegrass, therefore it is harder to find effective herbicides that do not cause unacceptable damage to the crop.

Herbicides were evaluated in two commercial rough bluegrass seed fields ('Saber' and 'Cypress') near Madras, Oregon. Plots 10 x 25 ft were replicated three times in a randomized complete block design. Treatments were applied with a CO_2 pressurized, hand-held, boom sprayer at 40 psi and 20 gal/a water. Crop oil concentrate was applied at 1 qt/a with Nortron. Spray Booster S was applied at 1 qt/100 gal in combination with Goal, Banvel, Axium, Raptor, and herbicides applied as a tank mix. Spray Booster S was applied at 0.5% v/v in combination with Mavrick. Ammonium nitrate was added at 1 qt/a to the Spray Booster S with the Raptor application. Prowl, Command, and Solicam were applied without additives. Applications were made October 30, 1998 to the 'Saber' field and November 2, 1998 to the 'Cypress' location.

Plots at both locations were evaluated for percent reduction in biomass March 1, 1999. At the 'Cypress' location percent cheatgrass control was evaluated March 4 and percent rattail fescue control was evaluated April 22. Rattail fescue was concentrated in the first replication, and so numbers reported are from that single replication. There was not adequate cheatgrass or rattail fescue at the 'Saber' location for evaluation. Percent reduction in seed set was evaluated shortly before harvest at both locations on June 23, 1999.

Nortron at 3 pt/a provided 95% control of both cheatgrass and rattail fescue, while reducing seed set 37 percent (Table 1). All other herbicide treatments reduced seed set at a significantly higher rate. Command, Goal plus diuron, and Goal plus Nortron provided 97 to 99 percent control of cheatgrass and 95 to 100 percent control of rattail fescue but reduced seed set by 93 to 98 percent. There was good correlation between percent reduction in biomass evaluated March 1 and percent reduction in seed set evaluated June 23. Although there were some differences in percent reduction of biomass and seed set between locations, results were generally consistent between the two locations (Table 2).

Table 2. Evaluation of injury to 'Saber' rough bluegrass following herbicide applications October 30, 1998 near Madras, Oregon.

Treatment	Rate	Reduction in crop biomass	Reduction in crop seed set
	(product/a)	----------------(%)------------	
Nortron	3 pt	30 b[1]	3 d
Goal	10 oz	28 b	17 cd
Prowl	2 pt	0 d	0 d
Banvel	4 pt	12 cd	7 bc
Axium	10 oz	75 a	37 bc
Raptor	3 oz	92 a	80 a
Mavrick	0.5 oz	88 a	57 b
Command	1 pt	88 a	85 a
Solican	5 oz	0 d	0 d
Nortron	3 pt	28 b	3 d
+Banvel	2 pt		
Prowl	2 pt	20 bc	20 cd
Banvel	4 pt		
Goal	10 oz	77 a	40 bc
+Nortron	3 pt		
Diuron	1 lb	78 a	53 b
+Goal	10 oz		
Untreated	---	0 d	0 c

[1]Mean separation with Student-Newman-Keuls $P \leq 0.05$.

Table 1. Evaluation of injury to 'Cypress' rough bluegrass and control of cheatgrass and rattail fescue following herbicide applications November 2, 1998 near Madras, Oregon.

Treatment	Rate	Reduction in crop biomass	Control of cheatgrass	Reduction in crop seed set	Control of Rattail fescue[1]
	(product/a)	(%)			
Nortron	3 pt	63 c[2]	95 a	37 bcd	95
Goal	10 oz	60 c	72 ab	27 cd	60
Prowl	2 pt	0 e	0 c	13 d	0
Banvel	4 pt	33 d	80 ab	0 d	0
Axium	10 oz	96 a	65 b	70 abc	50
Raptor	3 oz	75 bc	97 a	63 abc	0
Mavrick	0.5 oz	88 ab	93 a	77 ab	50
Command	1 pt	98 a	99 a	93 a	95
Solican	5 oz	0 e	0 c	30 bcd	0
Nortron +Banvel	3 pt 2 pt	75 bc	82 ab	10 d	85
Prowl +Banvel	2 pt 4 pt	32 d	72 ab	0 d	0
Goal +Nortron	10 oz 3 pt	99 a	99 a	98 a	100
Diuron +Goal	1 lb 10 oz	99 a	97 a	90 a	99
Untreated	---	0 e	0 c	0 d	0

[1]Data reflects evaluation of only one replication.
[2]Mean separation with Student-Newman-Keuls $P \leq 0.05$.

