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Edited by William C. Young III

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2000 SEED PRODUCTION RESEARCH AT OREGON STATE UNIVERSITY USDA-ARS COOPERATING

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DEFINING OPTIMUM NITROGEN FERTILIZATION PRACTICES FOR GRASS SEED PRODUCTION SYSTEMS IN THE WILLAMETTE VALLEY

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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 in 1998, two fine fescue fields in 1999 and two annual ryegrass fields in 2000. The fields were selected to represent soil types typically used for seed production in the Willamette Valley. Spring fertilizer was applied using precision application equipment. Perennial ryegrass and tall fescue received treatments of 0, 45, 90, 135, 180, 225, and 270 lb N/a as a split application (50/50). Annual ryegrass received single applications of 0, 45, 90, 135, 180, 225, and 270 lb N/a and fine fescue received single applications of 0, 30, 50, 70, 90, 110, and 140 lb N/a. Normal grower equipment was used to swath and combine plots. Seed yields were measured using a weigh-wagon. Crop and soil samples were obtained for yield components, N uptake, and soil N levels following harvest.

Results from the first two years (1998-1999) 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. First year results in fine fescue (1999) showed little response to spring N applications above 50 lb/a. Levels of soil NO_3-N were increased by the highest N rate (270 lb N/a) but were at low levels. 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. Results presented below are from the third (and final year) for perennial ryegrass and tall fescue, the second year (of at least three) for fine fescue and the first year (of two) in annual ryegrass.

Procedure

Large scale on-farm plots averaging 5 acres per site were established at 9 locations (2 perennial ryegrass, 3 tall fescue, 2 fine fescue and 2 annual ryegrass) prior to fertilizer applications. 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 except for the fine fescue which had rates of 0, 30, 50, 70, 90, 110, and 140 lb N/a. The seven treatments were replicated three times in a randomized complete block. Data were analyzed using appropriate statistical analyses (e.g., ANOVA, Regression).

All sites were fertilized between March 15 and April 20 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 14 and April 24, 2000, 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 all locations.

Location	County	Planted	Year trial started	Soil type
		PERENNIAL RYEGRASS		
L3 Farms	Linn	Fall 97	Spring 98	Concord and Amity silt loam
Venell Farms	Benton	Fall 97	Spring 98	Dayton silt loam
		TALL FESCUE		
Malpass Farms	Linn	Fall 96	Spring 98	Bashaw silty clay
Nixon Farms	Lane	Spring 97	Spring 98	Malabon silty clay loam
Roselawn Farms	Marion	Fall 98	Spring 98	Woodburn silt loam
		FINE FESCUE		
Sherman Farms	Marion	Spring 98	Spring 99	Jory silty clay loam
Taylor Farms	Marion	Spring 98	Spring 99	Nekia silty clay loam
		ANNUAL RYEGRASS		
Michael Hayes Farm	Linn	Fall 99	Spring 00	Dayton/Clackamas
Tim VanLeeuwen Farm	Linn	Fall 99	Spring 00	Dayton silt loam

Table 2. Dates of fertilization, windrowing, and combining for optimum N studies, 2000.

Location	Variety	Fertilizer application		Windrow	Combine
		1st date	2nd date		
		PERENNIAL RYEGRASS			
L3 Farms	DLF-1	3/24	4/18	7/12	8/1
Venell Farms	SR 4200	3/23	4/18	7/12	8/8
		TALL FESCUE			
Malpass Farms	Kittyhawk SST	3/23	4/20	6/30	7/14
Nixon Farms	Duster	3/23	4/18	6/30	7/15
Roselawn Farms	Tomahawk	3/20	4/15	7/8	7/21
		FINE FESCUE			
Sherman Farms	Brittany	3/17	N/A	7/8	7/17
Taylor Farms	Shademark	3/15	N/A	7/11	7/19
		ANNUAL RYEGRASS			
Michael Hayes Farm	Gulf	4/19	N/A	6/27	7/11
Tim VanLeeuwen Farm	Gulf	4/20	N/A	6/29	7/20

Plant samples were taken at maturity (during June). Yield components samples were obtained at or following pollination. Plots were swathed into windrows between June 27 and July 12 and combined between July 11 and August 8 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 (Table 3) in perennial ryegrass increased as fertilizer rates increased up to the 135 lb N/a rate at the Venell Farms site and up to 180 lb N/a at the L3 Farms site. The third site (J Bar V Farms) was taken out of production in 1999 after two years. The L3 site had a full straw load flail chopped for post-harvest residue management and could be a reason for the higher optimum N level responses as heavy straw loads can tie up nitrogen until it is decomposed completely. At the Venell Farms site, yield decreased considerably at the highest rate of N (270 lb N/a) showing a negative effect of excessive N rates. 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 these studies. Higher spring N application rates resulted in more biomass, higher tissue N concentration, and increased N uptake by the crop as shown in Table 5, 6 and 8. With harvest index remaining constant (Table 7), increased biomass generally increased seed yield. Table 8 shows the average of both perennial ryegrass sites had increased fertile tillers, increased 1000 seed weight and some increases in spikelet and floret numbers all of which made contributions to higher seed yield potential and thus higher yields. The statistics of the yield components measured for all sites are presented in Table 7.

Table 3. Seed yield (lb/a) of perennial ryegrass following varied rates of spring applied N, 2000.

Spring N rate (lb/a)	L3 Farms	Venell Farms	2-site average
0	797 d	506 d	652
45	1167 c	1038 c	1102
90	1350 c	1484 b	1417
135	1595 b	1736 a	1666
180	1704 ab	1662 ab	1683
225	1746 ab	1634 ab	1690
270	1790 a	1470 b	1630
LSD 0.05	191	224	---

*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 all 9 locations, 2000.

Location (variety)	ANOVA	Regression analysis Linear ($=r^2$)	Quadratic ($=r^2$)
PERENNIAL RYEGRASS			
L3 Farms	**	**(0.84)	**(0.94)
Venell Farms	**	**(0.52)	**(0.93)
TALL FESCUE			
Malpass Farms	NS	*(0.21)	NS
Nixon Farms	**	**(0.78)	**(0.92)
Roselawn Farms	**	**(0.64)	**(0.78)
FINE FESCUE			
Sherman Farms	**	NS	**(0.62)
Taylor Farms	**	NS	NS
ANNUAL RYEGRASS			
Michael Hayes Farm	**	**(0.54)	**(0.82)
Tim VanLeeuwen Farm	**	**(0.48)	**(0.76)

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

Table 5. Average tissue N concentration (%) in above ground biomass at maturity in perennial ryegrass, tall fescue, and annual ryegrass species following varied rates of spring applied N, 2000.

Spring N rate (lb/a)	Tissue N concentration (%) Perennial ryegrass	Tall fescue	Annual ryegrass
0	0.8	1.0	0.7
45	0.8	0.9	0.9
90	1.0	1.2	1.0
135	1.0	1.5	1.3
180	1.4	1.7	1.1[1]
225	1.5	1.5	1.3
270	1.6	1.8	1.4

[1] data from one location for this treatment

Table 6. Average equivalent N uptake (lb N/a) in above ground biomass at maturity in perennial ryegrass, tall fescue, and annual ryegrass species following varied rates of spring applied N, 2000.

Spring N rate (lb/a)	N uptake at maturity (lb N/a)		
	Perennial ryegrass	Tall fescue	Annual ryegrass
0	41	75	66
45	63	95	102
90	105	144	116
135	111	179	126
180	177	218	138
225	201	180	152[1]
270	224	230	154

[1] data from one location for this treatment

Table 8. Average aboveground biomass, 1000 seed weight, spikelet number per inflorescence, and floret number per spikelet of perennial ryegrass (2 sites) following varied rates of spring applied N, 2000.

Spring N rate	Total biomass	Fertile tillers	1000 seed weight	Spikelets per infl.	Florets per spikelet
(lb N/a)	(tn/a)	(no./sq ft)	(g)	(no.)	(no.)
0	2.6	113	1.761	19.2	5.0
45	4.0	173	1.785	20.3	5.5
90	5.4	209	1.775	19.8	5.8
135	5.5	215	1.798	21.6	6.8
180	6.4	249	1.867	21.8	7.2
225	6.8	226	1.885	20.9	7.1
270	6.9	271	1.851	22.8	7.5

Table 7. Statistical summary of yield component responses to varied spring applied nitrogen for all locations, 2000.

Location	Total above ground biomass (tn/a)	Harvest index (%)	1000 seed weight (g/1000 seed)	Fertile tiller density (no./sq ft)	Spikelets per inflorescence (no.)	Florets per spikelet (no.)
PERENNIAL RYEGRASS						
L3 Farms	**[1]	NS	*	*	NS	**
Venell Farms	**	NS	*	*	(*)	NS
TALL FESCUE						
Malpass Farms	(*)	NS	NS	NS	(*)	NS
Nixon Farms	*	NS	*	**	*	*
Roselawn Farms	NS	NS	**	NS	NS	NS
FINE FESCUE						
Sherman Farms	*	NS	**	(*)	NS	(*)
Taylor Farms	NS	NS	**	(*)	NS	NS
ANNUAL RYEGRASS						
Michael Hayes Farm	NS	NS	NS	NS	NS	NS
Tim VanLeeuwen Farm	NS	NS	NS	NS	NS	**

[1]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 when compared to perennial ryegrass. At the Malpass Farms site, seed yield (Table 9) was not statistically different though there was a trend of yield increase up to the 90 lb N/a rate. At the Nixon Farms site there was a seed yield response up to 225 lb N/a, which is a little higher than the previous year (1999) and much different from the first year (1998) when there was no seed yield response to increased N. The Roselawn Farms site responded up to 135 lb N and had no further response with higher N levels. Crop nitrogen uptake was similar to perennial ryegrass (Tables 5 and 6), which demonstrate the ability of the grass seed crops to take up considerable nitrogen into the biomass. Yield components in tall fescue also varied by location (Table 7) as indicated by the 1000 seed weight, fertile tiller density, spikelet and floret number. This may be a combination of both variety and location response which emphasizes the need to make recommendations site specific. Generally, fertile tiller density, spikelet number and floret number were improved by increasing N rates up to recommended levels thereby increasing yield potential and thus yields. 1000 seed weight tended to decrease slowly as the N rates increased and subsequent yields improved. This may be a result of yield component compensation as the yield increased, the individual seed size decreased. Yield response to nitrogen in tall fescue changed as the stands aged and will be analyzed across years and sites to determine the effect of age and soil types. 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 9. Seed yield (lb/a) of tall fescue following varied rates of spring applied N, 2000.

Spring N rate (lb/a)	Malpass Farms	Nixon Farms	Roselawn Farms	3-site average
0	1117	390 e	1546 c	1018
45	1272	661 d	1834 b	1256
90	1403	1009 c	1844 b	1419
135	1389	1117 abc	2239 a	1582
180	1368	1093 bc	2232 a	1594
225	1413	1226 ab	2372 a	1670
270	1366	1228 a	2201 a	1598
LSD 0.05	NS	134	235	---

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

Table 10. Average aboveground biomass, 1000 seed weight, spikelet number per inflorescence, and floret number per spikelet of tall fescue (3 sites) following varied rates of spring applied N, 2000.

Spring N rate	Total biomass	Fertile tillers	1000 seed weight	Spikelets per infl.	Florets per spikelet
(lb N/a)	(tn/a)	(no./sq ft)	(g)	(no.)	(no.)
0	3.7	61	2.323	41.9	4.6
45	5.1	65	2.287	47.8	4.8
90	6.0	65	2.238	53.2	5.4
135	6.0	70	2.211	55.8	5.5
180	6.4	74	2.202	64.0	5.7
225	5.6	73	2.165	64.5	5.5
270	6.4	76	2.167	61.5	5.6

Fine fescue: Seed yield responded to spring nitrogen at both sites. Optimum yield was obtained with the 30-50 lb spring N/a rate (Table 11). Higher applications did not increase seed yield and even showed a decline in yield as the application rate exceeded 70 lb N/a as was the case in 1999. The Taylor site was optimized at 30 lb N/a and the Sherman site at 50-70 lb N/a. Seed yield at both locations was well above the 2000 average yields of about 750 lb/a for these species. Fertile tiller densities (Table 12) were improved by the increased N rates as well as the floret number at the Sherman Farms site. 1000 seed weight followed yield by decreasing some as yields increased, then increasing as the N rates increased and yields decreased. This reflects similar responses in the tall fescue trials regarding yield component compensation. Total biomass increased some as well. The cause of decreased yield from higher N rates may be from excessive plant growth resulting in early lodging and shading of the crop thereby diminishing the realized yield potential. Tissue N concentration and N uptake both reflected increased N application rates (Table 13). The 0 N rate resulted in an average of 53 lb N/a in the plant as a result of soil mineralization and any fall applied fertilizer.

Table 11. Seed yield (lb/a) of fine fescues following varied rates of spring applied N, 2000.

Spring N rate (lb/a)	Sherman Farms	Taylor Farms	2-site average
0	1304 c	1304 c	1304
30	1623 ab	1477 a	1550
50	1688 ab	1353 bc	1520
70	1699 a	1388 b	1543
90	1606 ab	1369 b	1488
110	1563 b	1386 b	1475
140	1560 b	1362 b	1461
LSD 0.05	129	56	----

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

Table 12. Average aboveground biomass, 1000 seed weight, spikelet number per inflorescence, and floret number per spikelet of fine fescue (2 sites) following varied rates of spring applied N, 2000.

Spring N rate	Total biomass	Fertile tillers	1000 seed weight	Spikelets per infl.	Florets per spikelet
(lb N/a)	(tn/a)	(no./sq ft)	(g)	(no.)	(no.)
0	3.4	251	1.135	25.1	4.8
30	4.6	327	1.105	27.6	5.1
50	4.7	288	1.105	30.2	5.0
70	6.2	359	1.126	29.2	5.4
90	5.2	335	1.135	31.7	5.1
110	6.5	359	1.144	30.0	6.1
140	5.2	280	1.147	30.1	6.2

Table 13. Average tissue N concentration (%) and equivalent N uptake (lb N/a) in above ground biomass at maturity in fine fescue following varied rates of spring applied N, 2000.

Spring N rate	Tissue N Concentration	N uptake
(lb N/a)	(%)	(lb N/a)
0	0.8	53
30	1.0	87
50	1.0	89
70	0.9	108
90	0.9	88
110	1.1	148
140	1.3	134

Annual ryegrass: This is the first year in a two year trial with annual ryegrass. The two locations reflect both volunteer and planted crop N management. Seed yield responses to spring N in annual ryegrass was similar to first year perennial ryegrass reported in 1998 Seed Production Research. Seed yield (Table 14) was optimized at the 90 – 135 lb N/a rate at both locations. Using rates greater than this range did not result in increased seed yield. No significant yield component effects were measured (Table 15). Fertile tiller density tended to decrease as nitrogen was applied but the unfertilized tillers were smaller and lighter than plots from the fertilized tillers (data not reported here).

Table 14. Seed yield (lb/a) of annual ryegrass following varied rates of spring applied N, 2000.

Spring N rate (lb/a)	Michael Hayes Farms	Tim VanLeeuwen Farms	2-site average
0	1252 d	2133 c	1693
45	1835 c	2918 b	2377
90	1958 bc	2959 ab	2459
135	2143 ab	3041 ab	2592
180	2162 ab	3138 a	2650
225	2191 a	3076 ab	2633
270	2089 ab	3081 ab	2585
LSD 0.05	211	185	----

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

Table 15. Average aboveground biomass, 1000 seed weight, spikelet number per inflorescence, and floret number per spikelet of annual ryegrass (2 sites) following varied rates of spring applied N, 2000.

Spring N rate	Total biomass	Fertile tillers	1000 seed weight	Spikelets per infl.	Florets per spikelet
	Annual ryegrass				
(lb N/a)	(tn/a)	(no/sq ft)	(g)	(no.)	(no.)
0	4.5	208	2.864	22.0	7.5
45	5.4	190	2.853	22.0	9.5
90	5.1	177	2.823	21.6	10.4
135	4.6	172	2.811	20.9	8.7
180	5.0	156	2.812	19.7	10.1
225	5.4	175	2.747	20.0	9.8
270	5.0	183	2.778	21.1	10.4

Crop nitrogen uptake

The data presented here are from tissue uptake levels obtained in samples taken during pollination or just pre-bloom. Tissue N% (Tables 5 and 13) varied from 0.8% to 1.8%. N concentrations closely followed N application rates as expected. The average amount of nitrogen in the aboveground biomass by species is reported in Tables 6 and 13. The highest N rates ranged from 148 to 230 lb N/a uptake in the above ground biomass demonstrating the ability of these grasses to take up a large amount of N. Mineralized N is available for uptake by the plant in the spring as indicated with the 0 N rate. The 0 spring applied N still resulted in N uptake levels in the plant ranging from 41 lb N/a (perennial ryegrass) to 75 lb N/a (tall fescue).

Soil NO_3-N

Soil samples were obtained in the fall from three treatments: 0, 135, 270 lb N/a (0, 70, 140 in fine fescue) and at three depths: 0-1, 1-2, 2-3 ft. These results are detailed in Tables 16-19. At all locations except the Hayes annual ryegrass site, the highest fertilizer rate (twice a normal rate) increased the levels of NO_3-N in the top 12 inches of soil. The top one-foot concentrations ranged from 4.6 ppm at fine fescue site to 26.7 ppm at an annual ryegrass site. The normal rates of 135 lb N/a were all around 10 ppm or less. In addition, the lower profiles also increased in NO_3-N at most locations. The amount of NO_3-N in the lower two feet was very minimal with the highest concentration at 7.0 ppm and most < 5 ppm. similar 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. Using this criteria, all the sites had low to barely medium levels at normal rates of N fertilization and three were in the high range at the doubled N rate. 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.

Table 16. Soil NO_3-N concentrations (ppm) at three soil depths of perennial ryegrass following varied rates of spring applied N, 2000.

Spring N Rate (lb/a)	Post harvest sample depth 0-12 in.	13-24 in.	25-36 in
	L3 FARMS		
0	0.7	0.5	0.4
135	3.8	0.9	0.4
270	24.3	2.7	1.8
LSD 0.05 (0.10)	(14.8)	1.5	1.2
	VENELL FARMS		
0	1.0	0.4	0.5
135	4.2	1.1	0.8
270	7.6	2.4	2.3
LSD 0.05	2.2	0.5	0.6
	AVERAGE		
0	0.8	0.5	0.4
135	4.0	1.0	0.6
270	16.0	2.6	2.0

[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 17. Soil NO_3-N concentrations (ppm) at three soil depths of tall fescue following varied rates of spring applied N, 2000.

Spring N rate (lb/a)	Post harvest sample depth 0-12 in.	13-24 in.	25-36 in
	MALPASS FARMS		
0	3.2	1.8	1.5
135	9.2	3.3	2.7
270	15.0	5.0	3.8
LSD 0.05 (0.10)	(7.8)	(2.2)	NS
	ROSELAWN FARMS		
0	0.4	0.4	0.4
135	6.1	0.9	0.6
270	12.9	2.3	1.3
LSD 0.05	3.4	0.6	0.3
	AVERAGE		
0	1.8	1.1	0.9
135	7.6	2.1	1.6
270	14.0	3.6	2.6

Table 18. Soil NO_3-N concentrations (ppm) at three soil depths of fine fescue following varied rates of spring applied N, 2000.

Spring N Rate (lb/a)	Post harvest sample depth 0-12 in.	13-24 in.	25-36 in
	SHERMAN FARMS		
0	3.4	0.8	1.4
70	5.5	1.9	1.8
140	12.0	2.5	4.5
LSD 0.05	5.8	1.5	1.7
	TAYLOR FARMS		
0	1.2	0.5	0.6
70	2.9	1.1	0.9
140	4.6	1.5	1.8
LSD 0.05	0.9	0.4	0.6
	AVERAGE		
0	2.3	0.7	1.0
70	4.2	1.5	1.4
140	8.3	2.0	3.2

Table 19. Soil NO_3-N concentrations (ppm) at three soil depths of annual ryegrass following varied rates of spring applied N, 2000.

Spring N Rate (lb/a)	Post harvest sample depth 0-12 in.	13-24 in.	25-36 in
	MICHAEL HAYES FARMS		
0	11.8	3.1	2.4
135	10.8	3.5	2.7
270	21.5	4.9	4.6
LSD 0.05 (0.10)	NS	NS	(1.7)
	TIM VANLEEUWEN FARMS		
0	7.6	1.6	1.3
135	8.8	1.8	1.1
270	26.7	7.0	3.3
LSD 0.05	10.3	1.9	1.4
	AVERAGE		
0	9.7	2.4	1.9
135	9.8	2.7	1.9
270	24.1	6.0	4.0

Summary

Optimum levels of spring applied N for seed production were 135-180 lb N/a in the perennial ryegrass, 90-135 lb N/a in the tall fescue and annual ryegrass, and 30-70 lb N/a in the fine 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 2000 state averages of 1456 lb/a (perennial ryegrass) and 1421 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 very low for recommended use rates. The perennial ryegrass and tall fescue sites are finished, the fine fescue sites are in their third year in 2001 and the annual ryegrass sites will be continued in 2001 for a second year of data. These results from multi-year trials will be used to establish better economic and production recommendations for optimizing inputs in grass seed crops.

Acknowledgments:

This project was supported by the following: Oregon Tall Fescue Commission, Oregon Ryegrass Growers Seed Commission, and the Oregon Department of Agriculture. In addition, USDA-CSREES has supported other aspects of this research through the Grass Seed Cropping Systems for a Sustainable Agriculture (GSCSSA), Special Grant.

PHOTOGRAPHIC ANALYSIS TO HELP DEFINE OPTIMUM NITROGEN FERTILIZATION PRACTICES FOR GRASS SEED PRODUCTION SYSTEMS

M. Louhaichi, W.C. Young III, T.B. Silberstein, M.E. Mellbye, D.E. Johnson and M.M. Borman

Introduction

A study to define optimum nitrogen fertilization practices for perennial ryegrass and tall fescue seed production systems in the Willamette Valley has been underway since fall 1998. The study has involved measuring seed production, yield components to help explain yield differences, and plant tissue and soil nitrogen levels. During 2000, we tested aerial and ground-truth verification photography to evaluate photographic analysis as a potential technique for assessing residual nitrogen influence on plant growth and plant survival as a function of nitrogen application rates.

Procedure

Large-scale on-farm plots were established prior to fertilizer applications. Field trials were conducted with perennial ryegrass (*Lolium perenne*) variety SR 4200. The field was established in 1997. Plots were approximately 22 ft wide by 300 ft long. 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. The plots were managed the same as the rest of the field for all other cultural management practices by the grower-cooperator.

In order to visualize, manipulate, analyze and display spatial data we used Geographical Information Systems (GIS). GIS data can be derived from various sources including field sampling, digitized paper maps, remote sensing, and aerial photography. Each data set represents a single layer. These layers of information have to be geo-referenced to be linked together. This can be done by geo-rectifying (common points in each layer are positioned on top of each other) each layer through the use of Global positioning systems (GPS). The next paragraphs explain the tools we used in our study.

<u>Global Positioning Data</u>

We mapped treatment plots boundaries using a Trimble® Pathfinder Pro® XL GPS equipped with a data logger. Positions were differentially corrected (accurately positioned) using a local base station (Portland, OR) and averaged using Trimble® navigation software (Trimble, 1996).

<u>Color Aerial Photography</u>

We photographed the research plots eight months after the spring fertilizer. The flight was taken on December 19, 1999. We used Kodak® Royal Gold® ISO 400 film in a 35-mm camera fitted with a 28-mm wide-angle lens, mounted on a single-engine, fixed-wing aircraft. A mosaic of the images was scanned and saved as 24-bit tagged image format (TIF) files. These images were imported into Picture Publisher® software and converted into red, green, and blue digital images. Each of these images were then imported into IDRISI®, an image processing/GIS software package (Eastman, 1997).

<u>Image Rectification and Classification</u>

Images were rectified using a minimum of 10 ground-control points and a linear, nearest-neighbor algorithm (Richards, 1986). Pixels were resized to 1 m and UTM zone 10 North, WGS84 Datum coordinate system. UTM is Universal Transverse Mercator, which is a standard coordinate system used to locate positions on the earth's surface. WGS84 is World Geodetic System of 1984, which is the most recently developed information used in defining a geographic coordinate system. The root mean square error (Richards, 1986) for this operation was kept at less than one meter, which means the position on the map is accurate to within one meter of where it actually exists on the earth's surface.

