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The following authors have contributed to this report.

Central Oregon Agriculture and Research Center

C.K. Campbell, Faculty Research Assistant

Cooperative Extension Service – OSU

M.D. Butler, Extension Agent, Jefferson County
G.A. Gingrich, Extension Agent, Marion County
M.E. Mellbye, District Extension Agent, Linn, Benton and Lane Counties
D.L. Walenta, Extension Agent, Union County

Department of Crop and Soil Science – OSU

R.P. Affeldt, Faculty Research Assistant
B.D. Brewster, Senior Instructor, Weed Science
T.G. Chastain, Associate Professor Seed Crop Physiology
C.M. Cole, Faculty Research Assistant
J.B. Colquhoun, Assistant Professor and Extension Weed Control Specialist
R.L. Cook, Manager, Seed Certification
A.E. Garay, Manager, Seed Laboratory
C.J. Garbacik, Senior Faculty Research Assistant
J.M. Hart, Professor and Extension Soil Scientist
C.A. Mallory-Smith, Associate Professor of Weed Science
K.C. Ross, Former Graduate Student
L.R. Schweitzer, Director of Seed Services
T.B. Silberstein, Senior Faculty Research Assistant
W.C. Young III, Professor and Extension Agronomist

Department of Entomology – OSU

S. Rao, Assistant Professor

Department of Rangeland Resources – OSU

M.M. Borman, Associate Professor and Extension Rangeland Specialist
D.E. Johnson, Professor
M. Louhaichi, Graduate Research Assistant
D.R. Thomas, Emeritus Professor (Statistics)

Eastern Oregon University

P.L. Diebel, Agricultural Economist, EOU-OSU Agriculture Program, LaGrande
L.R. Gow, Agricultural Economist, EOU-OSU Agriculture Program, LaGrande
G.L. Kiemnec, Soil Scientist, EOU-OSU Agriculture Program, LaGrande

National Forage Seed Production Research Center - USDA-ARS

S.M. Griffith, Assistant Professor and Research Plant Physiologist
G.W. Mueller-Warrant, Associate Professor and Research Agronomist

Other

R.J. Burr, Contract Researcher, Ag Research, Inc., Sublimity, OR
L.G. Gilmore, Production Manager, Madras Group, Harvest States, Madras, OR
B.M. Quebbeman, Crop Consultant, Quebbeman's Crop Monitoring, LaGrande, OR

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

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

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 and unnecessary expense for additional nitrogen. 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 trials were conducted for three years in perennial ryegrass, three years in tall fescue field (1998-2000), four years in fine fescue fields (1999-2002) and two annual ryegrass fields (2000-2001). 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 these trials indicated N levels above 135-180 lb N/a for perennial and annual ryegrass, 90-135 lb N/a for tall fescue and 50 lb N/a for fine fescue did not statistically increase seed yield.

Procedure

Large scale on-farm plots averaging 5 acres per site were established at 10 locations (3 perennial ryegrass, 3 tall fescue, 2 fine fescue and 2 annual ryegrass). 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). At each site the seven treatments were replicated three times in a randomized complete block. Data were analyzed using appropriate statistical analyses (e.g., ANOVA, Regression).

Table 1. Site information for all locations.

Location	County	Planted	Variety	Trial duration	Soil type
			PERENNIAL RYEGRASS		
J Bar V Farms	Marion	Fall 97	Cutter	1998-1999	Woodburn silt loam
L3 Farms	Linn	Fall 97	DLF-1	1998-2000	Concord and Amity silt loam
Venell Farms	Benton	Fall 97	SR-4200	1998-2000	Dayton silt loam
			TALL FESCUE		
Malpass Farms	Linn	Fall 96	Kittyhawk SST	1998-2000	Bashaw silty clay
Nixon Farms	Lane	Spring 97	Duster	1998-2000	Malabon silty clay loam
Roselawn Farms	Marion	Fall 98	Tomahawk IIe	1998-2000	Woodburn silt loam
			FINE FESCUE		
Sherman Farms	Marion	Spring 98	Brittany	1999-2002	Jory silty clay loam
Taylor Farms	Marion	Spring 98	Shademark	1999-2002	Nekia silty clay loam
			ANNUAL RYEGRASS		
Michael Hayes Farm	Linn	Fall 99	Gulf	2000-2001	Dayton/Clackamas
Tim VanLeeuwen Farm	Linn	Fall 99	Gulf	2000-2001	Dayton silt loam