EVALUATION OF FUNGICIDES FOR POWDERY MILDEW CONTROL IN KENTUCKY BLUEGRASS IN CENTRAL OREGON, 1999

M.D. Butler and N.A. Farris

Several new fungicides (some with new chemistry) are currently, or soon expected to be, on the market for grass seed production. The objective of this research was to evaluate these new products against the current industry standards to provide the grass seed industry in central Oregon with the latest information for making management decisions concerning powdery mildew (*Erysiphe graminis*) control.

Fungicides were evaluated for control of powdery mildew in commercial fields of Kentucky bluegrass ('Kelly' and 'Geronimo') grown for seed near Culver and Madras, Oregon. The fungicides Tilt, Flint, Stratego, Folicur, Quadris, Laredo, Bayleton, and BAS 500 were applied to 10 ft x 25 ft plots replicated four times in a randomized complete block design. Fungicides were applied with 8002 TwinJet nozzles on a 9 ft CO_2 pressurized, hand-held, boom sprayer at 40 psi and 20 gals of water/a. The surfactant Sylgard 309 at 1 qt/100 gal of water was applied in combination with all fungicides. Treatments were applied May 8 at the Culver location and May 10 at the Madras location.

Plots were evaluated using a rating scale from 0 to 5, with 0 being no mildew present and 5 indicating total foliar coverage. Plots were evaluated before treatment at the Culver location May 5 and following treatment May 19, May 27, June 2, and June 9. At the Madras location the pre-treatment evaluation was conducted May 5 and post-treatment evaluations were made May 20, May 28, June 3, and June 9.

At the Culver location fungicides Tilt, Stratego, Folicur, Laredo and Bayleton significantly reduced severity of powdery mildew from 19 to 32 days after application compared to untreated plots (Table 1). Laredo, Bayleton and Stratego provided the best control, followed by Tilt and Folicur. Flint took longer before significantly reducing the level of disease. BAS 500 and Quadris were minimally effective.

At the Madras location all fungicide treatments significantly reduced powdery mildew from 10 days to 30 days following application compared to untreated plots (Table 2). The most effective fungicides were Stratego, Tilt, and Folicur, followed by Bayleton, Laredo and Flint. BAS 500 was minimally effective.

Table 1. Powdery mildew rating on Kentucky bluegrass ('Kelly') near Culver, Oregon following fungicide application May 8, 1999.

		Powdery mildew				
Treatment[1]	Rate	Pre-treat. 5/5/99	Post-treat. 5/19/99	Post-treat. 5/27/99	Post-treat. 6/2/99	Post-treat. 6/9/99
	(product/a)	(0-5)[2]				
Laredo	6 oz	1.9	1.4	0.2 b[3]	0.2 b	0.9 c
Bayleton	4 oz	1.6	1.2	0.3 b	0.3 b	0.9 c
Stratego	10 fl oz	1.7	1.3	0.3 b	0.2 b	1.1 c
Tilt	4 fl oz	1.7	1.3	0.4 b	0.5 b	1.2 bc
Folicur	4 fl oz	1.7	1.2	0.4 b	0.5 b	1.3 bc
Flint	2.75 oz	1.8	1.6	0.9 ab	0.9 b	1.5 bc
BAS 500	9 fl oz	1.8	1.6	1.5 a	1.7 a	2.1 ab
Quadris	12 fl oz	1.7	1.5	1.6 a	2.2 a	2.6 a
Untreated	---	1.7	1.6	1.6 a	1.7 a	2.1 ab
		NS	NS			

[1]All treatments applied with Sylgard 309 at 1 gt/100 gal.
[2]Rating scale was 0-5, with 0 = no mildew and 5 = the leaves completely covered.
[3]Mean separation with Student-Newman-Kuels Test at $P \leq 0.05$.