Image classification is the process of sorting pixels into a finite number of individual classes, or categories of data, based on their data file values. If a pixel satisfies a certain set of criteria, then the pixel is assigned to the class that corresponds to that criteria.

In our procedure, we used unsupervised classification, which is a technique for the computer-assisted interpretation of remotely sensed imagery. The computer routine does this by identifying patterns in the reflectance data. The patterns are usually referred to as clusters or classes. The procedure we used generated three classes. These classes are then identified by looking side by side at the computer classification (screen) and color photographs (print) plus the knowledge from the site visits and ground truthing to determine their interpretation.

<u>Ground level Photography</u>

To obtain higher resolution information at known locations within the field, we used a light-weight platform of polyvinyl chloride (PVC) tubing on which we mounted a 35-mm camera fitted with a 28-mm, wide-angle lens (Louhaichi, 1999). The camera was pointed vertically downward 5.6 ft. above the ground. A 1-m² frame was central in the photograph, which provided an estimate of scale and allowed us to measure objects and calculate surface areas in the photo. Photographs taken with this camera arrangement were scanned and converted to digital format.

Three uniformly spaced ground-level photographs were taken for each treatment on or close to the day of overflight. At each photographic location we recorded the following information: (1) plant height, (2) any unusual circumstances such as flooding and rodent activity, and (3) GPS location.

Ground Level Image Analysis

We were interested in determining the percent green leaf cover of perennial ryegrass. Cover is defined as the vertical projection of the crown and shoot areas of a plant species on the ground surface, expressed in percent or fraction of the area measured (Stoddart *et al.*, 1975). We measured cover in 1-m² quadrats at ground level by analyzing digital, color images. Pixels in the digital RGB (red, green, blue) images of plant leaves and stems had higher green digital numbers than red or blue. Soil, rocks, litter, and dead leaves tended to have lower values for green than for red or blue. This is to be expected since chlorophyll absorbs red and blue light and reflects green. We therefore classified images by determining if the average of red and blue digital numbers were greater or less than the green digital number.

The resultant image had pixel values between −1 and +1. Negative values tended to be soil/nonliving while positive values were green leaves and stems. We calculated percentage leaf cover. The classification process was programmed in Visual Basic® software so classification of 63 photographs can be completed in about 30 minutes.

Incorporation of Geographic Information Systems

Our objective was to evaluate photographic analysis as a potential technique for assessing residual nitrogen influence on plant growth and plant survival as a function of nitrogen application rates. We combined information in aerial photographs with platform photography and ground-truth data within a GIS to classify the response of each treatment. There are three main steps that summarize our methodology. In step 1, we scanned, rectified, and classified color aerial photography. This separated treatments into units with similar reflectance (usually two to four classes). In step 2, image processing of platform photography generated percent leaf cover in each treatment. Since all themes were geo-referenced, this allowed us to overlay ground-truth data points on the color aerial image and double check our output in step 3. In addition, we are able to seek relationships between computer classification of aerial photography and ground level platform photography.

Results and Discussion

The most remarkable result was that, based on aerial photography, class 1 (greener) decreased as N rates increased (Figure 1). It went up from 50% at 0 lb/a N to reach a peak of 84 % at 90 lb/a N and then decreased to about 30 % at 270 lb/a N.

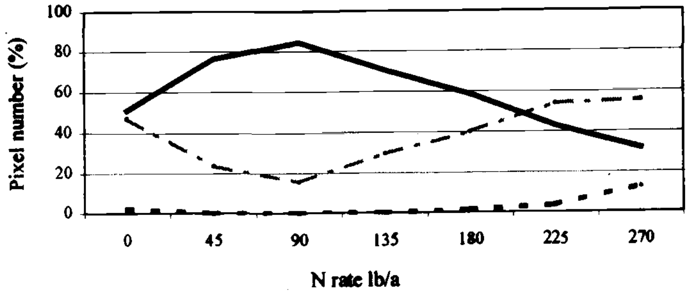

Figure 1. Computer classification of aerial photography. Class 1 is green leaf ______, class 2 is litter _._._._, class 3 is soil/non-living ....

The image processing of the 1-m² platform images illustrated similar trends. The overall response across three replications indicated that the lowest percent leaf cover coincided with the highest N rate application of 270 lb/a (Figure 2).

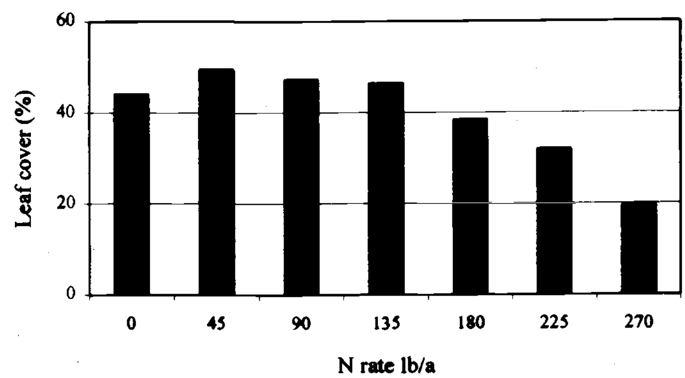

Figure 2. Overall percent leaf cover based on platform photograph analysis.

When comparing the response of percent leaf cover taken by the platform photography and computer classification of aerial photography, there was a correlation of 90 % (Figure 3). This would suggest that for large area we can use aerial photography and computer classification to stratify field into classes based on the amount of green cover.

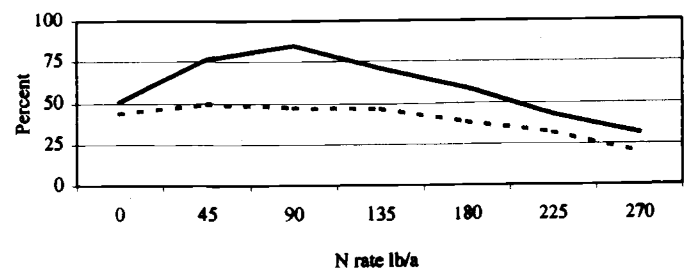

Figure 3. Comparison between percent leaf cover and class 1. Class 1 is green leaf classification from aerial photograph analysis ______. Percent leaf cover was calculated from platform photographs ....

The platform photography will be used for collecting ground truth that should help calibrate aerial photographs and their interpretation.

Conclusion

Our research demonstrates that using GPS-located ground photographs, geo-positioned field observations, and ortho-rectified aerial photography in concert, we were able to map the response of nitrogen application in grass seed production fields. This approach could provide farmers and researchers with reliable information to optimize nitrogen application.

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TALL AND FINE FESCUE: RELATIONSHIP BETWEEN GROWING DEGREE DAYS, DEVELOPMENTAL STAGE, AND NITROGEN ACQUISITION

S.M. Griffith and M.A. Nelson

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; for example, as was seen for tall fescue and fine fescue (Tables 1 and 2). 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.

Table 1. The relationship between accumulated growing degree days (GDD, °C) and fine fescue (cv. Bridgeport) developmental stage. Accumulated GDD corresponding with these calendar dates were calculated starting January 1 and using the centigrade temperature scale. This was recorded in the first seed production year of a spring planted crop. For the year 2000, 228, 440, 678, 979, and 1871 GDD corresponds to 15 February, 20 March, 13 April, 11 May, and 5 July, respectively.

Accumulated Growing Degree Days	Plant Developmental Stage
228	Third-leaf fully expanded - Fourth-leaf emerging
440	Fourth-leaf fully elongated
678	Boot emergence/post-emergence
979	30% Anthesis (flowering)
1871	Seed harvest

Table 2. The relationship between accumulated growing degree days (GDD, °C) and tall fescue (cv. Hounddog) developmental stage. Accumulated GDD corresponding with these calendar dates were calculated starting January 1 and using the centigrade temperature scale. This was recorded in the second seed production year of a spring planted crop. For the year 2000, 186, 312, 517, 825, 1168, and 1688 GDD correspond to 31 January, 29 February, 30 March, 27 April, and 29 June.

Accumulated Growing Degree Days	Plant Developmental Stage
186	Second leaf fully elongated; Third-leaf emerging
312	Third leaf elongated; Fourth-leaf emerging
517	Fourth-leaf elongated
825	Boot emergence
1168	Early stamen emergence
1688	Seed harvest

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. temperature + Min. temperature / 2 - Base temperature (0 °C or 32° F) = GDD. For example: If on March 3 the maximum temperature is 60 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 and 2). 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 for perennial ryegrass (Griffith and Thomson, 1997c). This is different for earlier growing species such as tall fescue (Figures 1 and 2) and fine fescue (Figures 3 and 4). Both growth and N uptake occur earlier in the season.

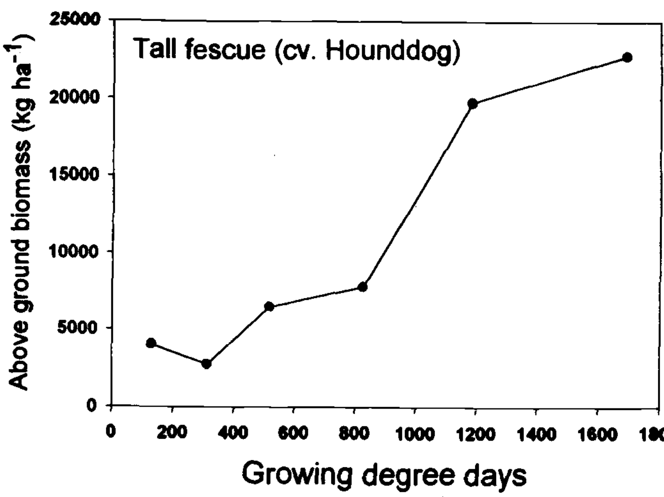

Figure 1. Tall fescue aboveground biomass accumulation, as a function of accumulated growing degree days (GDD), during the second seed production year. Accumulated GDD were calculated beginning January 1 and using the centigrade temperature scale.

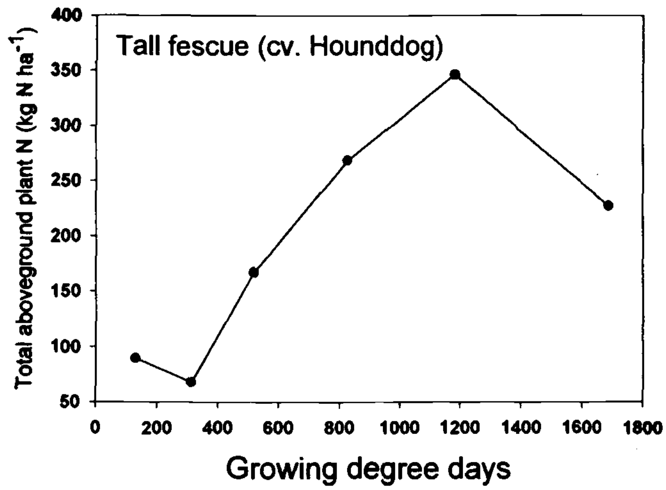

Figure 2. Tall fescue total aboveground plant N accumulation, as a function of accumulated growing degree days (GDD), during the second seed production year. Accumulated GDD were calculated beginning January 1 and using the centigrade temperature scale.

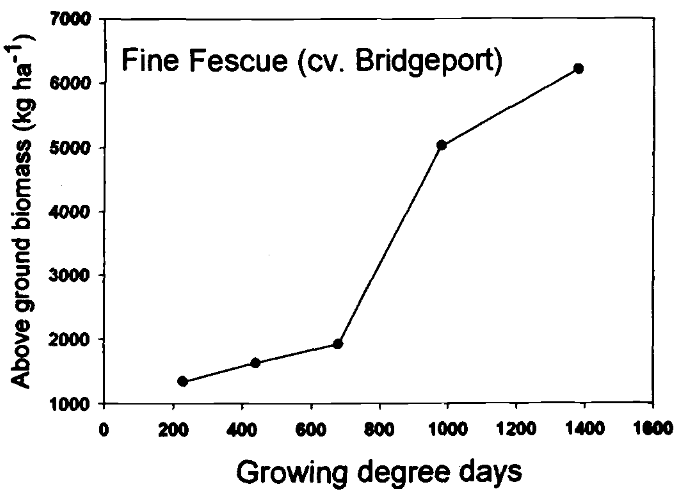

Figure 3. Fine fescue aboveground biomass accumulation, as a function of accumulated growing degree days (GDD), during the first seed production year. Accumulated GDD were calculated beginning January 1 and using the centigrade temperature scale.

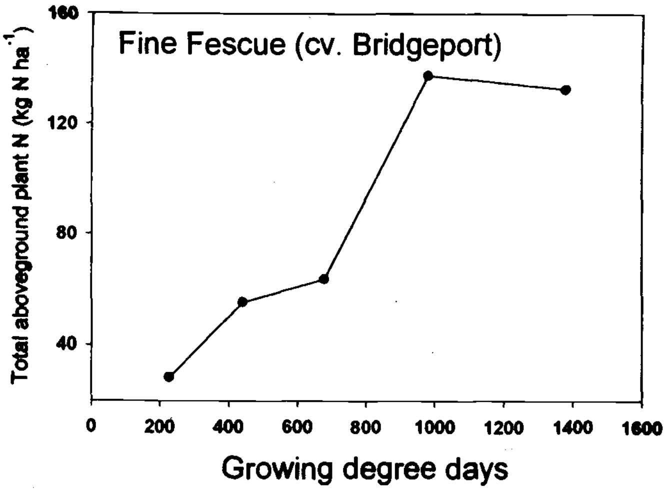

Figure 4. Fine fescue total aboveground plant N accumulation, as a function of accumulated growing degree days (GDD), during the first seed production year. Accumulated GDD were calculated beginning January 1 and using the centigrade temperature scale.

Split N applications in the spring have no seed yield advantage but may be necessary because of equipment constraints due to high fertilizer volumes necessary to meet crop needs. 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 in western Oregon from a nutritional standpoint. 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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N MINERALIZATION AS AFFECTED BY CONTRASTING SOIL DRAINAGE, TILLAGE, AND AGE OF GRASS SEED CROP

M.A. Nelson and S.M. Griffith

Introduction

The most limiting nutrient in western Oregon grass seed crops is nitrogen (N). Grass seed crops derive N from two major sources: grower applied N fertilizer and mineralized organic N in the soil. For years, the major focus of grass seed crop fertility research has been to optimize N fertilizer timing and rate, with little reference given to background N gains and losses from the soil-N cycling processes. To optimize site-specific crop fertility, one cannot use N fertilizer recommendations based on N rate trails alone. One must be able to reasonably determine the amount of N derived or lost from different N processes. To do this, an understanding of existing field conditions combined with the knowledge of how these conditions influence mineralization processes is needed for western Oregon. The focus of this research was to understand soil N inputs from mineralization processes and their relationship to crop N uptake and plant development for fine fescue grown on a well-drained soil and tall fescue on a moderately-drained soil.

Background Information

The contribution of mineralized N to grass seed crops can vary based on soil drainage class, tillage events, soil moisture, and temperature. This complexity could explain the varied response that grass seed growers show with different applied N rates under Willamette Valley conditions. Under some circumstances, little or no applied N is required for maximum seed yield, while under other situations crops may require applied N fertilizer amounts that exceed extension service recommendations. These differences have not been explained.

Soil-N mineralization is rarely measured in agricultural fields. Estimates of N mineralization when measured are often based on laboratory soil incubations under constant controlled conditions and have little relevance to environmental conditions in the field. Thus, laboratory mineralization analyses do not estimate when mineralization occurs and how it is related to crop-N demand. In contrast, methods for measuring soil-N mineralization directly in the field have been used in forest and natural ecosystems. The most commonly used method for in-field measurements relies on the incubation of soil cores within sealed polyethylene bags buried in the soil. In the absence of plant uptake and leaching of N from these buried bags, the difference in inorganic N concentrations between soil at the beginning and end of the incubation period is a direct measure of net N mineralization. The bags are assumed to reflect conditions in the surrounding soil. This methodology also allows for studies to be made in soil under variable climatic and management conditions throughout the year.

Hypotheses

We hypothesized that establishment year perennial grass seed crops using no-tillage will have net N mineralization rates lower than those found in tilled fields and that microbial biomass N will increase. Increased soil drainage will also enhance mineralization. Tillage incorporates crop residues and aerates the soil making it more conducive to soil microbial degradation and N mineralization, hence greater N loss. Following the establishment year, perennial grass seed production systems will return to a more N-conserving system that will reduced annual N mineralization losses and enhanced sequestration of N and C. With the absence of tillage during grass seed crop establishment, soil organic matter degradation will be slowed, less NO_3^- leached, greater C and N sequestrated, and more N will be available longer in the crop root zone.

Experimental

USDA-ARS research plots are located in Willamette Valley at two locations with contrasting soil drainage classifications and different grass species being grown that were established in 1992 as part of the long-term integrated agricultural systems project (www.pws.ars.usda.gov/nfsprc/steinerj.htm). One site is located on a diversified grass seed-cereal grain family farm located in the Silverton Hills region of eastern Marion County. The second site is located at the Oregon State University Hyslop Research Farm in Benton County.

The Marion County site has a Nekia-Jory Association soil, a well-drained, silty clay loam over clay and the Benton County site is a Woodburn soil series with poor to moderately drained silty loam over fine sandy loam. The Willamette Valley has a Maritime climate with hot, dry summers and cool, wet winters. The mean annual precipitation is 1114 mm with 60-70% occurring between October to April. The annual mean air temperature is 12 C°. The continuous grass treatment plots were planted in the spring to a three-year cycle with 'Bridgeport' fine fescue (Marion County) or 'Hounddog' tall fescue (Benton County). All no-till treatments were initially established in 1992.

The in-field buried bag method was used to quantify N mineralization using twenty-four incubations from September 1999 to June 2001, with an average duration of 26 days used to quantify N mineralization. An intact soil core, 5 cm diameter by 15 cm deep, was removed, sealed within a zip-seal polyethylene bag, and replaced in its original position in the ground. The bag was covered with loose soil and litter to reduce exposure. A second and third core was taken 10 to 15 cm away from the first to determine initial inorganic nitrate-N and ammonium-N.

One additional soil core per incubation soil core was taken and placed in polyethylene bags and transported to the laboratory for analyses of baseline soil properties Day-0). Two separate sub-samples from the cores were extracted with 100 ml of 0.5 M K_2SO_4, shaken for 30 minutes on a rotary shaker at 350 rpm, and filtered through a #1 Whatman filter. The filtrate was frozen for later analysis of nitrate-N, ammonium-N, and organic carbon. Nitrate and ammonium was analyzed using a Lachat Quick Chem 4200 analyzer. Additional sub-samples of soil were taken for determination of soil moisture by gravimetric methods and soil biomass (data not reported). Soil biomass C was determined using the chloroform fumigation extraction method with 48 h fumigation period (data not reported). Total organic carbon was quantified with high temperature catalytic combustion and infrared detection on a Rosemount/Dohrman DC-190 (data not reported). Soil pH was measured using a glass electrode (1:2, soil: water ratio). Soil organic matter was estimated using a loss on ignition method (data not reported).

To estimate mineralized N available to the crop, zero N plots and fertilized plots were established and temporal plant biomass and N uptake data was measured (Nelson and Griffith, 2001). These data were compared with temporal soil N and mineralization process data to determine relationships between soil N availability and plant uptake. Plant biomass was collected throughout the season at least monthly. Above and below ground plant samples were collected from three 30 x 30 cm randomly selected areas in each replicated treatment. Plant morphological development indicators were recorded throughout the season. All temporal biologic and physical data was expressed on a accumulated growing degree scale (T_{sum} scale). Plant biomass samples were forced-air oven dried at 70°C, and weighed. Plant material was ground using a Tecator Cyclotec 1093 sample mill and analyzed for total N using a Perkin Elmer 2400 Series II CHNS/O analyzer.

Preliminary Findings of Net Mineralization/Immobilization

Soil Drainage Effect

Net mineralization and immobilization (negative net mineralization rates indicate N immobilization) was greater for the well-drained Nekia-Jory soil with the fine fescue seed crop (Figure 1) compared to the moderately-drained Woodburn soil with tall fescue seed crop (Figure 2).

Tillage Effect

Conventional tillage resulted in greater net N mineralization and immobilization in the fall and spring compared to no till treatment. This was particularly pronounced for the Nekia-Jory soil (Figures 1 and 2).

Age of Stand

By the third year of fine fescue or tall fescue seed production, net immobilization was reduced (Figures 1 and 2).

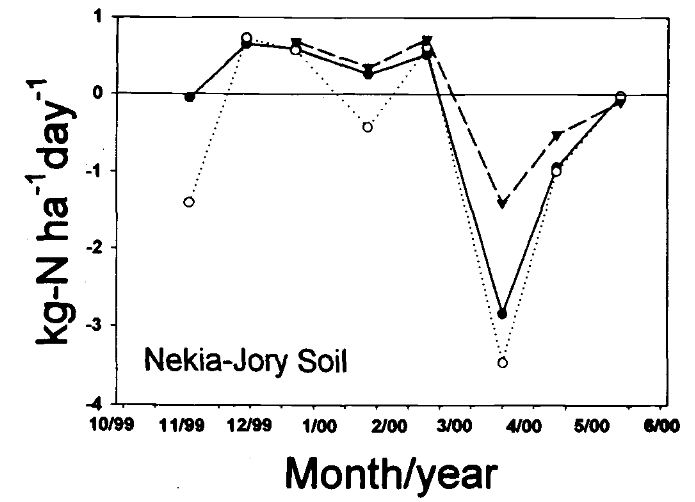

Figure 1. Temporal patterns of net N mineralization for fine fescue during the first seed-year no-till planted (closed circle), first seed-year tilled prior to planting (open circle), and third seed-year tilled prior (3 years previous) to planting (closed triangle). All crops were spring planted.

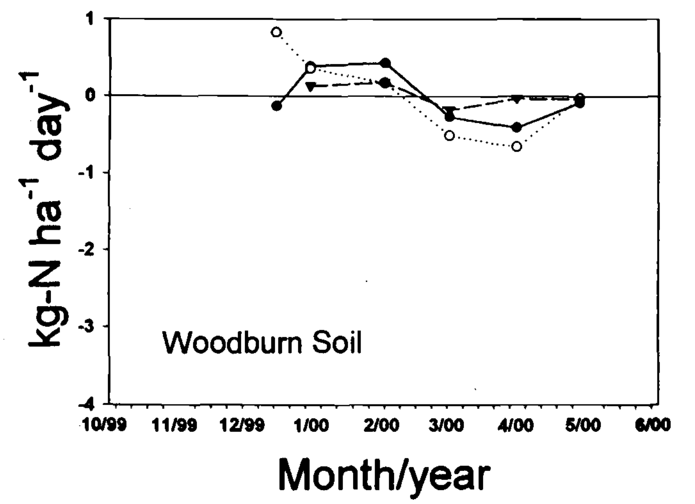

Figure 2. Temporal patterns of net N mineralization for tall fescue during the first seed-year no-till planted (closed circle), first seed-year tilled prior to planting (open circle), and third seed-year tilled prior (3 years previous) to planting (closed triangle). All crops were spring planted.

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DO GRASS SEED FIELDS IN THE WILLAMETTE VALLEY NEED BORON FERTILIZER?

M.E. Mellbye, G.A. Gingrich and J.M. Hart.

Introduction

Boron (B) is the most widespread of all micronutrient deficiencies in the Pacific Northwest. However, 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 fertilizer application to wheat or grass seed crops in Oregon. However, most grass seed fields in the Willamette Valley do not have a history of B fertilizer application and have soil test values at or below 0.3 ppm B. This study was conducted to determine if grass seed crops in the valley are responsive to B fertilizer.

Methods

To determine if boron fertilizer would increase seed yield of grass crops grown for seed, trials were conducted at nine farm locations on perennial ryegrass, annual ryegrass, and tall fescue fields. Field locations were selected that represented the range of soil types common to seed production in the region, including poorly drained clay loams and well drained river bottom soils. In one set of trials, granular Borate 48 (15% B) was mixed and applied with urea nitrogen (N) fertilizer in late March or early April at a rate of 1.25 lb B/acre. Total spring N application was 135 lb/acre for most sites (one test was at 180 lb N/acre). Plots also received 250 lb/acre of 0-15-20-10 in March.