All sites were fertilized between March 1 and April 20 at the pre-determined rates in each year of the study. Where a split application (50/50) was applied, approximately four weeks separated treatment dates. Applications were done between approximately 400 and 800 growing degree days (GDD) as is generally recommended. The 400 GDD and 800 GDD dates are typically around March 10 and April 20, 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. 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.

Plant samples were taken at maturity (during June). Yield components samples were obtained at or following pollination. Plots were swathed late June to mid July and combined within two to three weeks following swathing. 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, purity and germination analysis.

Results and Discussion

Perennial Ryegrass: Yield data is shown in Table 2 for perennial ryegrass. Seed yield in perennial ryegrass decreased as the stand aged with the first crop year yielding the highest. Optimum rates for seed yield over the life of the stand were in the 135-180 lb N/a rate. For the rest of this discussion see Tables PR-1and PR-2. Seed size (measured by 1000 seed weight) was the only factor consistently affected by stand age. The seed size decreased at all three sites as the stands aged.

Plant biomass, tissue N, and N uptake in the plant all increased as the level of spring applied N increased. The ratio of vegetative tillers decreased as the N levels increased at two of the three sites. Fertile tiller densities were generally maximized at the recommended rates of spring N. The harvest efficiency of the crop was generally decreased as the N rates increased. The potential seed number increased as the spring N increased but did not result in increased yields above 135-180 lb N/a. This resulted in a decrease in harvest efficiency as indicated by a decrease in the Floret Site Utilization. The crop showed good uptake of nitrogen and continued to increase up to the highest rates and shown in Plant N uptake. Levels of residual soil NO_3-N were all very low, generally <5 PPM at normal rates of spring N and were only a couple PPM above the 0 spring N rate (see Table 3). The causes of seed yield decline are not too clear for perennial ryegrass, but a general decline in floret numbers, a decrease in biomass and a decrease in seed size may all be contributed to the lower yields.

Table 2. Seed yield (lb/a) of perennial ryegrass following varied rates of spring applied N, 1998-2000.

Main Factors	L3 Farms	Venell Farms	J Bar V Farms	3-site average
CropYear				
1998	1963 a[1]	1911 a	1866 a	1913
1999	1377 b	1250 b	1485 b	1371
2000	1450 b	1361 b		1406
LSD 0.05	82	89	296	----
Spring N[2] (lb N/a)				
0	1078 d	774 d	1068 e	962
45	1396 c	1297 c	1458 d	1374
90	1548 bc	1566 b	1610 c	1570
135	1685 ab	1739 ab	1836 b	1743
180	1784 a	1708 ab	1880 ab	1780
225	1841 a	1772 a	1959 a	1844
270	1845 a	1697 ab	1917 ab	1808
LSD 0.05	172	173	114	----

[1] Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values (p=0.05).
[2] Data is the three year average at each N rate.

Table 3. Soil NO_3-N concentrations (ppm) at three soil depths of perennial ryegrass following varied rates of spring applied N, 1998-2000 (3 year average).