Table 2. Powdery mildew rating on Kentucky bluegrass ('Geronimo') near Madras, Oregon following fungicide application May 10, 1999.

		Powdery mildew				
Treatment[1]	Rate	Pre-treat. 5/5/99	Post-treat. 5/20/99	Post-treat. 5/28/99	Post-treat. 6/3/99	Post-treat. 6/9/99
	(product/a)	(0-5)[2]				
Stratego	10 fl oz	1.8	1.1 b[3]	0.8 b	0.4 c	0.1 b
Tilt	4 fl oz	1.8	1.1 b	0.8 b	0.4 c	0.2 b
Folicur	4 fl oz	1.7	1.1 b	0.9 b	0.4 c	0.2 b
Bayleton	4 oz	1.8	1.2 b	0.9 b	0.4 c	0.3 b
Laredo	6 oz	1.8	1.0 b	1.0 b	0.5 c	0.3 b
Flint	2.75 oz	1.8	1.3 b	1.3 b	1.1 c	0.5 b
BAS 500	9 fl oz	1.6	1.6 ab	1.5 b	1.8 b	1.9 a
Untreated	---	2.1	1.9 a	2.4 a	2.7 a	2.1 a
		NS				

[1]All treatments applied with Sylgard 309 at 1 gt/100 gal
[2]Rating scale was 0-5, with 0 = no mildew and 5 = the leaves completely covered.
[3]Mean separation with Student-Newman-Kuels Test at $P \leq 0.05$.

INSECTS ASSOCIATED WITH ERGOT IN KENTUCKY BLUEGRASS SEED PRODUCTION

S.C. Alderman, M.D. Butler, and G.C. Fisher

Ergot, caused by the flower infecting fungus *Claviceps purpurea*, is a well know disease of Kentucky bluegrass. Elongated, hard, black sclerotia, which replace the seed are characteristic of the disease and are easily recognized on panicles or among seed. During infection and prior to development of the sclerotia, a sugary exudate containing plant sap and fungal spores exude from infected flowers. Numerous reports have noted that the honeydew is attractive to insects, especially flies, and that these insects may help to spread the disease. However, few quantitative studies have been conducted and no studies have examined the association of insects and ergot in Kentucky bluegrass seed production.

During 1996-1998, insect-ergot surveys were conducted in Kentucky bluegrass seed production fields in Oregon and Idaho. Field locations and varieties surveyed are summarized in Table 1. Fields were surveyed for insects and ergot 1-2 weeks prior to cutting. Insect were collected using a modified sweep net, black light trap, and a Schuh shaker. The sweep net included a sticky card enclosed in a ¼ in. mesh hardware cloth cylinder and mounted at one end of a pole. Insects passed through the mesh and were collected on the sticky card, permitting sweeps without contamination by honeydew. Twenty straight-line sweeps were taken in each of four quadrats of each field.

Night flying moths were collected on sticky cards mounted under a black light. The black light traps were set up in the early evening and moths collected the next morning.

The Schuh shaker was modified by placing a sticky card in the bottom of a 5 gallon bucket rather than the traditional funnel-shaped base with a collecting jar in the bottom. Grass samples were placed over the bucket, exposed to methyl ethyl ketone and shaken to release insects onto the sticky card. A 2 ft. sq. grass sample was taken from each of four quadrats in each field.

For ergot assessment, a drop of water was placed on the mouth parts of each insect to wash off any adhering conidia. After 15 seconds the drop was removed, mounted on a glass slide, and examined at 200 x magnification under a compound microscope. Conidia of *C. purpurea* were identified based on comparison with known conidia collected from naturally infected flowers. Since species identification on sticky cards was difficult, insect identification to the species level was not attempted.