In a second set of trials, liquid B fertilizer (Solubor 20% B) was applied to two fields of perennial ryegrass at 1.25 lb B/acre on March 21, 2000. Total spring N application in these trials was 140-150 lb N/acre. 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 were arranged in a randomized complete block design with three replications. Individual plot size was 22 to 24 feet wide x 250 to 400 feet in length to allow swathing and harvest with grower equipment. An OSU weigh wagon (Brent YieldCart) was used to measure combine yields from each plot.

Results

Boron fertilizer increased the soil test levels and flag leaf tissue concentrations at all locations (Table 1 and 2). Soil test levels were increased from an average of 0.2 ppm to an average of 0.7 ppm B. Flag leaf concentrations of B were increased from an average of 12 ppm to 32 ppm. These results were consistent with those observed in similar trials in 1999 (Mellbye and Gingrich, 1999). Both dry granular and foliar methods of B application were effective in getting this micronutrient into the grass plants. However, we have observed a more consistent increase in soil tests levels and plant tissue concentrations from dry than from foliar application of B over the two years of this study.

Boron soil tests and tissue concentrations were not related to soil pH or Ca levels in this study. Boron is most available between a pH of 5 and 7. At high soil pH and Ca levels, or at excessive K concentrations, B availability to plants can be reduced. In B sensitive crops, these nutrient interactions are most common at pH levels above 7, and typically on coarser textured soils low in organic matter. These conditions are rarely observed in grass seed production in Western Oregon. Willamette Valley grass seed fields have fine soil texture (silt and clay loams), are relatively high in organic matter for mineral soils (>4%), and even with an aggressive liming program seldom have pH levels above 6.5. Liming fields for grass seed production is unlikely to produce a B deficiency at normal rates of application.

Flag leaf tissue concentrations ranged from 9 to 16 ppm B on untreated plots (12 to 22 ppm in 1999). No visual symptoms of B or other nutrient deficiencies were observed at these tissue concentration levels. Treated and untreated plots looked the same. A critical level for B on grass seed crops is not established. Normal concentration levels for monocots are 6-18 ppm. Plant or leaf tissue concentrations below 8 to 10 ppm B are considered low for crops in the grass family such as oats, pasture grasses, Timothy, corn, and wheat (Jones, 1991). Flag leaf tissue levels from the fields selected for this study are not in the range considered deficient for other crops in the grass family.

Seed yields above Willamette Valley averages were obtained from most fields in these trials. Of the nine locations, only one showed an increase in seed yield from the B application in 2000 (a 40 lb increase). This location was one of the tall fescue sites that received granular B. In the two years of this study, only two out of fifteen sites have shown a seed yield response to B fertilizer.

Analysis of over 300 Willamette Valley soil samples in the 1950s showed 80% tested low in B, or less than 0.5 ppm of hot water extractable B. Field trials conducted at that time 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). Our current work confirms that grass seed fields commonly test below 0.5 ppm B, and often below 0.3 ppm. The lack of seed yield response indicates that B is not a widespread limiting factor on Willamette Valley grass seed fields despite soil test levels considered low for other crops.

Seed yield response from B application was obtained in only 13% of the locations for the two years of this project. Most of the locations in the trial for 2000 had equal or lower soil test B values to the site where seed yield increase was measured. Therefore, we do not recommend application of B fertilizer to grass grown for seed to increase seed yield. If you are uncomfortable with low soil test B, an application of 0.75 to 1.25 lb B/acre every three to five years may be desirable to increase soil test levels and plant content of B on soils that have B test values below 0.3 ppm. Application of granular B with dry fertilizer in the spring is an effective and easy method of applying B on grass seed fields. The range between deficiency and toxicity is narrower for B than for other micronutrients. For this reason, B should only be broadcast. It should not be band applied or put with the seed at planting. Annual applications are not recommended because they may lead to excess B in the soil.

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Table 1. The effect of granular boron fertilizer on soil test values, flag leaf tissue concentrations, and seed yields on grass seed fields, 2000.

Site	Boron fertilizer rate[1]	Crop (Variety)	Site characteristics						Boron (5-24-00)		Clean seed yield[3]
			Soil series	pH	Ca	Mg	K	OM	Soil[2]	Flag leaf[3]	
	(lb/a)				(meq/100g)		(ppm)	(%)	------ (ppm) ------		(lb/a)
1.	0	Perennial ryegrass	Dayton	6.4	13	1.1	134	5.0	0.3	12	1736
	1.25	(SR4200)	silt loam						0.5	29	1618
2.	0	Perennial ryegrass	Concord	5.8	10	0.8	112	5.2	0.1	10a	1595
	1.25	(DLF-1)	silt loam						0.9	37b	1687
3.	0	Tall Fescue	Malabon	5.7	11	3.4	385	7.5	0.2	9a	1117
	1.25	(Duster)	silty clay loam						0.3	32b	1102
4.	0	Tall Fescue	Bashaw	5.4	12	5.7	261	11.2	0.3	12a	1389
	1.25	(Kittyhawk SST)	silty clay						0.7	27b	1402
5.	0	Tall Fescue	Amity	6.4	11	1.7	135	4.8	0.2	14a	2239a
	1.25	(Tomahawk)	silt loam						0.7	30b	2277b
6.	0	Annual Ryegrass	Dayton	5.0	2	0.6	76	7.4	0.2	10a	2143
	1.25	(Gulf)	silt loam						0.5	39b	2123
7.	0	Annual Ryegrass	Awbrig silty	5.4	7	0.8	91	7.8	0.1	9a	2098
	1.25	(Gulf)	clay loam						1.4	42b	1999
	0	Mean		5.7	9	2.0	171	7.0	0.2	11	1760
	1.25								0.7	34	1744

[1]Boron applied as dry granular boron mixed with urea nitrogen fertilizer (March, 2000).
[2]Soil samples taken from each rep and bulked for analysis. No statistics performed.
[3]Paired means in columns followed by different letters are significantly different (p=0.10).

Table 2. The effect of foliar boron fertilizer on soil test values, flag leaf tissue concentrations, and seed yields on perennial ryegrass seed fields, 2000.

Site	Boron fertilizer rate[1]	Crop (Variety)	Soil series	Site characteristics pH	Ca	Mg	K	OM	Boron (5-24-00) Soil[2]	Flag leaf[3]	Clean seed yield[3]
	(lb/a)				(meq/100g)		(ppm)	(%)	------ (ppm) ------		(lb/a)
8.	0	Perennial ryegrass	Amity	6.7	13	1.3	235	6.5	0.3	13a	1846
	1.25	(Express)	silt loam						0.7	28b	1891
9.	0	Perennial ryegrass	Woodburn	5.9	6	1.3	164	4.3	0.4	16a	1885
	1.25	(Brightstar II)	silt loam						0.7	24b	1938
	0	Mean		6.3	10	1.3	200	5.4	0.4	15	1866
	1.25								0.7	26	1915

[1]Boron applied as Solubor liquid spray (3-21-00).
[2]Soil samples taken from each rep and bulked for analysis. No statistics performed.
[3]Paired means in columns followed by different letters are significantly different (p=0.10).

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 burning allowances, other economic alternatives to managing low value crops such as annual ryegrass seed production are needed. Current 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 seed 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. Growers also reduce plant density by grazing with sheep during the winter-spring period. 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 of spraying out a portion of the volunteer seedling to improve yield conditions could be a viable alternative.

This study is the second year of a 2-year experiment 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 1998. This planting was harvested in 1999 and provided the volunteer seedling population for the 2000 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 factors reported for the different grazing durations are the averages of both the sprayed and unsprayed sub-plots in each main grazed plot. The factors reported for the rowspray are the averages of all the grazing durations across each rowspray (or non sprayed) treatment. The total plot area is about five acres. Fencing was shifted once to change exclusion areas in order to control the duration for each graze treatment. A shielded row sprayer was used to spray out a nine inch wide band on twelve inch centers thus leaving three inch wide "rows." Plots were row-sprayed January 28 using Roundup Ultra at 2 qt/a applied at 50 gal/acre coverage. Sheep were moved into the field March 1 and grazed until Mid-April. Fences were shifted March 28 to expose the late grazing plots and exclude the early grazing plots. On April 15 the sheep and fences were removed. The field was fertilized by the grower April 16 with 250 lb/a 32-0-11-5 and two weeks later with 12.5 gal/acre of Solution 32.

Plots were sampled for yield components at early bloom. Swathing and combining were done by the grower on June 29 and July 14 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

In contrast to last year, seed yield was not affected by grazing or row spraying (Table 1). The total grazing period this year was much shorter (6 weeks vs 15 weeks in 1999) and therefore not as much of the winter growth was removed. Fertile tiller density was decreased and harvest index was increased by the row spraying (P=0.10), but these were not enough to make a difference in seed yield. Also, 1000 seed weight tended to be greater in the non-row sprayed treatment. The overall health and appearance of the 2000 stand was not as vigorous and fast growing as the 1999 trial. The volunteer stand did not fully fill-in the field and provide a large quantity of winter growth. The effectiveness of using grazing or row-spray methods of stand thinning need to be used when the volunteer crop is dense enough to warrant these practices for reducing plant populations to a level that is beneficial for increasing seed yield.

Table 1. Seed yield and harvest components of annual ryegrass under graze and row spray treatments, 2000.

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	1756	2.74	4.2	21	185
Early	1621	2.70	4.4	19	157
Late	1737	2.68	4.7	19	173
Full season	1773	2.72	4.6	20	225
Row-spray					
None	1689	2.75 a*	4.7	18 b	204 (a)[1]
Spray	1754	2.67 b	4.2	22 a	165 (b)

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values P=0.05.
[1] P value <0.10

ROUGHSTALK BLUEGRASS CONTROL IN PERENNIAL RYEGRASS FROM GLUFOSINATE APPLIED IN EARLY SPRING

G.W. Mueller-Warrant

Previous research identified late March to early April as the latest safe timing to apply Rely (glufosinate) in perennial ryegrass for suppression of grassy weeds. Later applications were associated with lower crop yields, especially when higher rates were used. Little or no rate response existed between 0.3 and 0.5 lb ai/acre when Rely was applied in late March. However, a strong rate response occurred with later applications, especially when Rely was applied in mid to late April. The position of the apical meristem or growing point when Rely was applied served as a good indicator of ryegrass tolerance. Applications made when the growing point was less than 0.25 inches above the ground were safest, whereas yields were clearly reduced when the growing point exceeded 1.0 inch above the ground at herbicide application. Treatments were repeated in 2000 in an attempt to verify crop growth stage at application as an indicator of safety, and to more precisely evaluate the control of roughstalk bluegrass with Rely.

Test sites in the 1999-2000 growing season at the Hyslop Field Laboratory and near Tangent, OR were treated uniformly with 2.0 lb a.i./acre Prowl plus 0.38 lb a.i./acre Axiom in early fall (October 12 at Hyslop and October 7 at Tangent) followed by 0.12 lb a.i./acre Goal plus 0.38 lb a.i./acre metribuzin in mid-fall (November 18 at Hyslop and November 17 at Tangent). This treatment combination was selected to provide excellent control of volunteer perennial ryegrass along with good suppression of seedling annual bluegrass and roughstalk bluegrass. The tests were conducted under weed-free conditions at Hyslop and in a natural infestation of annual and roughstalk bluegrass at Tangent. At Hyslop, perennial ryegrass exhibited slightly greater injury than had been seen in 1999 (Table 1). The highest rate (0.5 lb a.i./acre) reduced seed yield compared to the two lower rates at all four application dates, March 29, April 10, April 17, and April 24. Greatest injury occurred with the April 17 applications, and yield for the highest rate applied at that date was only 44% of the untreated check. April 24 applications were somewhat less injurious than the April 17 applications, perhaps due to cool, wet weather in the first week after April 24. Shortage of rainfall during May and June restricted growth by perennial ryegrass, and may have limited its ability to fully recover from the tissue destruction caused by Rely.

Injury was less severe at Tangent than it had been at Hyslop, perhaps due to the less advanced growth stage at Tangent (Table 2). The test at Tangent was located on the field edge adjacent to a drainage ditch, and crop growth in the spring was visibly delayed compared to growth of plants located at higher elevations in the same field or at Hyslop. No yield reduction occurred at any rates for the March 29 applications at Tangent, unlike the results at Hyslop. Yield was reduced by 0.5 lb a.i./acre Rely applied on April 10, but not the two lower rates. April 17 was the most damaging application date, and the highest rate reduced yield to 66% of the untreated check. Damage from the April 24 applications was less severe than the April 17 applications, similar to what occurred at Hyslop. All three rates of Rely provided excellent control of roughstalk bluegrass when applied on March 29, April 10, or April 17 (Table 3). Control for these application dates ranged from 96.5 to 99.9%, and the rate response was minimal. In contrast, there was a strong rate response for the April 24 applications, with only the 0.5 lb a.i./acre rate achieving excellent control of roughstalk bluegrass. Control of roughstalk bluegrass by Rely exceeded the control usually achieved by Horizon (fenoxaprop), and Rely would provide an excellent alternative to Horizon for control of roughstalk bluegrass in perennial ryegrass if Horizon were withdrawn from market. However, the situation would be much more problematic in tall fescue if Horizon were withdrawn because of tall fescue's poorer tolerance to Rely.

Table 3. Roughstalk bluegrass response to rate and application timing of Rely in 2000 at Tangent.

	Rely rate (lb a.i./acre)		
Application date	0.3	0.375	0.5
	------------- (% control)---------------		
March 29	98.2 a	99.5 a	99.9 a
April 10	96.5 a	98.1 a	99.8 a
April 17	96.8 a	98.0 a	99.8 a
April 24	74.2 b	80.0 b	98.3 a

*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 significant.

Growing point position can be used to predict the general impact of Rely on perennial ryegrass seed yield. If the growing point is within 0.25 inches of the soil, applications up to 0.375 lb a.i./acre should cause little or no yield loss. If the growing point exceeds 1.0 inch above the soil, substantial yield loss is likely, especially at rates above 0.375 lb a.i./acre. Exact severity of loss probably depends on rainfall and temperature patterns during the first two months after application, but can exceed 50%.

Table 1. Perennial ryegrass seed yield response to rate and application timing of Rely in 2000 under nearly weed-free conditions at Hyslop.

			Rely rate (lb a.i./acre)			
Application date	Growing point position	Crop height	0.3	0.375	0.5	Average
	(inches above soil)	(inches)	----(lb/a clean seed) ----			
March 29	0.1	4.5	1005 a*	968 ab	807 cd	927 X*
April 10	0.6	7	1001 a	932 ab	757 d	897 X
April 17	1.2	9	879 bc	714 d	484 e	692 Y
April 24	5.5	13	990 a	879 bc	701 d	857 X
Average			969 A*	874 B	687 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 significant. Seed yield of untreated check = 1113 lb/a.

Table 2. Perennial ryegrass seed yield response to rate and application timing of Rely in 2000 under moderately weedy conditions in Tangent.

Application date	Growing point position	Crop height	Rely rate (lb a.i./acre) 0.3	0.375	0.5	Average
	(inches above soil)	(inches)	(lb/a clean seed)			
March 29	0.1	3.5	1270 ab	1274 ab	1271 ab	1272 X*
April 10	0.3	4	1342 a	1340 a	1185 bc	1289 X
April 17	0.4 (1.1)†	6	1154 bcd	1056 d	874 e	1028 Z
April 24	1.3 (2.6)	9	1267 ab	1124 cd	1070 d	1154 Y
Average			1258 A	1198 B	1100 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 significant. Seed yield of untreated check = 1328 lb/a.
†Growing point position in plants located immediately west of test at slightly higher elevation.

EVALUATION OF QUINCLORAC FOR FIELD BINDWEED CONTROL AND TOLERANCE OF PERENNIAL GRASSES

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

Introduction

Field bindweed infests many fields across Oregon. Although several herbicides are available to help manage field bindweed in grass seed fields, repeated applications are usually necessary to control the parent plant and seedlings that germinate later. Quinclorac (Paramount) was recently labeled for use in grass seed crops, but no research had been conducted on seed production nor on field bindweed control in grass seed fields.

Methods

We conducted trials in established stands of 'Charger' perennial ryegrass, 'Shortstop II' tall fescue, 'Potomac' orchardgrass, and 'Dawson' creeping red fescue to evaluate visible injury to the crop and seed production. We also compared quinclorac with 2,4-D ester for efficacy on established field bindweed in perennial ryegrass. Individual plots were 8 ft by 25 ft and treatments were replicated four times in each trial. Herbicides were applied in 20 gallons of water per acre with a bicycle-wheel plot sprayer. A crop oil concentrate was added to the spray solution at a rate of 1 qt/acre. The quinclorac was applied at the maximum labeled rate and at twice the maximum rate.

The orchardgrass, creeping red fescue, and perennial ryegrass tolerance trials were treated on October 18, 1999; the tall fescue was treated on November 10, 1999. The creeping red fescue site was irrigated and treatments at the tall fescue site were applied after fall rains had commenced. The other two sites were not irrigated and the soil was dry when treatments were applied. Treatments were applied in the field bindweed trial on September 20, 1999. The field bindweed had 12- to 18-inch long runners and was flowering when treated; the soil was dry.

Visual evaluations of crop injury and bindweed control were conducted periodically following application of the treatments. Seed yields of the tolerance trials were obtained by swathing and threshing the crops with plot-scale equipment. The seed was cleaned prior to weighing.

Results

There was no visible injury on the fine fescue (Table 1), perennial ryegrass (Table 2), or tall fescue (Table 3); but there was some minor stunting of the orchardgrass (Table 4). None of the four species suffered seed yield loss from the treatments. Field bindweed control 7 months after treatment was 97% with quinclorac and 95% with 3 qt of 2,4-D ester (Table 5). By 8 months after treatment, control in the 2,4-D plots had fallen to 83%, while that in the quinclorac plots was 93%. The field was worked and replanted in the fall so no further observations were conducted.

Table 1. Visible injury ratings and seed yield of creeping red fescue following applications of quinclorac, Chambers Farm, Linn County.

Treatment	Rate	Crop injury ratings 11/24/99	12/30/99	1/27/00	Seed yield
	(lb a.e./a)	(%)			(lb/a)
Quinclorac	0.375	0	0	0	978
Quinclorac	0.75	0	0	0	920
Check	0	0	0	0	871
LSD 0.05		--	--	--	NS

Table 2. Visible injury ratings and seed yield of perennial ryegrass following applications of quinclorac, Cook Farm, Linn County.

Treatment	Rate	Crop injury ratings 11/24/99	12/30/99	1/27/00	Seed yield
	(lb a.e./a)	------------ (%)		-----------	(lb/a)
Quinclorac	0.375	0	0	0	1165
Quinclorac	0.75	0	0	0	1007
Check	0	0	0	0	1049
LSD 0.05		--	--	--	NS

Table 3. Visible injury ratings and seed yield of tall fescue following applications of quinclorac, Stellmacher Farm, Linn County.

Treatment	Rate	Crop injury ratings 11/24/99	12/30/99	1/27/00	Seed yield
	(lb a.e./a)	------------ (%)		-----------	(lb/a)
Quinclorac	0.375	0	0	0	1348
Quinclorac	0.75	0	0	0	1335
Check	0	0	0	0	1263
LSD 0.05		--	--	--	NS

Table 4. Visible injury ratings and seed yield of orchardgrass following applications of quinclorac, Lindsey Farm, Linn County.

Treatment	Rate	Crop injury ratings 11/24/99	12/30/99	1/27/00	Seed yield
	(lb a.e./a)	------------ (%)		-----------	(lb/a)
Quinclorac	0.375	0	1	1	527
Quinclorac	0.75	0	6	8	515
Check	0	0	0	0	483
LSD 0.05		--	--	--	NS

Table 5. Field bindweed control in perennial ryegrass, Conrad Farm, Linn County.

Treatment	Rate	Field bindweed control 4/20/00	5/18/00	Perennial ryegrass injury 4/20/00	5/18/00
	(lb a.e./a)	----------------- (%)		-------------------	
Quinclorac	0.375	97	93	0	0
2,4-D ester	2.8	95	83	0	0
Check	0	0	0	0	0

IS THERE A DIFFERENCE BETWEEN THE STEM RUST PATHOGENS FROM TALL FESCUE AND PERENNIAL RYEGRASS?

W.F. Pfender

The fungus that causes stem rust in grasses and cereals is *Puccinia graminis.* Within this species, there exist distinct populations that differ in morphology and/or in the host species they can infect. The pathogen that infects cool-season grasses is a subspecies known as *Puccinia graminis* subspecies *graminicola.*

The host range of *P. graminis* subsp. *graminicola* populations from perennial ryegrass or tall fescue in Oregon has not been evaluated. For optimum progress in research on resistance breeding and epidemic management, it is important to know whether the rust pathogen affecting tall fescue is the same as that affecting perennial ryegrass, and whether the population(s) can infect other grass seed crops in the region as well.

Procedures

Stem rust inoculum. Rust spores (urediniospores) were collected from multiple-cultivar field plantings in two years at each of two locations near Corvallis. Separate collections were made from tall fescue and perennial ryegrass. To eliminate the possibility that a population used for experimental inoculations could contain contaminating spores from the other host, each population was passed sequentially through two increases on highly susceptible cultivars of the appropriate host under controlled conditions in a greenhouse.

Host plants. Certified seed of cool-season grass crop species was obtained from breeders or seed companies. Seed of annual bluegrass (*Poa annua*) was obtained from a field collection. The following hosts were chosen because they are commonly grown in the region and/or have a known susceptibility to rust diseases: perennial ryegrass (*Lolium perenne*), annual ryegrass (*L. multiflorum*), tall fescue (*F. arundinacea*), creeping red fescue (*F. rubra* subsp. *rubra*), Chewings fescue (*F. rubra* subsp. *commutata*), sheeps fescue (*F. ovina* subsp. *hirtula*), hard fescue (*F. brevipila*), orchardgrass (*D. glomerata*), and Kentucky bluegrass (*Poa pratensis*). Seed of cereal grains (oats, cereal rye, barley, wheat) was obtained from the USDA ARS Cereal Disease Laboratory, who provided cultivars known to be fully susceptible to stem rust. Grasses, grown from seed in a greenhouse, were 3-4 months old when inoculated. Cereal grain plants were 7 days old.

Inoculation. For each of the two rust populations, we prepared a suspension of 5 X 10^6 spores per ml Soltrol (a light mineral oil). One ml suspension was applied per 50 plants, and there were 14 plants of each cultivar inoculated with each rust population.

Disease assessment. At 10 d and 17 d after inoculation, we recorded the infection incidence (% of plants that were infected).

Results

Host range. Under greenhouse conditions, the inoculum from perennial ryegrass could infect not only perennial ryegrass, but also orchardgrass, annual ryegrass, Kentucky bluegrass, creeping red fescue and Chewings fescue (Figure 1). It caused only limited infection (low incidence and/or small pustules) on tall fescue, sheep's fescue, annual bluegrass, barley and cereal rye.

The inoculum from tall fescue had a host range (Figure 1) that included itself, orchardgrass, perennial ryegrass, annual ryegrass, creeping red fescue and Chewings fescue. There was no sign of infection on *Poa* species or the cereal grains tested.

Infection development rate. In most cases infection development was slower for hosts infected by the tall fescue population of *P. g.* subsp. *graminicola* than for the same hosts infected by the perennial ryegrass population of the pathogen (Figure 1).

Conclusions

Results of these experiments demonstrate that there is genetic variability within *P. g.* subsp. *graminicola* in western Oregon, evidenced by differences in host range. The inoculum obtained from perennial ryegrass had a different, and wider, host range than inoculum obtained from tall fescue. In each case, inoculum consisted of the population that had been collected from diverse, field-grown cultivars at two locations and in two years, so each inoculum may include a diversity of genotypes all adapted to the particular host species. Further study would be required to determine whether the populations used are representative of populations on these two grasses throughout the region, and whether other identifiable subgroups of the pathogen occur on one or both hosts. Nonetheless, it is clear that there are subgroups that differ in important ways within the morphological subspecies.

The host range of rust pathogens in nature is generally narrower than that determined in greenhouse inoculations, and it is unlikely that cereal rye, barley, annual bluegrass, or sheep's fescue can support a *P. g.* subsp. *graminicola* population of the perennial ryegrass type in the field. Further, it appears unlikely that the population from perennial ryegrass could be supported on most tall fescue varieties in the field. In contrast, the rust spores produced on tall fescue could cause infections on either tall fescue or perennial ryegrass.

The primary conclusion of this study, that there are subgroups of *P. g.* subsp. *graminicola* differentially adapted to perennial ryegrass and tall fescue in Oregon, is important for research and implementation of disease management in these crops. In testing for host genetic resistance, the appropriate population of the pathogen must be used. Disease management approaches that are related to sources of inoculum should also be based on knowledge of the existence and host ranges of pathogen populations adapted to the different hosts.

ASSESSMENT OF *ANGUINA* AND *CLAVIBACTER* IN ORCHARDGRASS

S.C. Alderman, J.A. Griesbach and G.M. Milbrath

Anguina species are flower-infecting nematodes of cereals and grasses. In Oregon, *Anguina* can occur in bentgrass and orchardgrass. In bentgrass, the nematode causes long, needle-like, black galls in the inflorescence; each gall replaces a seed. The nematodes overwinter in the galls and in the spring emerge to infect plants.

Little is known about *Anguina* in orchardgrass. It is believed to be a different species than attacks bentgrass. Unlike the galls in bentgrass, which are many times the length of the seed, and black in color, the galls from orchardgrass are smaller than normal seed, brownish to purplish in color, and nearly impossible to see with the lemma and palea covering the seed. Often associated with the nematode is a soil dwelling bacterium (*Clavibacter*) which attaches to the nematode body and is carried into the plant by the nematode. As infection occurs the bacterium proliferates and eventually overwhelms the nematode, replacing the nematode gall with a lemon yellow colored gall containing bacteria.

In order to quantify the level of *Anguina* and *Clavibacter* in orchardgrass, a procedure was needed to remove the lemma and palea from the orchardgrass seed. A small air powered scarifier was developed in association with Mater Industries. The unit proved successful in removing the lemma and palea with no visible damage to the seed and only minor damage to the galls of *Anguina* or *Clavibacter*.

One Hundred samples or orchardgrass submitted to the OSU Seed Lab were examined for galls of *Anguina* and *Clavibacter*. For each sample, 5 subsamples (each containing 5 grams of seed) were processed in the scarifier at 50 psi for 1.5 minutes.

Fines were removed on an air column, and galls screened from the seed with a 6 X 32 mesh sieve. The galls were visually identified under a dissecting microscope. Galls were verified by placing bisected galls in a drop of water for one minute and examination for the nematodes or bacteria. Following visual inspection the sample was coarsely chopped and flooded with water. After one minute the sample was examined again for any galls missed during the first inspection. When exposed to water, the nematodes immediately begin to swell and effuse from fractured galls.

The number of seed in 25 grams was estimated after removal of the lemma and palea. Weights of 200 hand counted seed samples were used to estimate total seed in the 25 gram samples. The percentage of seed replaced by *Anguina* or *Clavibacter* was calculated. *Anguina* was detected in 48% of the samples and *Clavibacter* was detected in 40% of the samples. The number of galls per 25 gram sample ranged from 1 to 22 for *Anguina* and from 1-39 for *Clavibacter*. In no case did percent infected seed exceed 0.25% for either *Anguina* or *Clavibacter*. Although not considered a production problem, presence of *Anguina* can prohibit shipment of seed to some countries.

RESPONSE OF COOL SEASON GRASSES TO FOLIAR APPLICATIONS OF PALISADE® (TRINEXAPAC-ETHYL) PLANT GROWTH REGULATOR, 2000

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Introduction

Perennial grasses grown for seed are 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 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 Syngenta Crop Protection, Inc., on perennial ryegrass grown for seed production were conducted on older perennial ryegrass stands in 1997 and 1998. The trials resulted in substantial yield improvement (see 1998 Seed Production Research report). How well this compound works on new stands of perennial ryegrass as well as other cool season grasses (primarily tall fescue and fine fescue) grown for seed in the Willamette Valley was not known. The trials summarized in this report are for the second crop year in perennial ryegrass, creeping red fescue, and chewings fescue. The first crop year results were reported last year (see 1999 Seed Production Research report). Also, trials were conducted in 2000 on a first crop year field of tall fescue.

Procedure

Established stands of Cutter perennial ryegrass (Hyslop Research Farm), Brittany Chewings fescue (Joe Schumacher Farm) and Silverlawn creeping red fescue (Ioka Farms) entering the second seed crop year were used for this experiment. In addition, a spring 1999 planted stand of Velocity tall fescue (Hyslop Research Farm) in the first year of seed production was included. A factorial design with rate and date as main factors was used as the main experimental design. 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 several rates of trinexepac-ethyl (100, 200, 400, and 600 g a.i./ha) as a single treatment on several dates. Treatment dates were selected to coincide with defined plant growth stages. Application dates (see Table 1) for perennial ryegrass and fine fescue coincided with 2 node stage (1st date), flag visible (2nd date), early heading (3rd date) and full heading (4th date). Tall fescue applications coincided with rapid node expansion and flag leaf emergence (1st date), early heading (2nd date) and fully headed (3rd date). Plot size ranged from 10 ft x 30 ft to 10 ft x 50 ft depending on location. Stem elongation and nodal development was assessed using a weighted average of tiller size and internode expansion from random plant samples to determine treatment dates.

Plots were sampled at early bloom for fertile tiller counts, length measurements, and above ground biomass dry 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 harvest dates). Combined harvested seed samples were cleaned using an M2-B clipper cleaner for final cleanout; sub samples of clean seed were taken for 1000 seed weights.

Results

Perennial Ryegrass

Seed yield increases from the PGR treated plots averaged 25 percent above the untreated check (Table 2). Increased rates of PGR application resulted in increased seed yield up to the highest rate (600 g a.i./ha). Although the highest rate yielded the highest, the greatest incremental response occurred at the lowest two rates (100 and 200 g a.i./ha). The earliest application date gave the best seed yield response. Later applications gave less yield response though still much better than the untreated. Increases in seed yield appear to come from increased seed number potential (data not included here) and from improved conditions by prevention of lodging.

Rate x date interactions with 1000 seed weight, plant height reduction, and lodging are presented in Table 3. 1000 seed weight decreased with higher PGR application on the 1st application date and as the treatment dates became later there was no effect of PGR rate on 1000 seed weight. The cause of decreased in seed weight at the 1st application date is not apparent, but may have been a result of yield component compensation due to plant resources going to more seeds but a little less to each. The two-way interaction on plant height indicates the greatest effect of holding back growth is from the earliest treatment, and as you apply PGR later the crop has already elongated and less growth can be restricted; thus the height reduction effect is diminished. The same effect as described for the height reduction also applies to the effect on lodging as this is greatly affected by the plant height.

Fertile tiller densities and total biomass were not affected by any treatments. Harvest index (a ratio of seed yield to total biomass) tended to increase with applications of Palisade. This is to be expected as the seed yield improved with no changes in total biomass. Culm length was reduced an average of 16% with progressively shorter stems as the rate increased, especially at the early dates (see Table 3). 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. Seed moisture was within 3 percent of the untreated plots at maturity. Thus, all plots were swathed at the same time. At harvest the treated plots were still off the ground, which allowed for easier windrowing. In the higher rate PGR treated plots the windrows were smaller and had less crop residue to combine. The evidence here, and in the previous three years, indicate the best timing for yield responses would be during early internode expansion and prior to flag and head emergence. Early application was especially important if using the higher rates, but at the lower rates (100 and 200 g a.i./ha) yield was less impacted by later application dates.

Table 3. Perennial ryegrass rate x date interactions for 1000 seed weight, percent plant height reduction, and lodging when treated with Palisade PGR, 2000.

Rate	Date of application			
(g a.i./ha)	4/18	4/24	5/5	5/1
	1000 SEED WEIGHT (g)			
100	1.99 a	1.96 ab	1.95 a	1.98 a
200	1.92 ab	1.98 a	1.91 a	1.98 a
400	1.88 b	1.94 ab	1.98 a	1.99 a
600	1.86 b	1.90 b	1.98 a	2.02 a
	PLANT HEIGHT REDUCTION (%)			
100	18 b	2 c	7 b	9 a
200	16 b	11 b	11 ab	11 a
400	32 a	21 a	9 b	10 a
600	33 a	30 a	18 a	15 a
	LODGING SCORE (1-5)			
100	4.7 a	4.5 a	4.3 a	3.8 a
200	4.3 b	4.2 a	4.2 a	3.7 a
400	3.7 c	3.7 b	3.7 b	3.8 a
600	3.2 d	3.5 b	3.7 b	3.5 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

In contrast to 1999, tall fescue was very responsive to PGR applications this year. Comparison of all treated plots with the untreated was highly significant (Table 4). Overall the seed yield was increased by 650 pounds. Harvest index increased by 5% with no statistical change in total biomass, which follows with the perennial ryegrass as previously discussed. Height of treated plots was 20% less than the untreated and lodging very effectively controlled by the PGR applications. Almost no lodging occurred at all treatment rates. Seed size and fertile tiller populations were not affected by PGR applications. There were no differences in seed yield due to rate or date of PGR treatment. There was a tendency for the higher rate to have a higher seed yield, but this was not statically significant. All treatments increased seed yield over the untreated check and all application dates were equally effective (as contrasted with the perennial ryegrass). This was a first-year seed crop for this stand and continued research will be needed to determine if tall fescue will be consistently responsive to Palisade.

Creeping red fescue

Silverlawn creeping red fescue showed very good seed yield responses to applications of Palisade. Seed yield averaged a 62% increase (~700 lb/a) over the check as shown (Table 5). In addition to the factorial design there were other treatments included in the trial (and the Chewings fescue trial) that could be analyzed as a randomized complete block (RCB). Seed yield results for these treatments are shown in Table 6. There was some positive response to the higher rates of Palisade. The 400 g a.i./ha rate and 600 g a.i./ha rate were about the same, but yielded more than the 200 g a.i./ha rate. Timing of the applications at the growth stages observed had an equal effect on seed yield, though the later treatments tended to yield higher at the 100 and 200 g a.i./ha rate (Table 6). The May 22 treatment (at full heading) was not nearly as effective as the same rate at early heading and yielded about 550 lb/a less. The late application at full heading was past the optimum timing and would not be recommended in these conditions. Above ground biomass, fertile tiller density, and 1000 seed weight were not affected by the increased rates of Palisade. Harvest index was improved by 7% as is reflected by the increased seed yield. Plant height was reduced an average of 17% with the highest treatment rate (600 g a.i./ha) reducing plant height by 22%. Lodging was well controlled with all treatments keeping the crop from laying flat on the ground as fine fescue is prone to do. The results from this 2nd year continue to indicate that creeping red fescues may be a good crop species to use Palisade on.

Table 6. Response of seed yield (lb/a) to different application dates and rates of foliar applied Palisade in Silverlawn creeping red fescue and Brittany Chewings fescue, 2000.

Treatment (Date)	(g a.i./ha)	Silverlawn		Brittany	
	Check	1151	f	1190	d
April 21 – onset of internode elongation					
	200	1643	cde	1731	abc
	400	1803	abcd	1673	bc
	600	1915	abc	1762	abc
May 1 – 1-2 nodes, flag leaves visible, some heads visible					
	100	1416	ef	1739	abc
	200	1604	de	1728	abc
	400	2028	a	1957	a
	600	1978	ab	1648	bc
May 12 – early heading, about 25% heads visible					
	100	1702	bcde	1529	c
	200	1795	abcd	1738	abc
	400	1984	ab	1808	ab
	600	1990	ab	1655	bc
May 22 – all heads visible, just pre-bloom					
	400	1434	ef	1530	c
LSD 0.05		295		249	

*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 results for Chewings type fescue in this study was also very good. Palisade plots averaged 47% greater seed yield than the untreated check (~550 lb/a) as shown in Table 7. In this trial there was no statistical effect by the rate or date of the PGR application. The additional treatments in this trial included in the RCB (Table 6) show an even lower rate (100 g a.i./ha) to be equal (May 1) to intermediate (May 12) at the 200 g a.i./ha rate, indicating this crop responds well to lower rates of Palisade. The 400 g a.i./ha rate tended to yield the best with the lower and higher rates yielding less. Total biomass, fertile tiller density, and 1000 seed weight were not affected by Palisade applications at this site. Harvest index increased 5% using a contrast comparison between the treated and the check plots. Treated plant height averaged 19% less than the untreated. Lodging was well controlled and even at harvest the crop was easy to swath in the treated plots. The May 1 (flag leaves emerging) 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. Creeping red fescue, Chewings fescue, and tall fescue were the most responsive in seed yield. Seed yield in perennial ryegrass was little less responsive to PGR applications. This compound was 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 crop development to apply Palisade for maximum 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 well to later applications. The fine fescues and tall fescue have a wider range of response and do well with the range of timings tested here, but very late applications (after 25% head emergence) are much less effective. The best timing and rate for tall fescue is yet to be identified, but it seems to respond similar to the fine fescues. Fine fescues and the tall fescue sites were responsive merely to PGR applications (though the creeping fescue showed an increase with higher rate of applications) and lower rates (100 g a.i./ha) are responsive, but less than the higher rates. Each year is unique, but the responses observed in perennial ryegrass yield and lodging control were very similar to those reported last year, just not as dramatic. In these four trials, every PGR treatment yielded higher than the untreated check. This product appears to be a useful and effective tool in helping improve and realize the yield potential of these grass seed crops.

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Table 1. Calendar dates for PGR application, swathing, and combining, 2000.

Species	1-2 nodes elongation	Flag leaf emergence	Early heading	Full heading	Swath	Combine
Per. rye.	4/18	4/24	5/5	5/19	7/5	7/21
Tall fescue	--------- 4/18 ---------		4/24	5/5	6/30	7/18
Cr. red fescue	4/21	5/1	5/12	5/22	7/17	7/25
Ch. fescue	4/21	5/1	5/12	5/22	7/3	7/13

Table 2. Main factor effects of foliar applied Palisade (trinexapac-ethyl) on seed yield, harvest components, and tiller length in Cutter perennial ryegrass, 2000.

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	1259 b[3]	100	6.9	445	1.93	9	0 b	5.0 b
Treated (all)	1570 a	125	6.2	509	1.95	13	16 a	3.9 a
Rate of application								
g a.i./ha (pt/a)								
100 (0.7)[2]	1437 c	114	6.0	510	1.97 [4]	12	9 [4]	4.3 [4]
200 (1.4)	1560 b	124	6.2	518	1.95	13	12	4.1
400 (2.9)	1612 ab	128	6.1	508	1.95	14	18	3.7
600 (4.3)	1671 a	133	6.5	500	1.94	13	24	3.5
Date of application								
Apr. 18	1658 a	132	6.1	518	1.91[4]	15	25 [4]	4.0 [4]
Apr. 24	1591 a	126	6.5	497	1.95	12	16	4.0
May 5	1566 ab	124	6.3	508	1.96	13	11	4.0
May 19	1466 b	116	6.0	512	1.99	13	11	3.7

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

[2]The pint/acre rate is for the 1 lb a.i./gal EC formulation

[3]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

[4] Rate x Date interaction significant $P \leq 0.05$

Table 4. Main factor effects of foliar applied Palisade (trinexapac-ethyl) on seed yield, harvest components, and tiller length in Velocity tall fescue, 2000.

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	1072 b[3]	100	6.9	70	2.37	8 b	0 b	4.0 a
Treated (all)	1728 a	161	6.7	61	2.39	13 a	20 a	1.7 b
Rate of application								
g a.i./ha (pt/a)								
100 (0.7)[2]	1684	157	7.1	67	2.38	12	11 c	2.6 a
200 (1.4)	1687	157	6.9	58	2.39	12	15 c	1.7 b
400 (2.9)	1731	161	6.6	62	2.41	14	24 b	1.4 b
600 (4.3)	1809	169	6.3	58	2.38	15	30 a	1.2 c
Date of application								
Apr. 18	1667	156	6.1	61	2.37	14	24 a	1.6
Apr. 24	1799	168	6.9	62	2.39	14	21 a	1.8
May 5	1717	160	7.2	61	2.40	13	16 b	1.8

[1] Lodging score at harvest 1-5: 1 = vertical; 5 = horizontal
[2] The pint/acre rate is for the 1 lb a.i./gal EC formulation
[3] 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

Table 5. Main factor effects of foliar applied Palisade (trinexapac-ethyl) on seed yield, harvest components, and tiller length in Silverlawn creeping red fescue, 2000.

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	1151 b[3]	100	4.8	309	1.06	13 b	0 b	4.7 b
Treated (all)	1860 a	162	4.9	301	1.04	20 a	17 a	3.2 a
Rate of application g a.i./ha (pt/a)								
200 (1.4)[2]	1680 b	146	4.5	293	1.04	19 b	15 b	3.4
400 (2.9)	1938 a	168	5.4	318	1.04	18 b	14 b	3.3
600 (4.3)	1961 a	170	4.6	292	1.04	22 a	22 a	2.9
Date of application								
Apr. 21	1787	155	4.6	298	1.05	20	16 ab	3.6
May 1	1870	162	5.2	300	1.03	18	13 b	3.0
May 12	1923	167	4.8	305	1.04	20	21 a	2.9

[1] Lodging score at harvest 1-5: 1 = vertical; 5 = horizontal
[2]The pint/acre rate is for the 1 lb a.i./gal EC formulation
[3]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

Table 7. Main factor effects of foliar applied Palisade (trinexapac-ethyl) on seed yield, harvest components, and tiller length in Britanny Chewings fescue, 2000.

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	1190 b[3]	100	4.8	311	0.980	11 b	0 b	3.5
Treated (all)	1744 a	147	4.8	312	0.987	16 a	19 a	2.7
Rate of application g a.i./ha (pt/a)								
200 (1.4)	1732	146	4.6	321	0.985 b	16	13 c	2.6
400 (2.9)	1812	152	5.2	334	0.981 b	15	21 b	2.5
600 (4.3)	1688	142	4.4	306	1.003 a	17	31 a	2.6
Date of application								
Apr. 21	1722	145	4.5	311	0.982 b	17	18	2.8 a
May 1	1778	149	4.5	314	0.978 b	17	26	1.9 b
May 12	1733	146	5.2	337	1.009 a	15	22	2.9 a

[1] Lodging score at harvest 1-5: 1 = vertical; 5 = horizontal
[3]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

SEED YIELD ENHANCEMENT BY PALISADE: YIELD COMPONENT AND STAND AGE EFFECTS IN PERENNIAL RYEGRASS SEED CROPS

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Introduction. Palisade (trinexepac-ethyl) is a powerful growth regulator registered for use in perennial ryegrass seed crops. Palisade retards plant growth by inhibiting the 3β hydroxylation of the growth inactive form of gibberellic acid to the active form. Application of Palisade can reduce or delay lodging in perennial ryegrass. Lodging of the crop during flowering is generally thought to restrict pollination, reduce the rate of fertilization, and can later inhibit seed filling due to self-shading of the lodged crop. Very little specific information is known about how this compound enhances seed yield in cool-season grasses. A better understanding of how Palisade functions in seed yield formation would allow for greater use efficiency and economy. We would also like to know the consequences of the long-term use of Palisade since stand-age related decline in seed yield is a widespread phenomenon in grass seed production.

The objectives of our investigation was to determine how Palisade improves seed yield in perennial ryegrass and to measure the long-term impact of annual applications of Palisade on stand life and seed yield. This report outlines our progress to date on this project.

Results. An experimental field of Cutter perennial ryegrass was established in autumn 1998 at Hyslop Farm. This trial was designed to determine the long-term impacts of annual and alternate year applications of Palisade on crop yield and yield components (spike number, spikelets per spike, florets per spike) of perennial ryegrass. Eight treatments were identified to provide all possible combinations of single applications over a three-year period and were replicated in four randomized blocks. Palisade was applied in single applications each year at 400 grams ai per acre in early May 1999 and 2000.

Yield components. There was no significant effect of Palisade on spike number, above ground dry weight, or spikelet number per spike in the 1st and 2nd year crops (Table 1). Application of Palisade did increase seed yield by 25% over the untreated control in the 1st year and by 41% in the second year. An increased number of florets per spikelet likely accounted for a portion of the seed yield increase noted in Palisade-treated plots. Significant increases in floret number were noted in spikelets located in the top, middle, and bottom portions of the spike in the 1st year, but only in the middle portion in the 2nd year. Palisade also caused reduction in spike length that may have contributed to the increase in seed yield.

Table 1. Palisade treatment effects on yield components and seed yield of Cutter perennial ryegrass.

Yield component	Year 1		Year 2	
	Untreated	Treated	Untreated	Treated
Spikes/ft^2	276	277	338	308
Spikelets/spike	21	21	24	23
Spike length (cm)	22.6	19.9	21.4	20.1
Florets/spikelet				
Top	8.4	9.7	7.1	7.3
Middle	10.8	12.3	7.5	7.8
Bottom	9.1	11.0	7.2	7.5
Seed yield (lb/a)	2215	2772	1354	1912

Spikes were harvested from the field trial in the 2nd year prior to seed shattering losses to determine whether Palisade alters source-sink relations within perennial ryegrass spikes and spikelets during seed maturation. Seeds were removed from paired spikelets in the top, middle, and bottom portions of each spike, and from within the distal (upper), central (middle), and proximal (lower) portions of these spikelets (Figure 1).

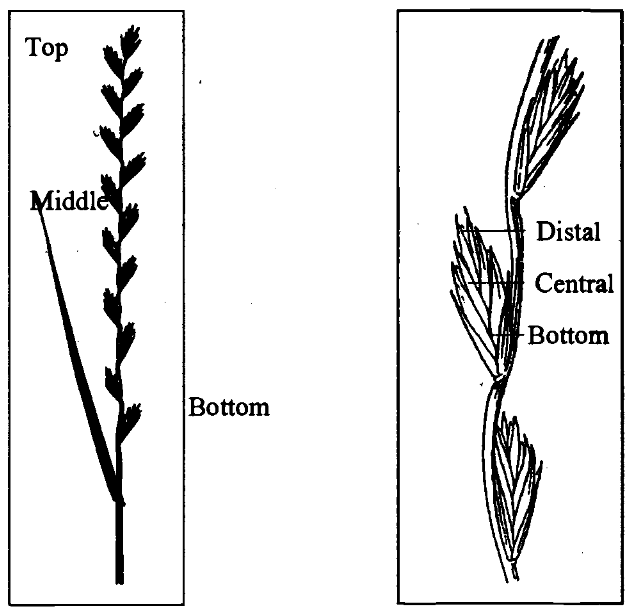


Figure 1. Seed positions within spikes and spikelets used to illustrate the effect of Palisade applications on seed partitioning in Cutter perennial ryegrass.

Floret conversion to seed (% seed set) was significantly increased by Palisade in top and middle spikelet positions within the spike (Table 2). In other words, more seed were produced in these spikelets when treated and this contributed to the seed yield increase. The greatest seed set was recorded in central and distal floret sites in Palisade-treated plots. Individual seed weight was affected by spike position and spikelet position but not by Palisade treatment. These results suggest that seed yield enhancement by Palisade resulted from increased seed number, not by increased seed weight in the 2nd seed crop.

Table 2. Effect of Palisade treatment and seed position within spikes and spikelets on seed partitioning in Cutter perennial ryegrass (Year 2).

Palisade treatment	Seed position: Spike position	Seed position: Spikelet position	Seed set	Seed weight
			(%)	(mg)
Treated	Top	---	87	1.94
	Middle	---	87	2.16
	Bottom	---	84	1.99
Untreated	Top	---	77	2.05
	Middle	---	80	2.14
	Bottom	---	80	1.95
Treated	---	Distal	76	1.68
	---	Central	91	2.10
	---	Proximal	92	2.31
Untreated	---	Distal	71	1.71
	---	Central	82	2.10
	---	Proximal	84	2.35

Seed yields were increased by Palisade in both years, but this increase was manifested via a different mechanism in each of the years. Seed number increases in the 1st year crop attributable to Palisade were based on greater numbers of florets per spikelet without an increase in seed set. Seed number in the 2nd year crop was increased through Palisade-induced increases in seed set. The ability of Palisade to increase yield by more than one mechanism contributes to the consistency of results observed with this treatment. However, it is not clear whether increased seed yield results solely from the lodging control provided by Palisade or by other effects of this compound on development of crop yield components.

Root samples taken during the winter indicate that Palisade application had no effect on root biomass density at all depths in the soil profile (Figure 2). However, shoot samples taken at this time had 8% less dry matter when treated with Palisade than in the untreated control.