The level of ergot varied among fields (Table 1). Sclerotia per 100 panicles ranged from 0-565 and ergot was found in all fields except Georgetown in 1998. Conidia of *C. purpurea* were found on a high percentage (67-100%) of moths and flies (11-77%). Up to 60% of leafhoppers, and up to 34% of thrips were also found with conidia. However, the number of insects with conidia did not appear to be related to the level of ergot within the field. This study indicates that a high percentage of a wide range of insects come into contact or feed on ergot honeydew. However, the efficiency of these insects to transfer conidia to healthy flowers remains to be determined.

Table 1. Association of *C. purpurea* with various insects collected from Kentucky bluegrass fields during 1997 and 1998 and level of ergot present in the fields.

	Total scleotia per sample[1]	Percent (%) panicles with		Percentage and total insects with *C. purpurea* conidia							
				Moths		Flies		leafhoppers		Thrips	
		sclerotia	honeydew	%[2]	total[3]	%[2]	total[3]	%[2]	total[3]	%[2]	total[3]
Rathdrum Prairie, ID											
1997											
Shamrock	20	12	7	67	(6)	75	(4)	19	(505)	14	(28)
Plush	65	26	32	80	(10)	63	(8)	60	(216)	32	(142)
Midnight	151	55	0	81	(16)	35	(23)	13	(15)	6	(66)
1998											
Shamrock	27	15	6	100	(16)	74	(19)	20	(329)	10	(99)
Plush	18	9	2	91	(11)	57	(37)	25	(188)	16	(108)
Midnight	88	33	4	67	(6)	24	(37)	7	(59)	3	(97)
Agency Plains, OR											
1997											
Coventry	212	51	54	100	(3)	52	(23)	-	-	17	(6)
Merit	122	49	64	100	(16)	69	(70)	42	(12)	34	(29)
Georgetown	3	1	0	-	-	11	(9)	0	(15)	3	(96)
1998											
Coventry	565	87	0	67	(15)	37	(402)	4	(24)	4	(237)
Georgetown	0	0	0	40	(5)	19	(32)	-	-	6	(17)
Grande Ronde Valley, OR											
1997											
Ascot	42	21	1	89	(66)	73	(15)	57	(28)	31	(39)
Nassau	82	31	22	84	(37)	14	(7)	10	(51)	0	(2)
Sidekick	42	0	100	(31)	60	(5)	39	(28)	6	(16)	
1998											
Fairfax	206	73	30	87	(31)	77	(160)	51	(69)	16	(318)
Nassau	12	8	1	43	(14)	32	(327)	22	(68)	8	(247)

[1]Number of scleotia from100 panicles.
[2]Percentage of individuals examined with conidia.
[3]Total number of individuals examined.

EVALUATION OF THE GROWTH REGULATOR PALISADE ON KENTUCKY BLUEGRASS, 1999

M.D. Butler and N.A. Farris

Research evaluating trinexapac-ethyl (Palisade) on ryegrass in the Willamette Valley during the 1997 and 1998 seasons indicated reduced lodging and increased yields with application of this growth regulator. Although lodging is not generally a problem in Kentucky bluegrass grown in central Oregon, a cost-effective method of increasing yields would generate interest in the industry for the use of a growth regulator like Palisade.

Plots 10 x 25 ft were replicated four times in a randomized complete block design in a commercial Kentucky bluegrass ('Geronimo') field near Madras, Oregon. Palisade was applied at 200, 400, and 600 g a.i./ha to one sets of plots on May 19, 1999 at late boot stage and to a second set of plots on May 27, 1999 when the top of the heads were even with the flag leaf. A split application at half the rate of 100, 200, and 300 g a.i./ha was applied on both dates to a third set of plots.

Treatments were applied with a CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal/a water. TwinJet 8002 nozzles were used to improve coverage. Plots were evaluated for plant height on May 20 and then again on June 17. Lodging was evaluated on June 25.