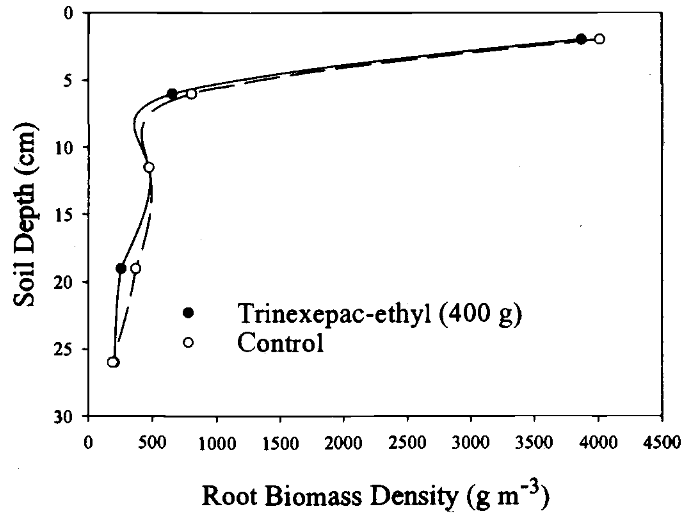


Figure 2. Palisade (trinexepac-ethyl) treatment and untreated (control) effects on root biomass distribution in Cutter perennial ryegrass.

Stand Age. Seed yields for the eight stand age treatments harvested in the 1st year (1999) and 2nd year (2000) crops are presented in Table 3. The 3rd year (2001) treatment data will be presented in the next update report.

Table 3. Effect of stand age and Palisade treatment on seed yield of Cutter perennial ryegrass through Year 2 of the trial.

Palisade treatment	Year 1	Year 2
(1st, 2nd, 3rd year)	---------(lb/acre)---------	
1. Untreated, Untreated, Untreated	2144 a†	1325 a
2. Treated, Treated, Treated	2719 b	1922 b
3. Treated, Untreated, Untreated	2785 b	1336 a
4. Treated, Treated, Untreated	2789 b	1926 b
5. Untreated, Treated, Untreated	2179 a	1922 b
6. Untreated, Treated, Treated	2209 a	1876 b
7. Untreated, Untreated, Treated	2262 a	1354 a
8. Treated, Untreated, Treated	2773 b	1399 a

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

Prior treatment of Palisade in the 1st year had no effect on seed yield in the 2nd year (Table 3). In other words, yield in the 2nd year was the same whether or not the crop was treated in the previous season. Therefore, there was no carry over effect of Palisade from the 1st to 2nd year. Palisade treatment in the 2nd year stand had more effect on seed yield than in the 1st year stand. Seed yield declined from the 1st to 2nd year regardless of treatment, but Palisade treatment in the 2nd year greatly lessened this yield loss.

Cumulative seed yield over the two seasons was 4678 lb/acre when treated with a single application of Palisade each year compared to 3543 lb/acre when not treated over the two seasons, a yield increase of 1135 lb/acre. The magnitude of this seed yield increase is essentially equivalent to the yield that might be normally harvested from a 3rd year crop of untreated perennial ryegrass. When the crop was treated in only one of the two seasons, yield averaged 4120 lb/acre or 558 lb/acre more than the untreated crop.

RESPONSE OF COOL SEASON GRASSES TO FOLIAR APPLICATIONS OF APOGEE® (PROHEXADIONE-CALCIUM) PLANT GROWTH REGULATOR, 2000

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

Introduction

Perennial grasses grown for seed are 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 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 Apogee (prohexadione-calcium), a foliar applied PGR manufactured by BASF Corporation, on perennial ryegrass grown for seed production were conducted on an older perennial ryegrass stand in 1998. The trial resulted in substantial yield improvement (see 1998 Seed Production Research report). How well this compound works on new stands of perennial ryegrass as well as other cool season grasses (primarily tall fescue and fine fescue) grown for seed in the Willamette Valley is not known. The trials summarized in this report are for the second crop year in perennial ryegrass, creeping red fescue, and chewings fescue. The first crop year results were reported last year (see 1999 Seed Production Research report). Also, trials were conducted in 2000 on a first crop year field of tall fescue.

Procedure

Established stands of Cutter perennial ryegrass (Hyslop Research Farm), Brittany Chewings fescue (Joe Schumacher farm) and Silverlawn creeping red fescue (Ioka Farms) entering the second seed crop year were used for this experiment. In addition, a spring 1999 stand of Velocity tall fescue (Hyslop Research Farm) in the first year of seed production was included. A factorial design with rate and date as main factors was used as the main experimental design. 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 as single or split treatments at several rates of prohexadione-calcium (3/16, 1/4, 3/8 lb a.i./a). Treatment dates were selected to coincide with defined plant growth stages. Application dates generally coincided with rapid node expansion with some flag leaves emerging (1st date) and early heading (2nd date). Plot size ranged from 10 ft x 30 ft to 10 ft x 50 ft depending on location. Stem elongation and nodal development was assessed using a weighted average of tiller size and internode expansion from random plant samples to determine treatment dates.

Plots were sampled at early bloom for fertile tiller counts, length measurements, and above ground biomass dry 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 harvest dates). Combined harvested seed samples were cleaned using an M2-B clipper cleaner for final cleanout; sub samples of clean seed were taken for 1000 seed weights.

Table 1. Calendar dates for PGR application, swathing, and combining, 2000.

Crop species	Flag leaf emergence	Early heading	Swath	Combine
Perennial ryegrass	4/24	5/5	7/5	7/21
Tall fescue	4/24	5/5	6/30	7/18
Creeping red fescue	5/1	5/12	7/17	7/25
Chewings fescue	5/1	5/12	7/3	7/13

Results

Perennial Ryegrass

Apogee applications to perennial ryegrass increased seed yield over the untreated check by an average 400 lb/a (32%) as shown in Table 2. Generally, yield was increased as application rate was increased. Splitting the application was not effective in increasing seed yield as it was last year (1999). Above ground biomass, fertile tiller density, and 1000 seed weight were not affected by PGR applications. The two timings used is this trial gave similar responses. Plant height was reduced an average of 14% and lodging was controlled more by the later than the earlier application. Improved seed yield without increased biomass resulted in an increase in the harvest index, a good measure of increased plant efficiency.

Tall fescue

Tall fescue was more responsive to applications of Apogee in 2000 than in 1999. The seed yield increase averaged almost 700 lb/a with the application of Apogee (Table 3) compared to the untreated check. There was no significant treatment effect from different rates or dates. There was a slight general increase (not significant) when using a split application. Fertile tiller density was not affected by the PGR applications, nor were above ground biomass and seed size (1000 seed weight). Harvest index increased by 6%, and plant height was reduced an average of 18% (with the greatest reduction from a split application). Lodging was effectively managed at all rates and dates. Very little lodging occurred in any of the treatments except the untreated check. The best lodging control was achieved at the higher application rates, the 1st date, and from the split application.

Creeping red fescue

The Silverlawn creeping red fescue site was similar in seed yield response to the tall fescue previously discussed. Treatment with Apogee increased yields an average of 455 lb/a (39%) over the untreated check (Table 4). In addition, there was significant response to a split application over a single application at the same rate with an increase of 230 lb/a (19%). Above ground biomass, fertile tiller density and 1000 seed weight were not affected by PGR treatments. Harvest index was increased 3%. Lodging was reduced more by the split application treatment than the single application, but both were effective at reducing the amount and severity of lodging. Later application at full heading (Table 5, May 22) was not as effective and yielded less than earlier applied treatments at lower rates (see Table 4).

Table 5. Response of seed yield to different application dates of foliar applied Apogee (1/4 lb a.i./a) in Silverlawn creeping red fescue, 2000.

Treatment	Seed yield (lb/a)
Check	1151
Date of application	
May 1 (single)	1417
May 12 (single)	1612
May 22 (single)	1392
May 1, May 12 (split)	1637
	NS*

*Not significantly different 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 492 lb/a (41%) as seen in the check vs treated data in Table 6. This crop was also responsive to a split application treatment of Apogee (Table 6). Above ground biomass and 1000 seed weight were not affected by the PGR applications, thus the increase in seed yield subsequently increased harvest index. Fertile tiller density remained constant. Crop lodging was decreased most by the higher rates and the single application.

Summary

All four species treated this year were responsive to Apogee applications. The creeping red, Chewings fescue, and tall fescue species were the most responsive in seed yield. Perennial ryegrass was little less responsive. This compound was 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. With all fescue crops the split application generally gave higher yields. This compound appears to work best as a split application, but the single applications also gave good yield responses. 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. 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, 2000.

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	1259[2]	100	6.9	254	1.93	9	0 b	5.0 b
Treated (all)	1661	132	6.9	217	1.92	12	14 a	4.0 a
Rate of application (lb a.i./a)								
3/16	1523	121	6.8	207	1.94	11	11	4.1
1/4	1675	133	6.8	203	1.91	13	13	4.1
3/8	1819	145	7.2	233	1.92	13	19	3.9
Date of application								
April 24 (single)	1659	132	6.4	198	1.94	13	12	4.2 b
May 5(single)	1693	135	7.2	227	1.90	12	14	3.9 a
April 24, May 5 (split)	1665	132	7.0	219	1.93	13	17	3.9 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] P-value between 0.05 and 0.10

Table 3. Main factor effects of foliar applied Apogee (prohexadione-calcium) on seed yield, harvest components, and tiller length in Velocity tall fescue, 2000.

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	1072 b	100	6.9	70	2.37	8 b	0	4.0 b
Treated (all)	1750 a	163	6.4	59	2.44	14 a	18	1.6 a
Rate of application (lb a.i./a)								
3/16	1717	160	6.9	63	2.42	13 b	14	1.6
1/4	1830	171	5.7	55	2.52	17 a	18	1.7
3/8	1726	161	6.8	64	2.37	13 b	21	1.6
Date of application								
April 24 (single)	1677	156	6.3	58	2.49	14 b	18	1.5
May 5(single)	1775	166	7.1	63	2.43	13 b	14	1.9
April 24, May 5 (split)	1821	170	6.1	61	2.39	16 a	21	1.6

*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 4. Main factor effects of foliar applied Apogee (prohexadione-calcium) on seed yield, harvest components, and tiller length in Silverlawn creeping red fescue, 2000.

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	1151 b	100	4.8	309	1.06	13[2]	0 b	4.7 b
Treated (all)	1606 a	139	5.0	297	1.03	16	12 a	4.0 a
Rate of application (lb a.i./a)								
3/16	1568	136	5.0	290	1.00	16	12	3.9
1/4	1527	133	5.0	293	1.06	16	11	4.2
3/8	1723	150	5.1	308	1.03	17	13	3.8
Date of application								
May 1 (single)	1491 b	130	4.9	303	1.03	15	9[2]	4.2 b
May 12 (split)	1721 a	149	5.1	290	1.02	17	14	3.7 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 6. Main factor effects of foliar applied Apogee (prohexadione-calcium) on seed yield, harvest components, and tiller length in Brittany Chewings fescue, 2000.

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	1190 b	100	4.8	311	0.98	11[2]	0	3.5
Treated (all)	1682 a	141	4.7	317	0.97	16	14	3.5
Rate of application (lb a.i./a)								
3/16	1602	135	4.3	285	0.98	16	13	3.9
1/4	1698	143	4.9	330	0.97	16	10	3.5
1/2	1746	147	4.9	338	0.96	16	18	3.2
Date of application								
May 1 (single)	1592 b	134	4.7	315	0.97	16	10[2]	3.5
May 12 (split)	1772 a	149	4.6	320	0.97	17	17	3.5

*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

THE EFFECT OF PLANT GROWTH REGULATORS ON SEED YIELDS OF GRASS CROPS

G.A. Gingrich and M.E. Mellbye

Introduction

The application of synthetic plant growth regulators (PRGs) is an accepted production practice on a number of agronomic crops. They are commonly used to reduce lodging and increase yields of cereal grains. In the 1980s, Parlay, a soil active growth regulator was labeled and used on commercial grass seed fields in western Oregon. However, due to its persistence in the soil and residual activity on certain rotation crops the label was withdrawn and Parlay use was discontinued.

In 1997, researchers at OSU began experimental work with a new group of PGRs on grass seed crops. These products are primarily foliar active, break down rapidly in the soil and have no activity on succeeding crops. The early trial plots on perennial ryegrass demonstrated that plant height could be reduced, lodging controlled and seed yields significantly increased. Additional small plot trials conducted in 1998 at the OSU Hyslop Field station provided similar results.

In the spring of 1999 Novartis Crop Protection, Inc. was successful in getting a registration to apply Palisade EC (trinexapac-ethyl) on a limited number of perennial ryegrass acres in western Oregon. At the same time research trials were expanded to include small and large-scale plots on several commercial seed fields though out the Willamette Valley. In addition to perennial ryegrass several other grass species were included in these studies. In 2000 the Palisade label was expanded to allow its use on fine fescue seed fields in western Oregon. A second PGR, Apogee (prohexadione-calcium), manufactured by BASF Corp. was also tested but has not yet received approval or a label for use on grass seed crops. BASF continues to pursue a registration for the application of Apogee DF on several commercial crops.

Methods

Large scale, on-farm trials were established on seven commercial grass seed fields in the Willamette Valley. Trials were conducted on fields of perennial ryegrass, fine fescue, tall fescue and orchardgrass. Trials were arranged in a randomized complete block design with three replications. Individual plots ranged in size from 20 to 24 ft. wide by 250 to 425 ft. long to fit individual fields and accommodate using grower equipment for harvest. A weigh wagon was used to determine seed yields harvested from each plot. Sub-samples of the harvested seed were collected to determine percent cleanout and calculate total clean seed weights.

The PGRs were applied with an ATV mounted boom sprayer equipped with TeeJet 11002 VS nozzles at 30 psi applying a spray volume of 14 gpa. The surfactant Preference@ 0.25% by spray volume was added to all Apogee treatments. No surfactant was used with Palisade. Application dates and crop growth stage at time of treatment for each location are listed below the data tables. All treatments were applied on the same date at each trial location except for the second treatment of the split Apogee application. There was no split Apogee or 2.0 pint/acre rate of Palisade treatment at the Plantation tall fescue and the orchardgrass sites. Growers made all fertilizer applications and treated fields with fungicides as needed. None of the fields were irrigated during the spring growing season.

Results

Perennial ryegrass. Treated plots at both locations gave significantly higher seed yields than the untreated plots (Table 1). This is consistent with similar on-farm trials conducted in 1999 where all PGR applications resulted in significantly greater seed yields. At the Palmer III site seed yields increased 10 to 16%, and on the Blackhawk site seed yields increased from 17 to 21% over the untreated checks. Although not statistically higher, the split application of Apogee yielded the highest at both locations. PGR treatments had no effect on seed cleanout percentage.

Table 1. Effect of PGR applications on seed yields of perennial ryegrass, 2000.

Treatment	Rate	Clean seed yield Palmer III	 Black-hawk	 2-site avg.
	(product/acre)	---------- (lb/a) ----------		
Check	0	2453	1285	1869
Palisade EC	1.5 pt	2745	1521	2133
Palisade EC	2.0 pt	2698	1557	2128
Palisade EC	2.5 pt	2710	1543	2127
Apogee DF	0.45 lb / 0.45 lb	2844	1558	2201
Apogee DF	0.91 lb	2811	1536	2174
Apogee DF	1.36 lb	2774	1505	2140
LSD 0.05		158	147	--

Application dates and stage of growth at treatment.

Palmer III

May 12	all treatments	2-3 nodes, flag leaves emerging
May 23	2nd Apogee only	heads emerging, some completely emerged

Blackhawk

May 5	all treatments	2 node to boot stage
May 15	2nd Apogee only	100% headed to pre-flowering stage

Fine fescue. Again in 2000 the on-farm trials resulted in significantly greater seed yields from PGR applications on fine fescue (Table 2). All treatments yielded higher than the untreated checks. Fine fescue had a greater response to PGR applications than other species included in this set of trials. Seed yield increases on treated plots ranged from 32 to 48 % over the untreated checks. Cleanout was unaffected by PGR applications.

Table 2. Effect of PGR applications on seed yields of fine fescue, 2000.

Treatment	Rate	Clean seed yield		
		K2	Southport	2-site avg.
	(product/acre)	-----------(lb/a)-----------		
Check	0	1057	1195	1126
Palisade EC	1.5 pt	1394	1766	1580
Palisade EC	2.0 pt	1485	1693	1589
Palisade EC	2.5 pt	1505	1731	1618
Apogee DF	0.45 lb / 0.45 lb	1491	1615	1553
Apogee DF	0.91 lb	1474	1615	1545
Apogee DF	1.36 lb	1516	1647	1582
LSD 0.05		169	112	--

Application dates and growth stage at treatment.

K2

May 12	all treatments	flag leaves emerged to 60% of headed
May 23	2nd Apogee only	heads mostly emerged

Southport

April 6	all treatments	flag leaves emerged to 50% of headed
May 12	2nd Apogee only	most heads fully emerged

Tall fescue. At each location all PGR treatments resulted in increased seed yields over the untreated checks (Table 3). Only the high (2.5 pt/a) rate of Palisade at the Heritage location failed to provide a significantly greater seed yield. In a similar trial on tall fescue in 1999 none of the PGR treatments provided significantly higher seed yields. Yield increases in 2000 ranged from 20 to 32% for the Heritage and 19 to 26% for the Plantation tall fescue sites. Similar to the results from the other sites there was no apparent affect of treatment on percent cleanout. *Neither PGR product tested is currently labeled for use on tall fescue.*

Table 3. Effect of PGR applications on seed yields of tall fescue, 2000.

Treatment	Rate	Clean seed yield		
		Heritage	Plantation	2-site avg.
	(product/acre)	---------- (lb/a) ----------		
Check	0	1405	2254	1830
Palisade EC	1.5 pt	1838	2796	2317
Palisade EC	2.0 pt	1838	----	----
Palisade EC	2.5 pt	1685	2781	2233
Apogee DF	0.45 lb / 0.45 lb	1859	----	----
Apogee DF	0.91 lb	1824	2675	2250
Apogee DF	1.36 lb	1843	2834	2339
LSD 0.05		417	226	--

Application dates and stage of growth at treatment.

Heritage

May 5	all treatments	2-3 nodes to boot stage
May 15	2nd Apogee only	80% headed, pre-flowering stage

Plantation

May 6	all treatments	flag leaves emerged, 30% of heads emerging

Orchardgrass. Of the four grass species included in these on-farm trials orchardgrass was the least responsive to PGR applications (Table 4). Although all treatments increased seed yields, only the high rate of Palisade provided a statistically significant yield increase over the untreated check. This is the first year of OSU trials on orchardgrass and application-timing data has not yet been developed. Additional trials are needed to determine optimum application timing and rate ranges. There was also a greater variation in the percent cleanout between treatments in the orchardgrass when compared with the other grass species. *Neither PGR product tested is currently labeled for use on orchardgrass.*

Table 4. Effect of PGR applications on seed yields of orchardgrass, var. Stampede, 2000.

Treatment	Rate	Clean seed yield
	(product/acre)	(lb/a)
Check	0	1041
Palisade EC	1.5 pt	1185
Palisade EC	2.5 pt	1241
Apogee DF	0.91 lb	1139
Apogee DF	1.26 lb	1179
LSD 0.05		177

Application dates and stage of growth at treatment.
April 14 all treatments most flag leaves emerged, <1% heads emerged

Results the past two seasons from these large, on-farm trials have shown consistent seed yield increases from PGR applications on perennial ryegrass and fine fescue. However, there has been less consistency on the tall fescue and we have only one year of data on orchardgrass. Additional trials should be conducted on both tall fescue and orchardgrass to determine optimum rates and application timing.

Acknowledgements: Appreciation is extended to Syngenta Crop Protection, Inc. and BASF Corp. for their financial assistance with this project. Appreciation is also expressed to the growers who provided the land and harvest equipment and labor for the conduct of these trials.

PRECIPITATION AND GRASS SEED YIELD IN THE WILLAMETTE VALLEY

T.G. Chastain

The climate of the Willamette Valley is uniquely suited for the production of cool-season grass seed crops. Even in this ideal climate weather events can have substantive impacts on the yield of grass seed crops. Rainfall events and short-term rainfall patterns appear to have much greater influence on seed yield than do temperature events or patterns. Furthermore, the majority of the Willamette Valley's grass seed acreage is grown without the aid of irrigation. Among the most frequently asked questions pertains to how rainfall affects yield in grass seed crops yet there has not been a systematic investigation of seed yield responses to precipitation. This article reports the preliminary results of my investigation into weather effects on grass seed yield.

The average annual seed yield in the Willamette Valley for three major perennial grass seed crops during the past two and one-half decades is shown in Figure 1. Note that the average seed yield has risen markedly for perennial ryegrass and tall fescue, and to a lesser extent for Chewings fescue. These increases are the result of the development of better management practices and also result from grass seed variety improvement efforts by the seed industry. While there has been a significant overall increase in seed yields, major fluctuations have been recorded in several harvest years during the period. These fluctuations in yield more often involve losses in yield rather increases from the long-term trend line. Are these yield variations related to precipitation events and seasonal patterns? To answer to this question, I compared these seed yields to the precipitation data base of the Oregon Climate Service for Hyslop Farm at Corvallis and at the weather recording site at Silverton.

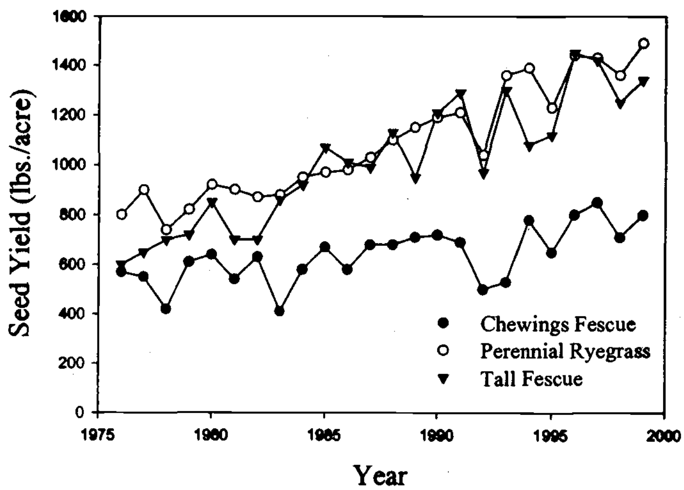


Figure 1. Willamette Valley seed yield averages for perennial ryegrass, tall fescue, and Chewings fescue during the 1976-1999 period.

The specific timing of the rainfall event or pattern is critical in determining the impact on grass seed yield. The overall or annual precipitation in a given year has virtually no effect on seed yield as some of our best seed yields have been harvested in very dry years (1985; 27.15 inches) or in very wet years (1996; 73.21 inches). Precipitation during the November through February period has little or no impact on yield unless the crop stand is lost due to flooding. The crop is usually dormant during this period and is not actively consuming much water. Rainfall during March and April may have minor effects on seed yield during a protracted drought.

The three major rainfall periods during the crop production cycle that affect seed yield of perennial grasses in the Willamette Valley are as follows:

1. September-October (Autumn Regrowth)
2. May-June (Flowering, Pollination, Early Seed Filling)
3. July-August (Late Seed Filling, and Harvest)

These periods are important because they occur during critical phases of the growth and development of the seed crop, or during harvest operations. These are listed in parentheses after each of the periods.

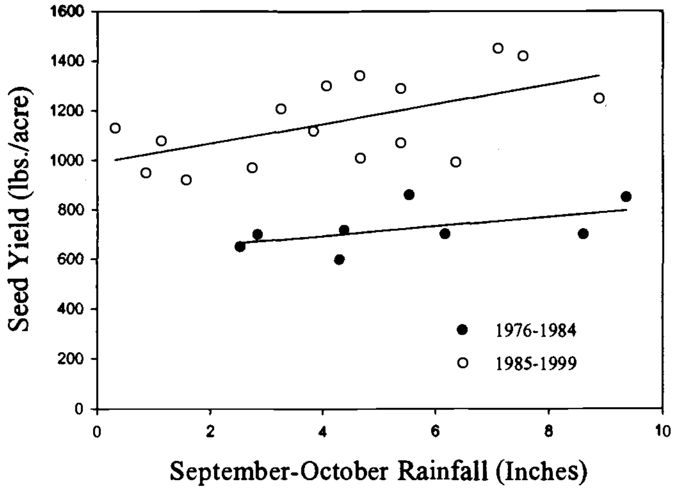
Low rainfall during September-October can result in the loss of plants in the stand (die-out) in perennial ryegrass. Furthermore, drought during this period reduces fall regrowth, which in turn, results in fewer fertile tillers produced in the following spring in both Chewings fescue and in tall fescue.