Prior to harvest a Jari mower was used to cut three-foot alleyways across the front and back of each row of plots. A 3 x 22-ft portion of each plot was harvested with a research-sized swather July 12. Samples were placed in large bags and hung in an equipment shed to dry, and then transported to Corvallis for stationary threshing with a Hege 180 combine at the OSU Hyslop Research Farm. The seed was then cleaned in the seed-conditioning lab at the USDA-ARS National Forage Seed Production Research Center.

Application of Palisade reduced plant height (Table 1) in plots treated on the earlier date (May 19) at the high rate (600 g a.i./ha), on the later date (May 27) at the medium (400 g a.i./ha) and high (600 g a.i./ha) rates, and the split application at the high rate (300 g a.i./ha) when compared to the untreated plots and the split application at the low rate (100 g a.i./ha).

Lodging was reduced by all Palisade applications except the low rate (200 g a.i./ha) for both application dates (May 19 and May 27). Although not statistically significant, negligible lodging was observed in plots treated with the high rate (600 g a.i./ha) for both single applications (May 19 and May 27) and the high rate (300 g a.i./ha) for the split application. Both height and lodging appear to be influenced by application rate across application dates.

There were no statistically significant differences in seed yield. This may have been due in part to a high level of variability between dirt weights and clean weights for a given treatment in replications one and two. As a result, replication two was discarded because of this variability and the uncharacteristically low weights compared to the other replications. This increased P-value of the significance test from 0.25 to 0.15.

The yield trend showed Palisade applied on the earlier date (May 19) at the high rate (600 g a.i./ha) produced the highest yield with 2,383 lb/a. This was followed by early application (May 19) at the medium rate (400 g a.i./ha) with 2,177 lb/a, and the split application (May 19 and May 27) at the high rate (300 g a.i./ha) with 2,052 lb/a. It would appear the earlier applications (May 19) had the most influence on yield, with the three rates applied early being three of the top four yielding treatments.

Table 1. Palisade growth regulator application to Kentucky bluegrass, Madras, OR, 1999.

Treatment	Application timing: May 19	Application timing: May 27	Height: Original	Height: Final	Height: Increase	Area lodged	Seed yield (clean): Weight	Seed yield (clean): Increase
	(g a.i./ha)		(in)	(in)	(%)	(%)	(lb/a)	(%)
Untreated	---	---	14.8	29.5 a[1]	101	100 a	1,655	
Palisade	200		13.8	27.3 abc	100	62 ab	1,882	14
Palisade	400		14.0	27.0 abc	94	18 b	2,177	32
Palisade	600		13.6	25.0 c	86	3 b	2,383	44
Palisade		200	15.7	26.9 abc	73	48 ab	1,834	11
Palisade		400	15.9	24.8 c	57	23 b	1,822	10
Palisade		600	14.0	23.9 c	71	3 b	1,593	-4
Palisade	100	100	14.1	28.5 ab	104	49 b	1,713	4
Palisade	200	200	14.5	25.7 bc	81	43 b	1,734	5
Palisade	300	300	13.8	24.1 c	75	1 b	2,052	24
			NS		NS		NS	

[1]Mean separation with Student-Newman-Keuls $P \leq 0.05$.

EVALUATION OF THE GROWTH REGULATOR APOGEE ON KENTUCKY BLUEGRASS, 1999

M.D. Butler and N.A. Farris

Research evaluating another growth regulator, Palisade, on ryegrass in the Willamette Valley during the 1997-1998 seasons indicated reduced lodging and increased yields with application of the growth regulator. Although lodging is not generally a problem in Kentucky bluegrass grown in central Oregon, a cost-effective method of increasing yields would generate interest in the industry for the use of growth regulators such as Apogee or Palisade.

Plots 10 x 25 ft were replicated four times in a randomized complete block design in a commercial 'Geronimo' Kentucky bluegrass field near Madras, Oregon. Apogee was applied at 0.25, 0.38, and 0.5 lb a.i./a to one set of plots on May 19 at late boot stage, and to a second set of plots on May 27 when the top of the heads were even with the flag leaf. A split application at half the rate of 0.125, 0.19, and 0.25 lb a.i./a was applied on both dates to a third set of plots. Silgard 309 at 0.25% v/v (1 qt/100 gal) was applied in combination with all Apogee treatments.

Treatments were applied with a CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal/a water. TwinJet 8002 nozzles were used to improve coverage. Plots were evaluated for plant height on May 20 and then again on June 17. Lodging was evaluated on June 25.

Prior to harvest a Jari mower was used to cut three-foot alleyways across the front and back of each row of plots. A 3 x 22-ft portion of each plot was harvested with a research-sized swather July 12. Samples were placed in large bags and hung in an equipment shed to dry, and then transported to Corvallis for stationary threshing with a Hege 180 combine at the OSU Hyslop Research Farm. The seed was then cleaned in the seed-conditioning lab at the USDA-ARS National Forage Seed Production Research Center.

There were no statistical differences between treatments for any of the parameters evaluated (Table 1). However, application of Apogee produced the greatest reduction in plant height with split-applications at the high (0.25 lb a.i./a) and medium (0.19 lb a.i./a) rates. Application at the low (0.25 lb a.i./a) rates tended to have the greatest increase in plant height. Apogee at the high (0.5 lb a.i./a) rate applied late (May 27) produced the lowest rate of lodging, while the low rate (0.25 lb a.i./a) applied early (May 19) had similar lodging to the untreated plots. Apogee applied on the earlier date (May 19) at the high rate (0.5 lb a.i./a) produced a yield of 2,670 lb/a, followed by a split-application at the high rate (0.25 lb a.i./a) with 2,549 lb/a. This compares to 2,107 lb/a for the untreated plots.

Table 1. Results of Apogee growth regulator application to Kentucky bluegrass, Madras, OR, 1999.

Treatment	Application timing		Height			Area	Seed yield (clean)	
	Early	Late	Original	Final	Increase	lodged	Weight	Increase
	------ (lb a.i./a) --------		---------- (in) ------------		(%)	(%)	(lb/a)	(%)
Untreated	---	---	14.8	28.5	93.6	98.8	2,107	---
Apogee	0.25		15.2	29.3	93.8	95.3	2,294	9
Apogee	0.38		15.0	28.2	87.7	75.8	2,318	10
Apogee	0.5		14.5	27.5	90.9	85.0	2,670	27
Apogee		0.25	13.8	28.0	103.4	62.5	2,241	6
Apogee		0.38	14.8	27.7	89.2	73.8	2,190	4
Apogee		0.5	15.3	30.1	82.0	60.0	2,371	12
Apogee	0.125	0.125	14.8	27.8	89.7	83.3	2,367	12
Apogee	0.19	0.19	15.7	27.3	75.4	62.5	2,289	9
Apogee	0.25	0.25	15.3	26.7	74.4	69.0	2,549	21
			NS[1]	NS	NS	NS		

[1]Mean separation with Student-Newman-Kuels Test at $P \leq 0.05$.

CLETHODIM TIMING IN MEADOWFOAM

M.D. Schuster and C.A. Mallory-Smith

Four trials were established in meadowfoam to determine the effects of clethodim (Select) applied at different timings on meadowfoam injury and yield, and Italian ryegrass control. Two trials were established in 1997 and two trials in 1998.

Individual plots were 8 by 25 ft arranged in a randomized complete block with four replications. Clethodim was applied at 0.1 lb ai/a and as a split application of 0.05 lb a.i./a at the beginning of each month. Herbicide treatments were applied with a CO_2 backpack sprayer calibrated to deliver 20 gpa at 32 psi and 3 mph. Meadowfoam seed yield was determined by collecting the aboveground biomass from a 2.7 by 25 ft area with a forage harvester. Biomass was air-dried and seed was threshed with a stationary thresher. Site 1 did not have Italian ryegrass; therefore, only crop injury was evaluated.