Drought during the May-June period can also result in lower fertile tiller numbers because fewer fail to fully develop. The number of spikelets and individual flowers are also reduced. If the crop is maturing early due to warm and dry conditions, then the seeds that are produced are often lighter in weight. High May-June rainfall often leads to poor conversion of flowers to seed as pollination is restricted. This situation is exacerbated by early lodging of the stand during high rainfall in this period which further restricts pollination and seed filling processes. Perennial ryegrass, Chewings fescue, and tall fescue yields are all adversely affected by either extreme in May-June rainfall.

High rainfall during July-August can cause reductions in the weight of late-maturing seed, but can also cause the premature sprouting of the seed in the windrow. Pollination of late-maturing varieties may also be restricted by rainfall events in this normally dry period. Harvest operations may be impeded directly by moisture in the crop or by regrowth stimulated in the windrows of wet fields. Removal of straw from fields after harvest by baling or by burning is often delayed by wet weather, which may affect seed yield in the following season. High rainfall events are infrequent during these months but when they do occur, problems often arise since field operations in the Willamette Valley are based on dry weather during July and August.

Nearly all the major fluctuations in grass seed yield depicted in Figure 1 may be explained by rainfall events and short-term rainfall patterns that have taken place during these three critical periods (Table 1). September-October rainfall was associated with seed yield only when the period was very dry. May-June rainfall caused low seed yields when the amounts were either high or low. High seed yields were recorded when rainfall during this period was normal to slightly below normal. Very high rainfall in July-August were associated with low seed yields. Chewings fescue and tall fescue were affected more by rainfall than was perennial ryegrass.

Relationships between rainfall in the September-October and May-June periods outlined in this article and seed yield have been identified and are similar to the one shown here for tall fescue (Figure 2). It is interesting to note that grass seed yields have gotten more sensitive to rainfall than they have in the past (Figure 2). It is unclear whether the varieties themselves are more sensitive to rainfall or that the farming practices employed today make the crops more sensitive to rainfall. One possible explanation is that modern varieties of these crops generally are later maturing than older varieties. Late maturing varieties flower and produce seed during periods with lower probability of precipitation than do varieties that mature earlier in the season.



Figue 2. Effect of September-October rainfall at Corvallis on seed yield in tall fescue in the Willamette Valley.

Maximum seed yield in Chewings fescue was attained when May-July rainfall at Silverton was about six inches in older varieties and about seven inches in modern varieties (Figure 3). Rainfall higher or lower than these amounts resulted in lower seed yields. One major exception among these relationships is that perennial ryegrass seed yields do not seem to be influenced by rainfall in the previous September-October period. However, the manifestation of stand die-out in older fields of perennial ryegrass is likely to be dependent on early autumn drought conditions. This progressive loss of stand might contribute to lower yields in older stands.

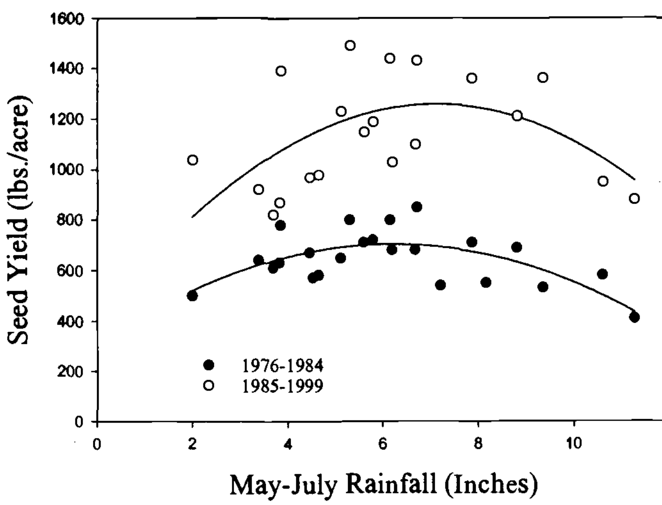


Figure 3. Effect of May-July rainfall at Silverton on seed yield of Chewings fescue in the Willamette Valley.

Forecasting seed yields based on rainfall in one or more prior critical periods may benefit those interested in future seed supply considerations. This knowledge may also be useful in modifying management practices for the purpose of better matching inputs to yield potential in dry or wet seasons. The principle relationships between critical rainfall periods (September-October, May-June) and seed yield in tall fescue outlined earlier in this article have been enumerated (Table 2). Average seed yields in the Willamette Valley have been converted to percentages of the average or base yield under the conditions depicted in the table. This approach obviously ignores variability in yield responses among varieties (one variety may be more drought tolerant than another); however, yield data for individual varieties is not available. Also, the responses of tall fescue seed crops on different soil types cannot be considered in this approach. Users of this table can determine rainfall effects on tall fescue seed yield by calculating the percentage gain or loss given the seasonal rainfall level indicated in the table. For example, suppose that September-October rainfall is 4 inches and May-June rainfall is 2 inches, then the available rainfall would reduce seed yield to 92% of normal. If the average yield is for your field is 1000 lbs./acre, then the expected seed yield would be 920 lbs./acre.

Information on rainfall effects in other grass seed crop species will be presented in future reports.

Table 1. Precipitation involvement in selected fluctuations in seed yield of Willamette Valley grass seed crops. Precipitation values in bold are related to the seed yield response for a given crop year in bold.

Crop Year	Precipitation (% of normal)			Seed yield response		
	Sept.-Oct.	May-June	July-Aug.	Perennial ryegrass	Chewings fescue	fescue
1978	54	118	**191**	Normal	**Low**	Normal
1980	94	**83**	18	**High**	Normal	**High**
1981	201	**144**	8	Normal	Low	Low
1983	185	75	**344**	Normal	**Low**	Normal
1984	119	**207**	14	Normal	**Low**	Normal
1985	34	**82**	74	Normal	High	High
1989	**7**	68	87	Normal	Normal	Low
1992	116	**30**	117	Low	Low	Low
1993	59	**171**	80	Normal	Low	Normal
1995	**25**	98	97	Low	Low	Low
1998	162	**175**	7	Low	Low	Low

Table 2. September-October and May-June rainfall effects on tall fescue seed yield in the Willamette Valley. To use: find the point where the two rainfall periods intersect and multiply the percent gain or loss by your average seed yield.

Sept.-Oct. rainfall (inches)	May-June rainfall (inches)							
	0	1	2	3	4	5	6	7
0	68	73	78	83	89	94	99	104
1	72	77	82	87	93	98	103	114
2	75	80	85	90	96	101	106	117
3	79	84	89	94	100	105	110	121
4	82	87	92	97	103	108	113	124
5	85	90	95	100	106	111	116	127
6	89	94	99	104	110	115	120	131
7	92	97	102	107	113	118	123	134
8	96	101	106	111	117	122	127	138
9	99	104	109	114	120	125	130	141
10	102	107	112	117	123	128	133	144

METHODS TO MEASURE GEESE IMPACTS ON GRASS SEED PRODUCTION

M.M. Borman, M. Louhaichi, D.E. Johnson and W.C. Krueger

Introduction

Conservation programs have resulted in an increase of Canada goose (*Branta canadensis*) wintering and resident populations in the lower Columbia River and Willamette River Valleys of southwest Washington and western Oregon. The increase has been from approximately 20,000 to 25,000 in the 1970s, historical average, to over 225,000 by 1996 (Oregon Department of Fish and Wildlife, 1998).

From autumn to spring, geese prefer to eat wheat (*Triticum aestivum*), peas (*Pisum* sp.), clover (*Trifolium* sp.), corn (*Zea mays*), grass seed, and other farm crops. Substantial crop damage has been reported by farmers and the Oregon Department of Agriculture (Oregon Department of Agriculture, 1998).

Results of several studies differ on the extent and impact of geese foraging on wheat and other crops. Clark and Jarvis (1978) suggested that goose grazing did not adversely impact production of annual ryegrass (*Lolium multiflorum*) seeds in the Willamette Valley, Oregon. However, in other studies, geese have reduced yields of winter wheat in relation to intensity of grazing (Allen et al., 1985; Flegler et al., 1987) and to timing of grazing (Kahl and Samson, 1984).

Significant yield losses in grass and cereal crops have been reported at a wide range of grazing levels by geese (Patterson, 1991). However, estimating loss of yield at specific levels of grazing was difficult. Patterson (1991) suggested that exclosures should be used to measure actual yield losses.

Recent technologies such as Geographical Information Systems (GIS) and Global Positioning Systems (GPS) provide new opportunities to more accurately measure crop yields and damage caused by wildlife or other factors. GIS has the ability to spatially interrelate multiple files or data layers once the layers are in geographic registration (Lillesand and Kiefer, 1994). With GPS we can accurately determine the position of every sample point. Combining these technologies provides visual representations of changes through time (Anderson, 1996) and provides the tools necessary to create yield maps.

During 1996 through 1998 we conducted a preliminary study on winter wheat to develop methods to document when and where geese were grazing on the test fields and to measure the impact of goose grazing on crop yields. A combination of methods proved effective for documenting goose grazing activity and measuring the impacts of grazing on wheat yields. Our methods included:

1. We constructed exclosures with poultry wire and electric fence posts to keep geese from entering small areas scattered throughout the test fields. These areas served as controls that provided the basis for knowing wheat production without goose grazing impacts. The exclosures were large enough for a commercial-size combine to harvest through them.
2. We took aerial photographs through the growing season to see plant cover differences within the fields. Cover differences were generally due to goose grazing impacts, but were also due to soil differences and to standing water.
3. We used ground-level photography and data collection to serve as ground truth verification for causes of the cover differences seen in the aerial photographs.
4. We used a yield-mapping-system equipped combine to record wheat yields throughout the field.

Our results demonstrated that grazing by geese impacts wheat yields (Louhaichi, 1999). Yield reductions were as high as approximately 25% for areas of fields heavily grazed in April, before geese departed for the summer. Lower levels of yield reductions were measured for less intensive grazing or earlier grazing. We recorded specific instances where yields increased, apparently due to goose grazing. We were able to measure impacts on yields for whole fields and for portions of fields subjected to different timing and intensity of grazing by geese.

During September 1999, we initiated a subsequent study to evaluate the methods we developed for wheat for their suitability for use on grass seed fields. Our objectives are to:

1. Identify timing (both season and frequency) and intensity of goose use of selected grass seed fields.
2. Develop reliable methods that farmers can use (or contract out) to document the impact on yield.
3. Provide an estimate of goose impact on grass seed yield on specific fields during the research period.

Timing of plant growth and maturity and harvest procedures are different between wheat and grass seed production. Those differences are likely to require modifications of methods developed for wheat.

Methods

1. Goose-proof exclosures paired with naturally grazed plots are concentrated in parts of the fields in which heavy grazing is anticipated. Others are located in areas anticipated to have moderate to light grazing. Exclosures serve as controls. They have to be large enough to avoid edge effects and to allow a commercial combine to harvest through them.
2. Ground photos are taken from a camera mounted on a frame constructed to place the camera directly above, and at a given height from, ground level. Ground photos and associated data (e.g. goose droppings, plant height, category of grazing intensity, etc.) serve as ground-truth verification of cause of reduced yield where it occurs.
3. Aerial photos taken of entire fields to show grass cover differences within fields at field scale. Ground-truth photographs verify cause of cover differences.

4. Combines equipped with precision-farming, yield-mapping systems (John Deere GreenStar Precision Farming System or its equivalent) to map yields adjacent to and including the goose-impacted portions of the field(s).

Progress

We are cooperating with a mid-Willamette Valley farm, which has provided fields subject to goose grazing pressure for use in the project. During September and October 1999, we selected three tall fescue and two perennial ryegrass fields for the study. Of the three tall fescue fields, one was a new seeding, one was a second year seeding that had been intensively grazed during its first year, and the third was an established field which has been consistently subject to heavy grazing pressure. Of the two perennial ryegrass fields, one was newly seeded and the other was an established field, part of which has been consistently subject to heavy grazing pressure. We established 20 x 65-feet exclosures in all fields. A total of 48 exclosures were installed, numbers per field varied by field size.

We conducted ground-level photography and data collection along transects within each field during December 1999 and March and April 2000. We took aerial photographs from a camera mounted on a fixed-wing aircraft during December, January, March and April, while geese were present, and during July, between swathing and combining of the grass seed. In the newly seeded fields, grass had not yet grown sufficiently to show in the aerial photographs until March.

Crops were swathed beginning in early July and continuing through most of the month. Combining commenced during mid-July and continued through early August on the fields we were using. Each exclosure had one or two swaths through it. Depending on the field and crop, five to nine combines operated in a field. Of those, four were equipped with yield-mapping systems. Two of those were GreenStar® systems and two were AgLeader® systems. We encountered data recording and reporting differences between the GreenStar® and AgLeader® systems.

For the 2000-2001 field season, we returned to three of the five fields we used the previous year. The other two were only slightly used and will be of little benefit in terms of methods development unless they receive heavier use this year. We added one established tall fescue field that was heavily used last year and one newly-seeded tall fescue field. We erected exclosures in all 2000-2001 fields. Number of exclosures per field varies by size of field. We placed exclosures in the same locations as last year on the fields we used last year. In March we will add additional exclosures in areas that have been grazed to enable us to better evaluate early season grazing.

In addition to techniques we used during Phase I on wheat, we are attempting to automate data collection and analysis. If we are successful, we will have better ground coverage of the fields and we will be able to more quickly analyze and interpret data.

Preliminary Results and Discussion

In the preliminary study on wheat, we used a single combine equipped with a yield-mapping system. The analysis was fairly straightforward. In this study, we are using four combines and two different yield-mapping systems. We have machine-to-machine and system-to-system variability to consider in statistical analysis. We are still working at identifying the most appropriate analysis for the type of sampling involved with this study. Initial, very preliminary, data analysis for a portion of the newly seeded perennial ryegrass field indicates that grazing by geese in April reduced seed yield by 11 to 27%. Because we are still refining our analysis procedures, these numbers are subject to change.

Calibration of the yield-mapping system is an important process for reducing system-to-system and machine-to-machine variability.

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CRANE FLIES, AN EMERGING PEST COMPLEX IN GRASS SEED FIELDS

S.U. Rao, G.C. Fisher and L.A. Royce

We are currently studying the crane fly complex in grass seed fields to determine the biology, seasonal occurrence and extent of damage caused by these insects. The non-native species, the European crane fly, *Tipula paludosa,* has been in the Pacific Northwest for several years (Jackson and Campbell, 1975) while the closely related *T. oleracea* appears to be a recent introduction. In addition, several species of native crane flies are present in and around grass seed fields. These crane flies have not previously been associated with damage.

Procedures

Crane fly larvae collected in the winter of 2001 were reared in the laboratory until adult emergence using procedures described by Wiegers *et al.* (1992). The larvae were collected from grass seed fields in the Willamette Valley and from a dryland wheat field near Heppner in the Columbia Basin.

Results

An identification key by Brindle (1960) that separates the larvae is not suitable for Oregon or Washington. Certain characters listed in the key appear to be influenced by habitat, and larvae collected from the same habitat are, at times, indistinguishable. Hence adult characters need to be used for species identification.

Adults from larvae collected in the Willamette Valley and the Columbia Basin were identified as native *Tipula* spp. In addition, a crane fly collected from a tall fescue field in the Valley was identified as *T. oleracea*. This is perhaps the first record of *T. oleracea* collected from a commercial grass field in Oregon.

Based on the literature, and our observations, the following information is presented about crane flies in Oregon:

Identification: Adult crane flies look like large mosquitoes and are called 'mosquito hawks'. However, they do not feed, nor do they bite, pierce or sting. They tend to emerge in large numbers over a short period of time. They are weak fliers and often accumulate on buildings downwind of infestations. Crane fly larvae live in the soil around roots or below straw. They are gray-brown, 24 to 38 mm long when fully grown, and are called "leather jackets" because of their tough skin. Young or small crane fly larvae are often confused with March fly larvae that do not cause direct damage to plants.

Life cycle: *T. paludosa* has one generation per year. Adults appear in late summer and early fall. Females mate and lay eggs immediately. Eggs usually hatch within two weeks and young larvae commence feeding in late fall. Feeding is reduced in winter except on warm days but is resumed in early spring. In contrast, adults of *T. oleracea,* and at least one native *Tipula* sp., emerge in early spring. *T. oleracea* adults have also been collected in the fall indicating that the species either has bimodal emergence or two generations a year. *T. oleracea* is a new introduction, and there is little additional information about its biology. The biology of native crane flies also remains relatively unknown.

Detection: Crane flies are found in pastures, lawns, turfgrass and commercial grass seed fields as well as in clover, peppermint and a few other crops. The larvae appear to feed on organic matter in the soil, and on the roots and crowns or stems of grasses and other host plants. The extent of damage caused can be extensive but is variable. It appears that some plants such as many grasses are able to compensate for damage. Other pests in the soil such as cutworms, slugs and sod webworms produce damage similar to that caused by crane flies.

Control: Larval populations often decline considerably in fall and spring due to natural mortality and predation by birds, moles and probably other organisms. Chemical control with chlorpyrifos provides excellent suppression of larvae when applied to crops appearing on its label.

Summary: Considerable controversy exists about the damage crane fly larvae cause to crops. Some turf specialists believe that they do not injure crowns, reduce stands or affect the aesthetics of well-managed turf and lawns. This is assuming all other pests are reasonably suppressed and the grass is in 'good health'.

Our current studies are designed to determine the nature of crane fly injury to grasses, particularly those varieties grown for seed under non-irrigated conditions. Appropriate management techniques are to be researched as well.

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GRASS-FEEDING MOTHS COLLECTED IN COMMERCIAL KENTUCKY BLUEGRASS FIELDS OF CENTRAL AND EASTERN OREGON, 2000

M.D. Butler and P.C. Hammond

A detailed study of moths collected in black-light traps was conducted in the Grande Ronde Valley near La Grande and near Madras and Culver in central Oregon during 2000. This study expands on an earlier three-year study of field sites on the Rathdrum Prairie in Idaho, sites in Jefferson County in central Oregon, and sites in the Grande Ronde Valley of Union County in northeast Oregon from 1996 to 1998. The previous work was more qualitative, while the present study specifically examines the quantitative abundance of various species of moths over a longer time period.

Three fields were collected in the Grande Ronde Valley (Coventry, Abbey North, Abbey South) on June 13, June 22 and June 27. Likewise, three fields were collected in Jefferson County of central Oregon (Kelly, Geronimo North, Geronimo South,) on June 12, June 21, and June 26. Moths were sampled using a single universal black light trap placed 100 feet from the edge of each field at dusk and insects were collected the following morning. A Bio-Strip 2½ x 6 inches fumigant strip was placed in the bottom of the traps to kill the moths. Moths were placed in 1 gallon zip-lock bags and refrigerated until placed in a freezer. They were later thawed and identified by Paul Hammond.

A total of nearly 30,000 moths (29,997) were collected at all sites during this study. This included 58 moths representing 16 species that feed on herbs and hardwoods, and were merely strays flying through the area. By contrast, 29,939 moths of 11 species that feed on grasses were collected in these fields. Of the latter number, 29,772 (99%) were *Protagrotis obscura* and only 167 (1%) comprised the remaining 10 species.

Table 1 shows the total numbers for all grass-feeding moths collected at each site in 2000. *Protagrotis obscura* was quite abundant in the central Oregon fields, but numbers were modest compared to the extraordinary massive numbers of this species found in the Union County fields. The Coventry field in particular produced 14,733 individuals of *P. obscura* including 9,431 in a single trap from a single night. This must represent a substantial amount of bluegrass biomass that was converted into moth biomass within this field. In dramatic contrast, the remaining 10 species were collectively quite insignificant in numbers, and only 6 species were even frequent to moderately common.

Post-harvest field burning may be an important limiting factor for these latter species. Most moths lay their eggs in dead or live vegetation on the ground, which then overwinter either as young larvae or dormant eggs. Field burning cultural practices would normally kill most of these early stages, and few larvae would probably survive to become adult moths the following year. However, *P. obscura* tends to be a subsurface burrower in the soil, and eggs and larvae may be well protected from fire within the soil. In the absence of competitors and alternate hosts for predators and parasitoids, *P. obscura* may be free to expand into the massive population levels observed in this study.

Still, it is quite interesting that smaller numbers of *P. obscura* occurred in the central Oregon fields, suggesting that some limiting factor may be severely impacting the central Oregon populations that is absent from Union County. Clearly, the biology and ecological interactions that may affect the reproductive success of the species must be complex. One potential factor could be flocks of exotic European starling (*Sturnus vulgaris*) which are ground foragers on soil invertebrates. Although this bird is usually considered to be a noxious pest itself, it could be an important biocontrol agent against soil cutworms in agricultural field systems.

Of the other species, two climbing cutworms and two soil cutworms were also present in both central and eastern Oregon fields. Of the climbing species, *Aletia oxygala* was fairly common in Union County fields while *Leucania farcta* was less common. Likewise with the soil cutworms, *Crymodes devastator* was common while *Apamea amputatrix* was less frequent. *Agroperina dubitans*, a soil cutworm previously found to be quite common on the Rathdrum Prairie in Idaho, was present but very rare in Union County and did not occur in the Jefferson County fields.

Two species of sod webworm pyralid moths were also collected in this study. *Chrysoteuchia topiaria* (cranberry girdler) was frequent in northeastern Oregon, particularly in the Abbey North field, but did not appear in central Oregon fields. A second species of sod webworm, *Pediasia dorsipunctella*, occurred in both areas but was not common.

Two species of grass-feeding cutworm moths appeared in 2000 that were not seen during the 1996-1998 study. *Apamea cuculliformis* is a normally rare species, and was probably just incidental in the bluegrass fields. However, *Dargida procincta* was collected in both central and eastern Oregon during the 2000 field season. This species has an early flight season, and was probably missed during the previous study where collections were only made in late June. Kamm (1985) found *D. procincta* to be an important pest of ryegrass seed fields in the Willamette Valley of western Oregon. This species is not strongly attracted to black-light traps, and it was probably more common than the numbers in Table 1 would indicate.

Seasonal population dynamics for the most common cutworms are illustrated in Figures 1-5. Figure 1 shows that numbers of *Protagrotis obscura* were consistently higher in the Union County fields compared to the Jefferson County fields during 2000. Numbers gradually increased through June in the Union

County fields, and dramatically increased in the Coventry field by June 27.

The remaining cutworm species only occurred in sufficient numbers within the Union County sites to be considered in Figures 2-5. *Apamea amputatrix* (Fig. 2) was absent or at very low numbers except for a slight increase in the Coventry field in late June. *Crymodes devastator* (Fig. 3) showed a similar pattern but increased in all three fields in late June, again with the Coventry field having the highest numbers. *Leucania farcta* (Fig. 4) was absent until late June when low numbers occurred in all three fields. *Aletia oxygala* (Fig. 5) was absent or rare in early June, gradually increased in mid-June, and greatly increased in all three fields by late June. Again the Coventry field showed a particularly dramatic increase of *A. oxygala* in late June.

In summary, all grass-feeding moths were at moderate numbers (*Protagrotis obscura*) or extremely low numbers (all other species) in the Jefferson County fields. By contrast, most species occurred at proportionately much higher numbers in the Union County fields, with 99% of these moths consisting of *P. obscura*. All species in Union County fields increased in abundance through June with the highest numbers occurring in late June. The Coventry field produced proportionately parallel increases in four species that became particularly dramatic by the end of June, including *P. obscura, Apamea amputatrix, Crymodes devastator, and Aletia oxygala.*

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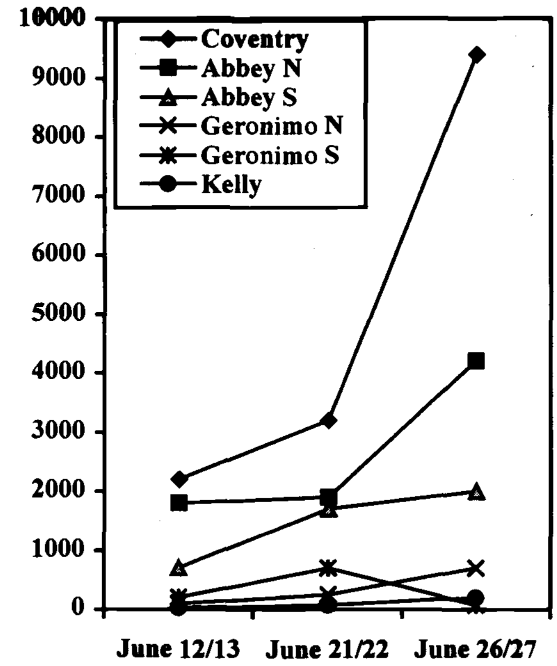

Figure 1. Seasonal emergence numbers of *Protagrotis obscura* in Kentucky bluegrass fields at each site in 2000.