All treatments provided 98 to 100 percent Italian ryegrass control at Site 2 in 1997-98 and Site 1 in 1998-99 (Table 1). In 1998-99, severe water damage at Site 2 resulted in 13 to 72 percent control and increased crop injury from the November, December, January, and November/January treatments. The other treatments provided 94 to 100 percent Italian ryegrass control. In 1997-98, injury from the April treatment resulted in lower seed yields compared to the untreated check at both sites. All other treatments resulted in equal or higher seed yields (Table 2). In 1998-99, seed yield from the treated plots did not differ or was higher than the untreated check at Site 1 (Table 3). At Site 2, the crop injury from the November, December, and April treatments resulted in lower yields compared to the untreated check. In the other treatments, yields were equal or higher than the untreated check.

Table 1. Control of Italian ryegrass from clethodim application at Site 2 1998 and Site 1 and 2 in 1999.

Treatment		Italian ryegrass control		
		5/6/98	5/27/99	
date	Rate	Site 2	Site 1	Site 2
	(lb a.i./a)	(%)		
November	0.10	98	99	15
December	0.10	98	100	13
January	0.10	100	100	72
February	0.10	100	100	94
March	0.10	100	99	100
April	0.10	100	100	100
November/ January	0.05/ 0.05	100	100	49
December/ February	0.05/ 0.05	100	100	98
January/ March	0.05/ 0.05	100	100	99
Check	0.00	0	0	0
LSD (0.05)		4	1	37

Table 2. Percent injury and yield of meadowfoam at Site 1 and 2 from clethodim application for 1997-98.

Treatment date	Clethodim Rate	Meadowfoam injury 12/4/97		1/8/98		2/11/98		3/5/98		4/7/98		5/11/98		Seed yield 7/7/98	7/27/98
	(lb a.i./a)	(%)												(lb/a)	
November	0.10	35	9	38	6	36	21	25	13	8	1	6	1	768	662
December	0.10			31	21	23	34	13	16	3	0	6	10	768	641
January	0.10					21	33	10	15	6	5	6	0	759	676
February	0.10							4	8	0	0	14	25	677	609
March	0.10									4	10	20	15	685	647
April	0.10											69	85	422	211
November/ January	0.05/ 0.05	16	15	9	6	36	44	23	31	3	5	15	9	763	653
December/ February	0.05/ 0.05			10		6	25	11	25	1	1	16	11	731	658
January/ March	0.05/ 0.05					4	19	4	11	3	8	16	3	740	627
Check	0.00	0	0	0	0	0	0	0	0	0	0	0	0	686	501
LSD (0.05)		26	36	15	9	13	19	8	13	6	8	19	14	101	101

Table 3. Percent injury and yield of meadowfoam at Site 1 and 2 from clethodim application for 1998-99.

Treatment date	Clethodim Rate	Meadowfoam injury 12/3/98		1/7/99		1/9/99		3/5/99		4/6/99		5/27/99		Seed yield 7/2/99	7/2/99
	(lb a.i./a)	(%)												(lb/a)	
November	0.10	43	44	66	84	75	80	66	75	46	66	3	41	1541	1478
December	0.10			71	79	83	79	70	73	50	63	1	29	1828	1481
January	0.10					34	51	30	32	20	29	0	20	1721	1759
February	0.10							30	14	20	11	0	1	1599	1713
March	0.10									34	9	5	4	1467	1546
April	0.10											18	19	1443	1537
November/ January	0.05/ 0.05	25	38	49	66	51	63	40	72	25	65	0	34	1494	1614
December/ February	0.05/ 0.05			39	29	35	28	33	34	20	15	3	4	1581	1754
January/ March	0.05/ 0.05					15	4	3	5	16	8	0	5	1530	1639
Check	0.00	0	0	0	0	0	0	0	0	0	0	0	0	1032	1764
LSD (0.05)		33	8	28	31	26	28	25	29	24	32	4	31	412	205

CONTROL OF *SCAPTOMYZA* FLY IN MEADOWFOAM WITH BIFENTHRIN

J.T. DeFrancesco, D.T. Ehrensing and G.C. Fisher

Four field trials were conducted to further evaluate the effects of bifenthrin on control of the *Scaptomyza* fly in meadowfoam and subsequent effects on flower density and seed yield. Three trials were placed in commercial meadowfoam fields in the Willamette Valley and one at OSU's Hyslop Research Farm near Corvallis.