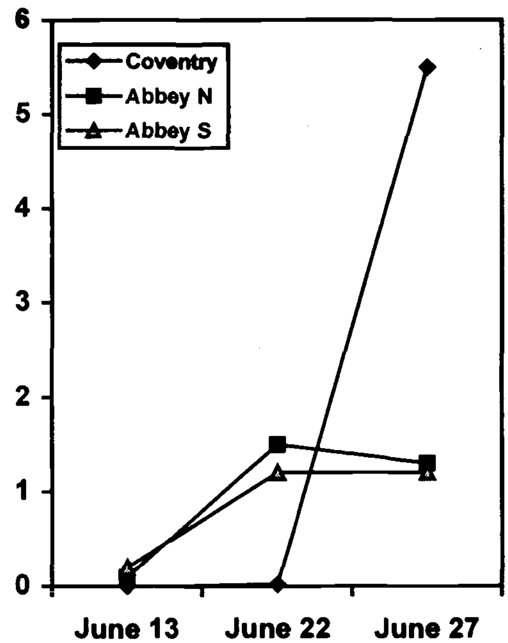

Figure 2. Seasonal emergence numbers of *Apamea amputatrix* in Kentucky bluegrass fields at Union County sites in 2000.

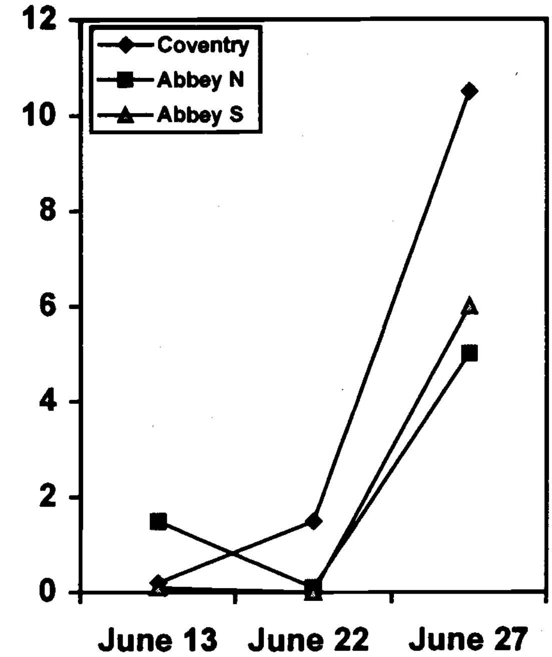

Figure 3. Seasonal emergence numbers of *Crymodes devastator* in Kentucky bluegrass fields at Union County sites in 2000.

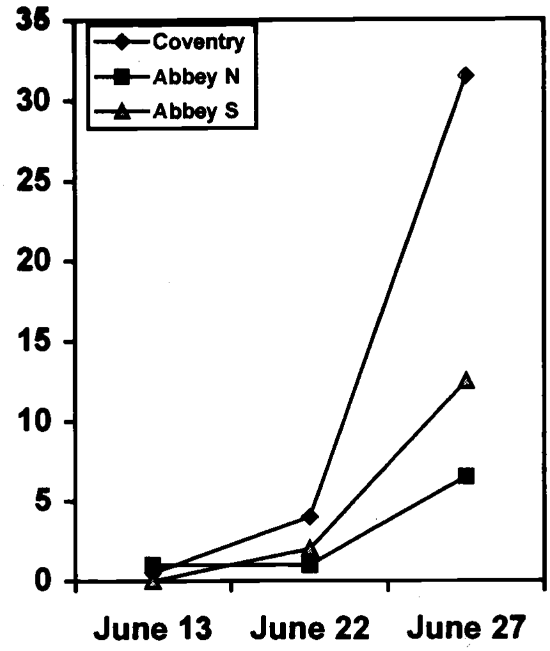

Figure 5. Seasonal emergence numbers of *Aletia oxygala* in Kentucky bluegrass fields at Union County sites in 2000.

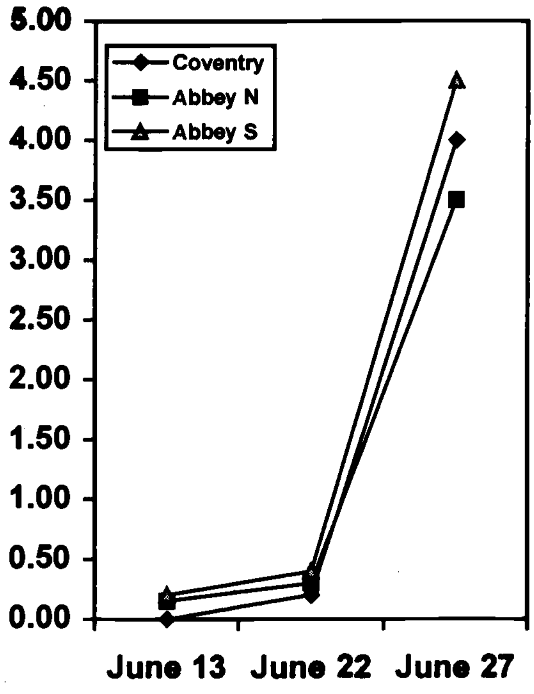

Figure 4. Seasonal emergence numbers of *Leucania farcta* in Kentucky bluegrass fields at Union County in 2000.

Table 1. Total number for all grass-feeding moths collected at each site in 2000.

Genus species	Union County			Jefferson County		
	Abbey North	Abbey South	Coventry	Geronimo South	Kelly	Geronimo North
Protagrotis obscura	8051	4568	14733	845	586	989
Apamea amputatrix	2	2	6	0	0	1
Apamea cuculliformis	0	0	0	0	1	0
Agroperina dubitans	1	0	0	0	0	0
Crymodes devastator	6	6	11	1	0	4
Chortodes rufostrigata	0	0	0	1	0	0
Aletia oxygala	8	14	35	1	1	1
Leucania farcta	4	4	4	3	1	0
Dargida procincta	1	1	0	0	1	0
Chrys. topiaria	7	27	3	0	0	0
Ped. dorsipunctella	2	4	2	0	0	1
Total	8082	4626	14794	851	590	996

EVALUATION OF FUNGICIDES FOR CONTROL OF POWDERY MILDEW IN KENTUCKY BLUEGRASS IN CENTRAL OREGON, 2000

M.D. Butler

Fungicides were evaluated for control of powdery mildew in Kentucky bluegrass during 1998 and 1999. The new fungicides Quadris, Folicur and Rally (Laredo) were compared to industry standards and other registered fungicides. During 2000 the first objective was to evaluate the fungicides applied at the first sign of disease infection, some of which were applied in combination with sulfur (Microthiol). The second objective was to evaluate fungicides applied after moderate levels of powdery mildew had developed as in previous years. In addition to being able to evaluate each set of plots separately, the performance of fungicides could be evaluated for differences in application timing.

Fungicides were evaluated for control of powdery mildew in commercial fields of Kentucky bluegrass ('Merit' and 'Geronimo') grown for seed near Madras, Oregon. The fungicides Rally (Laredo), Tilt, Stratego, Folicur, Bayleton, and Quadris plus Microthiol were applied to 10 x 25 foot plots replicated four times in a randomized complete block design.

The first set of plots had treatments applied at the first sign of disease on April 8, and re-applied on May 19 when the disease began to rebuild. Treatments for the first and second applications were the same except for treatments 3 and 4, which were initially treated with Tilt but were followed by Quadris at 6 oz/a plus Microthiol and Quadris at 9 oz/a plus Microthiol, respectively. The second set of plots (adjacent to the first plots in the same two fields) were treated April 26 once powdery mildew was established. All fungicide treatments were applied with TeeJet 8002 nozzles on a 9-ft, CO_2 pressurized, hand-held boom sprayer at 40 psi and 20 gal of water/a. Crop oil concentrate at 1% v/v was applied with fungicides to the first set of plots, while Sylgard 309 was applied at 0.25% v/v with fungicides to the second set of plots.

Plots were evaluated using a rating scale from 0 to 5, with 0 being no mildew present and 5 indicating total coverage. Since the first set of plots were treated at the first sign of disease, no pre-treatments evaluations were made. These plots were evaluated April 17, April 24, May 2, May 10, May 18, May 26 and June 2. The second set of plots were evaluated before treatment April 25 and following treatment on May 3, May 10, May 17, May 24 and May 30.

In the early set of plots (Tables 1 and 2) all fungicides significantly reduced disease compared to untreated plots. All fungicides provided similar protection. On some evaluation dates there were significant differences between fungicides, with Quadris plus Microthiol providing less control and Tilt alone or in combination with Microthiol and Rally (Laredo) applications providing better control than other fungicide treatments. Fungicides remained effective 32 days after treatment, but performance was eroding by 40 days after treatment so follow-up treatments were applied. There was some evidence that Tilt applied in combination with Microthiol performed slightly (non-significantly) better than Tilt alone. No change in disease control was observed when Tilt was followed by Quadris plus Microthiol rather than a second Tilt application. However, there could be resistance management reasons for using products with varying modes of action.

Table 1. Powdery mildew ratings on Kentucky bluegrass ('Merit') near Madras, Oregon following fungicide application on April 8 and reapplication May 19, 2000.

Treatment[1]	Rate	Evaluation dates[2]						
		April 17	April 24	May 2	May 10	May 18	May 26	June 2
	(product/a)							
Quadris + Microthiol	6 oz + 5 lb/a	0.48 b[3]	0.31 b	0.15 b	0.33 b	0.48 b	0.52 b	0.75 b
Quadris + Microthiol	9 oz + 5 lb/a	0.39 b	0.33 b	0.21 b	0.21 b	0.44 b	0.27 b	0.54 b
Tilt	6 fl oz/a	0.44 b	0 c	0 b	0.02 b	0.42 b	0.25 b	0.36 b
Quadris + Microthiol	6 oz + 5 lb/a							
Tilt	6 fl oz/a	0.46 b	0.04 c	0 b	0.11 b	0.40 b	0.21 b	0.27 b
Quadris + Microthiol	9 oz + 5 lb/a							
Tilt	6 fl oz/a	0.40 b	0.09 c	0 b	0.06 b	0.19 b	0.11 b	0.13 b
Tilt + Microthiol	6 fl oz + 5 lb/a	0.24 b	0.05 c	0 b	0 b	0.17 b	0.10 b	0.06 b
Stratego	10 fl oz/a	0.23 b	0.08 c	0 b	0.08 b	0.54 b	0.25 b	0.19 b
Rally	10 oz/a	0.45 b	0.05 c	0 b	0 b	0.17 b	0.15 b	0.04 b
Untreated	----	1.05 a	1.11 a	1.17 a	2.13 a	2.38 a	2.46 a	3.25 a

[1]All treatments applied with Sylgard 309 at 1 qt/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 ratings on Kentucky bluegrass ('Geronimo') near Madras, Oregon following fungicide application on April 8 and reapplication May 19, 2000.

Treatment[1]	Rate	Evaluation dates[2]						
		April 17	April 24	May 2	May 10	May 18	May 26	June 2
	(product/a)							
Quadris + Microthiol	6 oz + 5 lb/a	0.59	0.80 ab[3]	0.56 b	0.46 b	0.98 b	0.88 b	0.88 b
Quadris + Microthiol	9 oz + 5 lb/a	0.56	0.29 b	0.29 b	0.36 b	0.48 b	0.65 b	0.85 b
Tilt	6 fl oz/a	0.45	0.25 b	0.02 b	0.02 b	0.44 b	0.65 b	0.44 bc
Quadris + Microthiol	6 oz + 5 lb/a							
Tilt	6 fl oz/a	0.21	0.04 b	0 b	0.04 b	0.29 b	0.22 b	0.28 bc
Quadris + Microthiol	9 oz + 5 lb/a							
Tilt	6 fl oz/a	0.54	0.16 b	0 b	0.04 b	0.33 b	0.36 b	0.21 c
Tilt + Microthiol	6 fl oz + 5 lb/a	0.44	0.19 b	0 b	0 b	0.23 b	0.13 b	0.15 c
Stratego	10 fl oz/a	0.53	0.31 b	0.10 b	0.09 b	0.37 b	0.48 b	0.33 bc
Rally	10 oz/a	0.38	0.08 b	0 b	0.02 b	0.38 b	0.40 b	0.15 c
Untreated	----	0.99	1.29 a	1.44 a	1.65 a	2.15 a	2.65 a	2.67 a
		NS						

[1]All treatments applied with Sylgard 309 at 1 qt/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 $P \leq 0.05$

Fungicides applied after disease establishment (Tables 3 and 4) all significantly reduced disease compared to the untreated plots and all provided similar protection. Fungicides in these plots where application was delayed until powdery mildew had developed to moderate levels had begun losing effectiveness by 34 days after treatment.

Table 3. Powdery mildew ratings on Kentucky bluegrass ('Merit') near Madras, Oregon following fungicide application on April 26, 2000.

Treatment[1]	Rate	Evaluation dates[2]					
		April 25	May 3	May 10	May 17	May 24	May 30
	(product/a)	(pre-trtmt)					
Rally	8 oz/a	1.20	0.53 b[3]	0.17 b	0.02 b	0 b	0.19 bc
Rally	10 oz/a	1.29	0.75 ab	0.17 b	0.02 b	0 b	0.06 c
Tilt	4 fl oz/a	1.11	0.61 ab	0.17 b	0 b	0.08 b	0.38 bc
Tilt	6 fl oz/a	1.20	0.74 ab	0.19 b	0.02 b	0 b	0.19 bc
Stratego	8 fl oz/a	1.06	0.40 b	0.13 b	0.06 b	0.11 b	0.19 bc
Stratego	10 fl oz/a	1.11	0.51 b	0.11 b	0.02 b	0.04 b	0.52 bc
Folicur	6 fl oz/a	1.30	0.80 ab	0.29 b	0.04 b	0.19 b	0.84 b
Bayleton	4 oz/a	1.20	0.81 ab	0.13 b	0.06 b	0.02 b	0.32 bc
Untreated	----	1.30	1.06 a	1.67 a	2.15 a	2.81 a	2.73 a
		NS					

[1]All treatments applied with Sylgard 309 at 1 qt/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 4. Powdery mildew rating on Kentucky bluegrass ('Geronimo') near Madras, Oregon following fungicide application on April 26, 2000.

Treatment[1]	Rate	Evaluation dates[2]					
		April 25	May 3	May 10	May 17	May 24	May 30
	(product/a)	(pre-trtmt)					
Rally	8 oz/a	1.2	0.99	0.90	0.29 b[3]	0.13 b	0.46 b
Rally	10 oz/a	0.95	0.86	0.33	0.23 b	0 b	0.17 b
Tilt	4 fl oz/a	1.31	1.15	0.83	0.42 b	0.25 b	0.47 b
Tilt	6 fl oz/a	1.34	1.19	0.98	0.71 b	0.33 b	0.38 b
Stratego	8 fl oz/a	1.30	0.95	0.50	0.34 b	0.10 b	0.50 b
Stratego	10 fl oz/a	1.39	0.90	0.46	0.23 b	0.08 b	0.34 b
Folicur	6 fl oz/a	1.18	1.03	0.65	0.23 b	0.15 b	0.33 b
Bayleton	4 oz/a	1.41	1.20	0.85	0.56 b	0.27 b	0.31 b
Untreated	----	1.06	1.06	1.19	1.21 a	1.52 a	1.96 a
		NS	NS	NS			

[1]All treatments applied with Sylgard 309 at 1 qt/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 $P \leq 0.05$

EVALUATION OF PALISADE ON KENTUCKY BLUEGRASS, 2000

M.D. Butler

Research evaluating Palisade on ryegrass in the Willamette Valley from 1997-1999 indicates reduced lodging and increased yields with application of the growth regulator. Although lodging is not often a problem in Kentucky bluegrass grown in central Oregon, a cost-effective method of increasing yields would generate interest in the industry for Palisade. First year research using Palisade on Kentucky bluegrass during 1999 provided promising increases in yield.

Plots 10 ft x 25 ft were replicated four times in a randomized complete block design in a commercial 'Geronimo' Kentucky bluegrass field near Madras, Oregon. The first treatment of Palisade was applied at 200, 400, and 600 g a.i./ha to plots on April 26 at Feekes 7 when one to two nodes were detectable. A second set of plots was treated at the three rates on May 10 at Feekes 10.1 when the head was just becoming visible. The late treatments were applied May 22 at Feekes 10.4, when heads extended just above the flag leaf. Treatments were applied with a CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal/a water using TeeJet 8002 nozzles. Plots were evaluated for plant height on May 26, June 12 and June 29. No lodging had occurred by May 12, but lodging was evaluated on June 12 and June 29.

Prior to harvest, a Jari mower was used to cut 3-foot alleyways across the front and back of each row of plots. A 3 x 22 foot portion of each plot was harvested with a research-sized swather June 29. Samples were placed in large bags and hung in an equipment shed to dry, and then transported to Corvallis for combining with a Hege 180 and was subsequently cleaned at the Hyslop Farm. Thousand seed counts were conducted using the seed-conditioning lab at the National Forage Seed Production Research Center, and germination testing was done at the Central Oregon Agricultural Research Center.

Yields were increased 36 percent by Palisade applied at 400 g a.i./ha from detection of the first and second node (Feekes 7) to when the head just becomes visible (Feekes 10.1) compared to untreated plots. Palisade at 600 g a.i. did not increase yields over the 400 g a.i./ha rate for any of the three application timings. On the early application date (Feekes 7) the 400 g a.i./ha rate significantly increased yields over the 200 g a.i./ha rates, as well as the untreated plots.

Increasing the rate of Palisade application increasingly reduced plant height and lodging. The late application when the heads extended just above the flag leaf (Feekes 10.4) produced the greatest reduction in plant height and lodging. Plants out-grew earlier Palisade applications when the first and second nodes were detectable (Feekes 7) and the head were just visible (Feekes 10.1).

There were no significant differences between treatments for weight per 1,000 seeds. There were differences in percent germination, but all Palisade treatments had equal or greater percent germination than the untreated plots.

Table 1. Effect of Palisade growth regulator on plant height and lodging of Kentucky bluegrass, Madras, OR, 2000.

Treatment	Application date	Plant height May 26	Plant height June 12	Plant height June 29	Lodging June 12	Lodging June 29
(g a.i./ha)		(inches)			(%)	
200	4/26	20.3 abc	27.8 bc	28.8 abc	33 b	48 ab
400	4/26	17.3 d	26.5 d	28.3 abc	0 c	5 cd
600	4/16	14.8 e	25.0 e	27.0 cd	0 c	0 d
200	5/10	21.5 ab	28.5 ab	29.0 ab	8 bc	30 bc
400	5/10	18.5 cd	27.3 cd	28.3 abc	5 c	18 cd
600	5/10	16.8 d	26.3 d	27.5 bc	1 c	0 d
200	5/22	21.5 ab	26.8 cd	28.3 abc	3 c	6 cd
400	5/22	20.5 ab	24.5 e	25.5 de	0 c	0 d
600	5/22	20.0 bc	22.8 f	23.8 e	1 c	0 d
Untreated	----	22.0 a	29.3 a	29.8 a	63 a	65 a

Mean separation with LSD $P \leq 0.05$.

Table 2. Effect of Palisade growth regulator on yield, thousand seed weight and percent germination of Kentucky bluegrass, Madras, OR, 2000.

Treatment	Application date	Seed yield	Percent of check	Above ground biomass	1,000 seed weight	Germination
(g a.i./ha)		(lb/a)	(%)	(ton/a)	(g)	(%)
200	4/26	2,140 bc	108 bc	3.8 ab	0.438	93.5 a
400	4/26	2,708 a	136 a	4.1 ab	0.432	90.3 ab
600	4/16	2,617 ab	132 bc	3.7 b	0.430	90.0 ab
200	5/10	2,214 abc	111 abc	4.2 ab	0.440	87.7 ab
400	5/10	2,713 a	136 a	4.7 a	0.431	87.5 ab
600	5/10	2,221 abc	112 abc	4.5 ab	0.437	85.7 ab
200	5/22	2,482 abc	125 abc	4.6 a	0.426	85.4 ab
400	5/22	2,377 abc	120 abc	4.0 ab	0.430	82.2 bc
600	5/22	2,362 abc	119 abc	4.1 ab	0.436	81.0 bc
Untreated	----	1,989 c	100 c	4.1 ab	0.431 NS	76.2 c

Mean separation with LSD $P \leq 0.05$.

GRASS SEED VARIETY YIELD TRIALS FOR NORTHEASTERN OREGON

D. Singh and D.A. Ball

Grass seed acreage in the Lower Umatilla and Columbia Basin regions of northeastern Oregon and south central Washington has steadily increased since the early 1990s. Climate, soils, and production practices, including the use of overhead irrigation, differ considerably from other production regions in Oregon. Because of differences in grass seed growing conditions from the more traditional productions regions, performance of grass seed cultivars were evaluated under Lower Umatilla Basin growing conditions.

Cooperative research trials were originally initiated in 1997 at the Hermiston Agricultural Research and Extension Center to determine grass seed cultivar yield potential of fine fescues, Kentucky bluegrass, tall fescue and perennial ryegrass under Lower Umatilla Basin growing conditions. Results of these trials were previously reported (Singh et al. 2000). This report summarizes results of a second series of trials initiated in 1998. Trials were established under center pivot irrigation in fall 1998. Thirteen fine fescue (FF) varieties, nine Kentucky bluegrass (KBG) varieties, thirteen tall fescue (TF) varieties, and twelve perennial ryegrass (PRG) varieties were seeded in separate studies. Each varietal entry was seeded at 5 lb/a with a plot drill at 12-inch row spacing. The studies were arranged 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 second (1999-00) crop year of the grass seed variety trials. Data from the 1998-99 crop year is not presented because grass seed yields were adversely affected by a severe hailstorm during harvest. During the 1999-00 cropping season the study areas were treated with the pesticides listed in Table 1.

Fine fescue varieties were swathed with a plot swather at approximately 35-40 percent seed moisture (Table 2) and were harvested with a plot combine on July 11, 2000. Clean seed yield data from the fine fescue variety seed yield trial are presented in Table 2. Kentucky bluegrass at approximately 28 percent seed moisture (Table 3) and harvested with a plot combine on July 14, 2000. Clean seed yields from the Kentucky bluegrass varieties seed yield trial are presented in Table 3. Tall fescue varieties were swathed with a plot swather on June 22, 2000 at approximately 43 percent seed moisture and harvested with a plot combine on July 11, 2000. Clean seed tall fescue variety seed yield trial is presented in Table 4. Perennial ryegrass varieties, except Spring Green, were swathed with a plot swather at approximately 35 percent seed moisture. Spring Green (Festulolium) was harvested at 40 percent seed moisture. All perennial ryegrass varieties were harvested with a plot combine on July 14, 2000. Clean seed yields of perennial ryegrass varieties are presented in Table 5.

Table 3. Clean seed yield of Kentucky bluegrass varieties established September 12, 1998 at Hermiston, OR, 2000

Variety	Seed company	Swathing date	Seed yield
			(lb/a)
Gnome	Turf Merchants	June 10	1104
B2-42	Turf-Seed	June 14	1042
Viva	Turf Merchants	June 10	1015
Blue Star	Turf-Seed	June 10	1002
A96-328	Turf Merchants	June 10	967
A7-60	Turf-Seed	June 10	896
Cobalt	Turf Merchants	June 14	774
A7-245A	Turf-Seed	June 10	537
LSD 0.05			310

Table 4. Clean seed yield of tall fescue varieties established September 18, 2000 at Hermiston, OR, 2000

Variety	Seed company	Swathing date	Seed yield
			(lb/a)
5E5	Turf-Seed	June 22	3392
5R94E	Turf-Seed	June 22	3208
Wolfpack	Turf-Seed	June 22	2900
MB 211	Pennington	June 22	2879
Plantation	Pennington	June 22	2863
5DU	Turf-Seed	June 22	2789
Tar Heel	Turf-Seed	June 22	2763
Regiment	Advanta	June 22	2737
ISI TF 23	International	June 22	2664
AG-T981	Lesco	June 22	2421
Bravo	Lesco	June 22	2408
Rebel Sentry	Lofts	June 22	2309
AG-T982	Lesco	June 22	2169
LSD 0.05			510

Table 5. Clean seed yield of perennial ryegrass varieties established (September 18, 1998) at Hermiston, OR, 2000.