Trials at Grower Sites

Plots were established at three commercial grower sites in the Willamette Valley. Each plot was 25 x 400 ft. and replicated four times. Treatment was bifenthrin, at 0.1 lb. a.i./a (Capture 2EC @ 6.4 fl. oz/a), compared to an untreated control. Treatments were applied on March 11, 1999 with a tractor-drawn Rears sprayer in 20 gallons of water per acre. Each site had been planted with meadowfoam cultivar OMF-69 the previous fall; plants were about four to six inches tall at time of application. Yellow stick traps had revealed about 15 adults per trap 10 to 14 days prior to the bifenthrin application.

Numbers of larvae per plant were determined by randomly cutting at the soil line 10 plants per plot on March 30, 1999 (19 days after treatment). Larvae were extracted from plants over a three-day period using Berlese funnels. Flower counts from a 1.0 sq. ft. area in each plot were made on June 2, 1999. Seed harvest occurred in early July: Sites 1 and 2 were windrowed on July 2 and combined on July 9, 1999; Site 3 was windrowed on July 4 and combined on July 25, 1999.

One application of bifenthrin in early March caused a significant decrease in larval populations and a significant increase in flower number and seed yield (Table 1).

Trial at Hyslop Research Farm

Plots were established to determine the effects of number and timing of bifenthrin applications on *Scaptomyza* fly larvae control and seed yield. Each plot was 8 x 25 ft. and replicated four times in a randomized complete block experimental design. Treatments were applied at various dates in early 1999 (see treatments below) with a CO_2 backpack sprayer, equipped with a 3-nozzle boom (8003vs flat fan tips), at 40 psi in 30 gallons of water per acre. Meadowfoam, cultivar Floral, had been planted the previous fall. Yellow stick traps had revealed 15 to 20 adults per trap starting on February 15, 1999.

Numbers of larvae per plant were determined by randomly cutting at the soil line 10 plants per plot on March 2, March 29 and April 30, 1999. Larvae were extracted from plants over a four-day period using Berlese funnels. Seed harvest occurred on July 15, 1999 (direct combine).

Neither timing nor number of bifenthrin applications had a significant effect on larval populations or seed yield. Larval populations were low in both the treated and untreated plots. However, although not statistically significant, the trend was for the untreated plots to have the highest larval populations and the lowest seed yield (Table 2).

Table 1. Effects of bifenthrin application on *Scaptomyza* fly larvae, meadowfoam flower density and seed yield, at three grower sites, Willamette Valley, 1999.

	No. larvae per plant			No. flowers per sq. ft.			Seed yield (lb/a)		
Treatment	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
Bifenthrin	0	0.3	0	1,655	1,198	3,142	1,286	1,601	1,632
Untreated	0.6	4.2	0.7	1,209	1,093	1,723	1,186	1,517	1,522
Significance	*	**	NS	*	NS	*	*	*	*

*, **, NS = Significance at $P \leq 0.05$, $P \leq 0.01$, not significant, respectively.

Table 2. Effects of timing of bifenthrin application (0.1 lb a.i./a) on *Scaptomyza* fly larvae and meadowfoam seed yield, Hyslop Research Farm, 1999.

Application date(s)	No. larvae per plant March 2	March 29	April 30	Seed yield (lb/a)
Feb. 20	0	---	0.2	885
March 19	0.2	0	0	857
April 20	0.5	---	0.5	812
Feb. 20 + March 19	0	0	0	871
Feb. 20 + March 19 + April 2	0	0.5	0	951
Untreated	1.0	0.5	6.8	767
Significance	NS	NS	NS	NS

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