Variety	Seed company	Swathing date	Seed yield
			(lb/a)
Charger II	Turf-Seed	June 26	2222
ASP 400	Advanta	June 24	2208
BFP	Pennington	June 24	2136
R.2	International	June 24	2111
Prelude III	Lofts	June 24	2083
Manhattan 3	Turf-Seed	June 24	2029
Imagine	Olsen-Fennel	June 24	1940
Essence	International	June 26	1842
Catalina	Turf-Seed	June 24	1796
Sonata	Pennington	June 24	1792
Brightstar II	Turf-Seed	June 24	1586
Spring Green	Turf-Seed	June 24	1317
LSD 0.05			393

References

Singh, D., and Ball, D.A.., and J.P. McMorran. 2000. Grass seed variety yield trials for northeastern Oregon. 1999 Seed Production Research Report, OSU Ext/CrS 114: 52-55.

Table 1. Pesticides applied in the four-grass seed crop variety yield studies

Date of application	Grass seed crop	Pesticide name	Rate
September 22, 1999	All	Goal 2XL + Lexone 75 DF	4 oz/a + 4 oz/a
November 12, 1999	All	Admire* + Siltek	3.3 oz/a + 8.6 oz/a
November 22, 1999	All	Quadris+ NIS	6 oz/a
Mar 24, 2000	All	Goal 1.6 EC + Buctril	2 oz/a + 1.5 pt/a
April 7, 2000	All	Tilt + Sulphur DF + Silwet	4 oz/a + 2 lbs/a + 10 oz/100 gal
May 1, 2000	KBG	Laredo + Sulphur DF + Silwet	8 oz/a + 2 lbs/a + 10 oz/100 gal

* Admire is not registered for use in grass seed crops. Only used for experimental purpose.

Table 2. Clean seed yield of fine fescue varieties established September 18, 1998 at Hermiston, OR, 2000.

Variety	Type	Company	Swathing date	Seed yield
				(lb/a)
Longfellow II	Chewings Fescue	International	June 22	2806
ISI Fl 11	Hard Fescue	International	June 21	2794
8CHF	Chewings Fescue	Barenbrug	June 22	2647
8HF	Hard Fescue	Barenbrug	June 14	2552
ISI Frr 7	Strong Creeping Red Fescue	International	June 22	2499
4 RU	Hard Fescue	Turf-Seed	June 14	2489
ISI Fl 12	Hard Fescue	International	June 14	2455
ISI Frr 6	Strong Creeping Red Fescue	International	June 22	2193
85 CHF	Strong Creeping Red Fescue	International	June 22	2105
ISI Frr 5	Strong Creeping Red Fescue	International	June 22	1843
Discovery	Hard Fescue	Turf – Seed	June 21	1839
8 CRF	Creeping Red Fescue	Barenbrug	June 22	1822
4 VB	Strong Creeping Red Fescue	Turf-Seed	June 22	1692
LSD 0.05				492

CATCHWEED BEDSTRAW CONTROL IN GRASS SEED CROPS

D.A. Ball and D. Singh

Catchweed bedstraw (*Galium aparine* L.) is a persistent annual broadleaf weed problem in grass seed crops throughout much of the grass seed producing region of the Pacific Northwest. Catchweed bedstraw can interfere with crop growth and reduce seed yield. In addition, bedstraw seed is difficult to separate in seed cleaning operations thereby reducing quality of harvested seed. For these reasons, effective herbicides for control of bedstraw in grass seed crops are desired by grass seed producers.

In 2000, several field trials were conducted at various locations in northeastern Oregon to evaluate catchweed bedstraw control effectiveness and grass seed crop tolerance from several herbicide treatments. Field trials were conducted near Echo, Hermiston, and Imbler, Oregon, and Walla Walla, Washington on seedling hard fescue, Kentucky bluegrass, and tall fescue, and on established chewings fescue, creeping red fescue, Kentucky bluegrass, tall fescue, and perennial ryegrass. Table 1 contains a summary of field locations, our experiment number for identification purposes, and the grass seed crop type evaluated. Herbicides evaluated included fluroxypyr (Starane®), prosulfuron (Peak®), tribenuron (Express®), and carfentrazone (Aim®), alone and in combination with an isooctyl ester of 2,4-D (Salvo®). Fluroxypyr is currently registered for use under 24c special local needs (SLN) labels in Oregon and Washington. Carfentrazone is registered for use under a 24c SLN in Oregon. Tribenuron and 2,4-D are currently labeled for use in grass grown for seed in Oregon and Washington. Prosulfuron is not presently labeled for use in grass seed crops. The results of these trials are considered to be of a preliminary nature and should not be considered as a product endorsement or recommendation for commercial use. Several treatments evaluated in these trials are not registered for use. Consult herbicide labels for appropriate application rates and requirements.

Herbicide treatments were applied postemergence with a hand-held CO_2 backpack sprayer in 15 gal/acre water at 30 psi spray pressure. A non-ionic surfactant at 0.25% (v/v) was added to all treatments except for fluroxypyr applied alone where no surfactant was used. Plots were generally 10 ft by 30 ft in size, and arranged as randomized complete block designs with 4 replications. Grass seed crops and weeds were actively growing at time of application. Visual estimates of percent bedstraw control of were made on three trials (#00-500, #00-502, #00-520). At time of herbicide application, bedstraw was 5-7 inches in height in the first two trials, and 3 inches in height at the third site. Visual estimates of percent henbit (*Lamium amplexicaule* L.) were made on two trials (#00-502, #00-740). At time of herbicide application, henbit was 5-10 inches in height at the first trial, and 3 inches in height at the second trial. At the time of weed control evaluations, observations of crop injury were recorded. At crop maturity, plots were swathed, combined, and seed cleaned to obtain estimates of clean seed yield. Three of the trials had no weeds present (#00-510, #00742, #00-743), so evaluations were made of crop tolerance to applied herbicides.

A summary of bedstraw control effectiveness is presented in Table 2. In general, treatments containing fluroxypyr provided a moderately high level of bedstraw control. Addition of 2,4-D to the fluroxypyr treatment only slightly improved bedstraw control. Carfentrazone treatment was also effective at two of the three experimental sites. Bedstraw control at one of the three sites (#00-500) was poor due to the large size of bedstraw (5 to 7 inch) at time of treatment (Table 2). Prosulfuron and tribenuron were generally ineffective for control of bedstraw (Table 2).

Henbit is another annual broadleaf weed common in grass seed production fields. An evaluation of henbit control in two studies is summarized in Table 3. Fluroxypyr and tribenuron treatments were the most effective for suppression of henbit.

Grass seed crop injury from herbicide treatments was limited to only a few specific instances. In seedling tall fescue (#00-502), prosulfuron treatments produced slight, visible injury in the form of foliar discoloration and transient slowing of growth (data not shown). This particular trial was not harvested for seed, so effect of prosulfuron on seed yield was not determined. In another trial on established perennial ryegrass (#00-743), treatments containing prosulfuron or tribenuron (sulfonylurea type herbicides) caused moderate crop injury that reduced seed yield compared to other treatments or to the untreated control (Table 4). Other than these specific instances, herbicide treatment had no significant effect on clean seed yield (Tables 4 and 5). Herbicide treatments containing fluroxypyr or carfentrazone were both effective for managing bedstraw. Treatments containing fluroxypyr or tribenuron demonstrated effectiveness for controlling henbit. Because of the minor crop status of grass seed crops, herbicide registrations are limited. It is necessary to fully consult product labels to determine if particular treatments are registered for use in a specific location. Consideration also needs to be given to crop and weed growth stage to obtain maximum effectiveness of applied treatments.

Table 1. Summary of field trial locations, crop evaluated, soil type, and herbicide application dates.

Location	Experiment number	Grass seed crop type	Variety	Soil type	Herbicide application date
Walla Walla	#00-500	Seedling hard fescue	Oxford	Silt loam	March 21, 2000
Echo	#00-501	Seedling Kentucky bluegrass	-	Sandy loam	March 21, 2000
Echo	#00-502	Seedling tall fescue	-	Loamy sand	March 21, 2000
Imbler	#00-510	Seedling Kentucky bluegrass	-	Sandy loam	April 7, 2000
Imbler	#00-520	Established chewings fescue	-	Loam	April 7, 2000
Hermiston	#00-740	Established fine fescue	Shademark	Loamy sand	March 22, 2000
Hermiston	#00-741	Established Kentucky bluegrass	Gnome	Loamy sand	March 22, 2000
Hermiston	#00-742	Established tall fescue	Bravo	Loamy sand	March 22, 2000
Hermiston	#00-743	Established perennial ryegrass	Top Hat	Loamy sand	March 22, 2000

Table 2. Visual estimates of percent catchweed bedstraw control in several grass seed crop types at various times after postemergence herbicide application.

Treatment	Rate	Trial no. = Seedling hard fescue #00-500	Seedling tall fescue #00-502	Established chewings fescue #00-520	Average
		Date of visual control evaluation			
		6/16/00	4/12/00	5/2/00	
		(% bedstraw control)			
Fluroxypyr	3 oz a.e./a	50	40	90	60
Fluroxypyr + 2,4-D	3 oz a.e./a + 12 oz a.e./a	60	63	94	72
Prosulfuron	0.57 oz a.i./a	60	13	37	37
Prosulfuron + 2,4-D	0.43 oz a.i./a + 12 oz a.e./a	50	15	18	28
Tribenuron	0.25 oz a.i./a	50	36	28	38
Tribenuron + 2,4-D	0.187 oz a.i./a + 12 oz a.e./a	30	37	30	32
Carfentrazone	0.264 oz a.i./a	30	80	72	61
Carfentrazone + 2,4-D	0.132 oz a.i./a + 12 oz a.e./a	50	50	80	60
2,4-D	12 oz a.e./a	-	13	-	13
LSD 0.05		NS	12	32	--

Table 3. Visual estimates of percent henbit control in several grass seed crop types at various times after postemergence herbicide application.

Treatment	Rate	Seedling tall fescue #00-502	Established creeping red fescue #00-740	Average
	Trial no. =	Date of visual evaluation		
		4/29/00	5/3/00	
		(% henbit control)		
Fluroxypyr	3 oz a.e./a	86	73	79
Fluroxypyr + 2,4-D	3 oz a.e./a + 12 oz a.e./a	88	65	77
Prosulfuron	0.57 oz a.i./a	43	37	40
Prosulfuron + 2,4-D	0.43 oz a.i./a + 12 oz a.e./a	56	32	44
Tribenuron	0.25 oz a.i./a	84	62	73
Tribenuron + 2,4-D	0.187 oz a.i./a + 12 oz a.e./a	78	65	71
Carfentrazone	0.264 oz a.i./a	58	50	54
Carfentrazone + 2,4-D	0.132 oz a.i./a + 12 oz a.e./a	59	42	50
2,4-D	12 oz a.e./a	54	-	54
LSD 0.05		18	20	--

Table 4. Influence of herbicide treatment on clean seed yield of established grass crops.

Treatment	Rate	Trial no. =	Established Chewings fescue #00-520	Established creeping red fescue #00-740	Established KBG #00-741	Established tall fescue #00-742	Established perennial ryegrass #00-743
			(lb/a clean seed)				
Fluroxypyr	3 oz a.e./a		1570	3060	1080	1930	2140
Fluroxypyr + 2,4-D	3 oz a.e./a + 12 oz a.e./a		1760	3380	1190	2150	2150
Prosulfuron	0.43 oz a.i./a		1780	3340	1150	2260	1750
Prosulfuron + 2,4-D	0.57 oz a.i./a + 12 oz a.e./a		1670	3260	1310	1990	1830
Tribenuron	0.25 oz a.i./a		1890	3150	1250	2110	1830
Tribenuron + 2,4-D	0.187 oz a.i./a + 12 oz a.e./a		1660	3410	1310	2340	1750
Carfentrazone	0.264 oz a.i./a		1860	3530	1040	2170	2260
Carfentrazone + 2,4-D	0.132 oz a.i./a + 12 oz a.e./a		1390	3490	1120	1760	2390
2,4-D	12 oz a.e./a		-	-	-	-	-
Untreated	--		1780	3210	1250	1980	2180
LSD 0.05			NS	NS	NS	NS	310

Table 5. Influence of herbicide treatment on clean seed yield of first year (seedling) grass crops.

Treatment	Rate	Trial no. =	Seedling hard fescue #00-500	Seedling KBG #00-501	Seedling KBG #00-510
			----------------- (lb/a clean seed)		---------------------
Fluroxypyr	3 oz a.e./a		350	1020	1390
Fluroxypyr + 2,4-D	3 oz a.e./a + 12 oz a.e./a		350	890	1340
Prosulfuron	0.57 oz a.i./a		430	900	1360
Prosulfuron + 2,4-D	0.43 oz a.i./a + 12 oz a.e./a		410	800	1260
Tribenuron	0.25 oz a.i./a		380	830	1290
Tribenuron + 2,4-D	0.187 oz a.i./a + 12 oz a.e./a		360	850	1280
Carfentrazone	0.264 oz a.i./a		380	840	1410
Carfentrazone + 2,4-D	0.132 oz a.i./a + 12 oz a.e./a		340	750	1300
2,4-D	12 oz a.e./a		-	-	-
Untreated			330	780	1300
LSD 0.05			NS	NS	NS

DODDER CONTROL IN CLOVER GROWN FOR SEED IN WESTERN OREGON

G.W. Mueller-Warrant

Dodder control tests were conducted in two red clover fields in spring and summer of 2000. The tests compared Prowl 3.3 EC, Treflan TR10, two formulations of the biocontrol agent Smolder, and an untreated check. Prowl and Treflan were intended to be applied at rate of 4 lb ai/acre after hay harvest, but a calibration error increased the rate of Prowl to 4.7 lb a.i./acre (Table 1). A granular, "time-release" formulation of the biocontrol agent Smolder, an *Alternaria destruins* fungus, was applied prior to hay harvest in the standing clover crop. A WP formulation of Smolder mixed in water and oil was sprayed on individual dodder patches in early August. Roundup was not tested in 2000 because it had consistently reduced yield in tests conducted in 1998 and 1999.

Table 1. Timing of herbicide applications and management operations in two red clover test sites, 2000.

Treatment or operation	Bayley Road	N. Valley Road
Smolder granules applied	May 12	NA
Hay harvest	May 19	May 20
Pendimethalin & trifluralin applied	May 24	May 24
Smolder WP applied postemergence	Aug. 2	Aug. 2
Swathing	Aug. 30	NA
Combining	Sept. 12	NA

Global Positioning System (GPS) coordinates of dodder patches found in 1999 at the Bayley Rd. site were used to locate and align plots in 2000. There were 573 dodder patches in 1999 within the 4-acre section of the field used for testing in the year 2000. Prowl, Treflan, and the untreated check were all replicated five times, while granular preemergence Smolder was replicated 15 times. The postemergence spray application of Smolder WP was applied on Aug. 2 to five patches at Bayley Rd. and six patches at N. Valley Rd.

Germinating dodder was found at the Bayley Rd. site on April 20 near the center of the area of the densest patches in 1999. Newly germinated dodder seedlings were seen growing along the moist soil surface then. Dodder seedlings were found again on May 12 and May 15, and some were attached to small weeds and red clover. No dodder was found at the N. Valley Rd. site in April, May, or June. The soil surface was dry when Prowl and Treflan were applied on May 24, but subsurface moisture was good. Rainfall in the first two weeks after Prowl and Treflan applications was very light, and neither new nor old dodder seedlings could be found on June 2. Some stunting and leaf distortion was visible in early June on red clover in Prowl-treated plots, especially at the Bayley Rd. site, but stunting was no longer detectable by the end of June. The soil surface remained dry from hay harvest until rains on June 6-12. Newly emerged seedlings were found on June 8. Clover regrowth was rapid, and the canopy shaded the ground and kept the soil surface moist for two weeks after the rain. Dodder was found attached to a young sowthistle plant on June 8 and attached to red clover on June 21. By July 6 red clover was in early bloom, and dodder patches were 3 inches wide. By July 20 dodder patches were up to 3 feet wide and were attached to dozens of clover stems. The first patch was found at the N. Valley Rd. site on July 27. Dodder was just beginning to flower in late July. Flowering and seed production by dodder continued until swathing on Aug. 30.

Prowl and Treflan both provided 100% control of dodder in 2000, the same as they had in 1998 and 1999. A total of 61 patches were found within the test area at Bayley Rd., 36 in Smolder-treated plots and 25 in the untreated check. This represented a frequency of patch recurrence of 13.6% in areas treated with Smolder granules and 32.9% in the untreated check. The limited rainfall in late May and June undoubtedly influenced our results, and much higher numbers of dodder seedlings would have emerged if normal rainfall had occurred. Additional rainfall might have also improved the performance of the biocontrol agent, as secondary infections would have spread the disease. Weather was very dry before and after the Aug. 2 application of Smolder WP, and the only effect observed on dodder from its application was a slight stunting by late August. While the 59% control by Smolder granules exceeded the performance of Smolder WP in 1999 and 2000, Prowl and Treflan clearly gave the best weed control.

Prowl and Treflan were the highest yielding treatments, although the difference between them and the untreated check was not statistically significant. Granular Smolder treatment was lower yielding than Prowl and Treflan, but it did not differ statistically from the untreated check. A substantial portion of the yield differences between Smolder and Prowl or Treflan may have been caused by trampling and physical removal of the crop when the dodder patches were cut out by hand in August. Yield differences between Smolder and Prowl or Treflan were greatest in reps 3 and 4, which was also the location of most of the dodder patches. However, it is possible that there were other unidentified reasons for the small yield advantage to Prowl and Treflan. Moisture was in short supply in the summer of 2000, and any changes in rooting patterns and shoot to root ratios caused by Prowl and Treflan might have been beneficial in this environment.

No treatment effects on clover seed germination have been found, although some samples remain to be tested. The Oregon Clover Commission and clover growers should encourage BASF Corporation and Dow AgriSciences to pursue registration of Prowl EC and Treflan TR10 after hay harvest for dodder control. Both herbicides are safe to use on established clover grown for seed and provide good control of dodder germinating after hay harvest. Roundup remains useful for spot spraying of dodder patches at rates causing crop destruction. The biocontrol agent Smolder merits some additional testing, especially the granular formulation.

Table 2. Dodder patch frequency of recurrence and density and red clover seed yield, 2000.

Herbicide treatment	Number of dodder patches in 1999 within 2000 test area	Frequency of recurrence from 1999 to 2000	Dodder patch density in 2000: Bayley Rd.	Dodder patch density in 2000: N. Valley Rd.	Red clover seed yield at Bayley Rd.
(lb a.i./acre)	(total in all plots)	(%)	(#/5670 ft^2)	(#/6300 ft^2)	(lb/a)
4.7 Pendimethalin	147	0.0 a*	0.0 a	0.0 a	862 a
4.0 Trifluralin	85	0.0 a	0.0 a	0.0 a	893 a
Smolder granules	265	13.6 b	2.4 ab	NA	778 b
Untreated	76	32.9 c	5.0 b	0.9 b	812 ab
Probability level		0.0001	0.1297	0.0529	0.023
CV(%)		21.7	157.1	154.5	9.0

* Means followed by the same letter do not differ at the *P*=0.05 level of significance. Frequency of recurrence was log(x+1) transformed for analysis of variance and means separation, and then converted back to raw units.

ERRATUM[1]

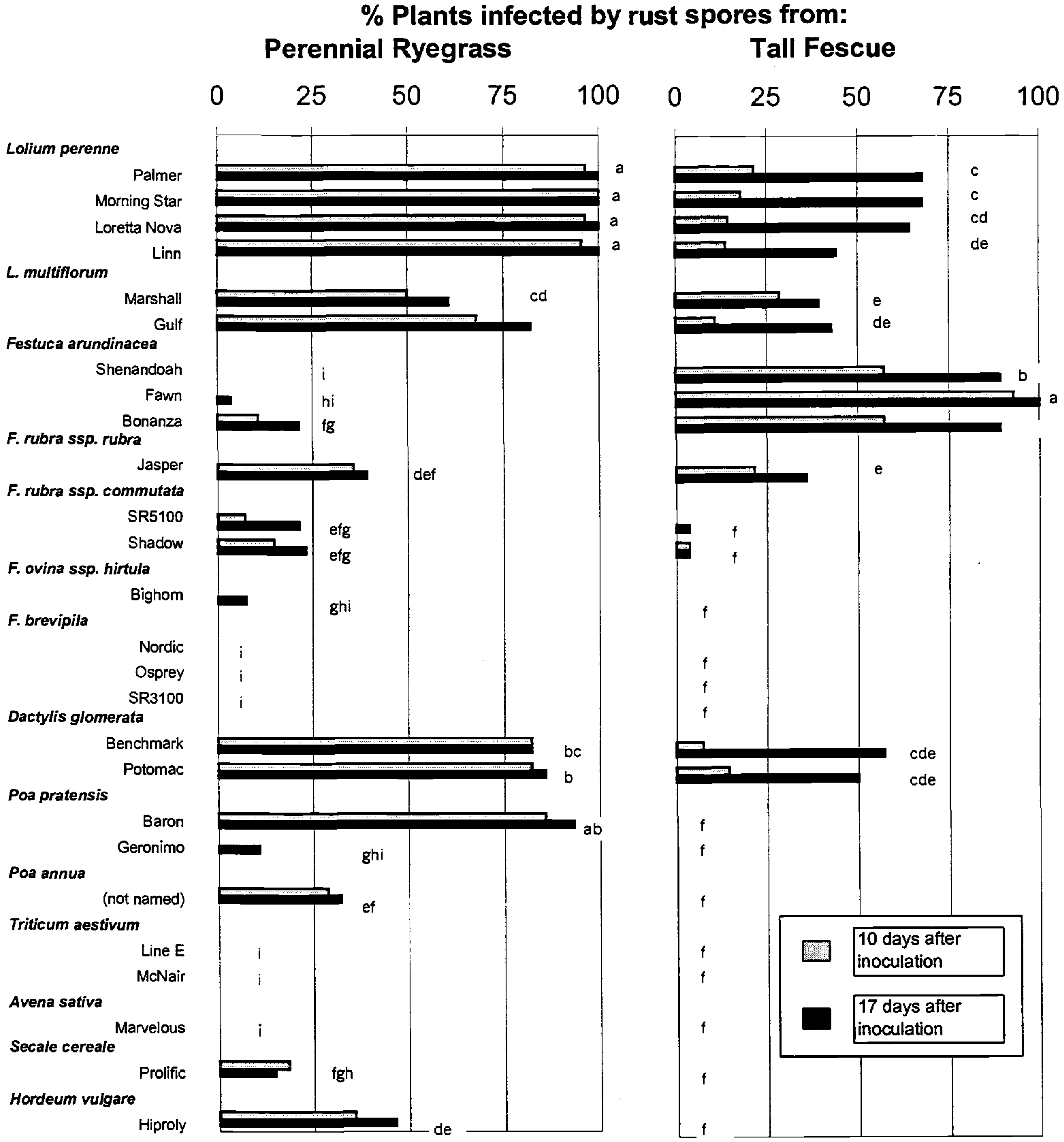

Figure 1. Incidence of stem rust (% plants infected) on indicated cultivars of grass species inoculated with urediniospores of *P. graminis* subsp. *graminicola* that had been produced on either perennial ryegrass or tall fescue. Incidence was assessed at 10 and 17 days after inoculation. Within an inoculum treatment, 17-day incidence bars with the same letter to the right are not significantly different ($P < 0.05$).

[1] ***This figure should have accompanied the article by W.F. Pfender, "Is There a Difference Between the Stem Rust Pathogens from Tall Fescue and Perennial Ryegrass?" on p. 22-23***

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