Spring N Rate (lb/a)	Post harvest sample depth 0-12 in.	13-24 in.	25-36 in
	L3 Farms		
0	1.3	0.8	0.7
135	3.3	1.2	0.9
270	13.4	3.9	2.7
	Venell Farms		
0	1.7	0.9	0.8
135	4.5	1.3	1.1
270	10.3	3.0	2.3
	J Bar V[1]		
0	0.7	0.8	0.6
135	2.3	1.1	0.9
270	3.1	1.0	1.0

[1] J Bar V Farms - one year of data (1998)

Tall Fescue: Seed yield (Table 4) decreased with stand age at two of the three sites (Malpass, Nixon) and held fairly stable at the Roselawn Farms site. Optimum seed yield was obtained at 90 – 135 lb N/a. Other factors measured are reported in Tables TF-1and TF-2. In addition to a decrease is seed yield, 1000 seed weight, spikelet number per inflorescence, and total biomass decreased over time. In addition, other negative effects on seed production include an increase in the portion of biomass that is vegetative at harvest and a general increase in seed cleanout.

Increases in spring N resulted in higher yield up to 135 lb N/a, an increase in plant biomass, plant tissue N and N uptake, and spikelet number. 1000 seed weight tended to decrease with increased spring N, and though there were increases in potential seed number at two of the three sites it did not increase yields, and thus caused the floret site utilization to decrease. Contributors to the overall decline in seed yield as the stand ages may come from fewer spikelets formed, smaller seed, and more of the plant biomass remaining vegetative.

Soil residual NO_3-N was low (<10 PPM) at the 135 lb /a N rate at all sites (Table 5). As the N was increased to 270 lb/a, NO_3-N increase at all depths and was above 10 PPM in the top foot of soil at two of the three sites. Generally, when using a typical 135 lb N/a spring rate the crop was able to effectively utilize the N applied. Higher rates are shown to be more prone to NO_3-N being left in the soil profile.

Table 4. Seed yield (lb/a) of tall fescue following varied rates of spring applied N, 1998-2000.

Main Factors	Malpass Farms	Nixon Farms	Roselawn Farms	3-site average
CropYear				
1998	1724 a[1]	1715 a	1957 b	1799
1999	1169 c	1355 b	2315 a	1613
2000	1333 b	961 c	2051 b	1448
LSD 0.05	67	108	233	----
Spring N[2] (lb N/a)				
0	1234 d	871 d	1674 d	1260
45	1388 bc	1099 c	1922 c	1470
90	1521 a	1349 b	2066 bc	1646
135	1516 ab	1445 ab	2223 ab	1728
180	1351 cd	1520 a	2238 ab	1703
225	1408 abc	1570 a	2372 a	1783
270	1441 abc	1548 a	2259 a	1750
LSD 0.05	132	140	208	----

[1] Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values (p=0.05).
[2] Data is the three year average at each N rate.

Table 5. Soil NO_3-N concentrations (ppm) at three soil depths of tall fescue following varied rates of spring applied N, 1998-2000 (3 year average).

Spring N rate (lb/a)	Post harvest sample depth 0-12 in.	13-24 in.	25-36 in
	Malpass Farms		
0	5.1	2.4	2.3
135	9.6	3.6	2.6
270	19.7	6.8	4.4
	Nixon Farms[1]		
0	1.7	1.3	1.3
135	3.2	1.3	1.5
270	9.8	2.5	1.9
	Roselawn Farms		
0	1.6	0.8	0.7
135	5.1	1.2	0.9
270	15.6	4.5	2.9

[1] Nixon Farms - two years data (1998-1999)

Fine Fescue: Seed yield responded to spring nitrogen at both sites. Optimum yield was obtained at the 50 lb N/a spring rate (Table 6). Higher applications did not increase seed yield and even showed a decline in yield as the application rate exceeded 70 lb N/a. The Taylor site was optimized at 30 lb N/a and the Sherman site at 50-70 lb N/a. Seed yield decreased as the stand aged and especially so in the fourth year. Tables FF-1 and FF-2 report other harvest components. Stand age also resulted in lower 1000 seed weight, fewer spikelets, and fewer florets, all of which contribute to yield. Increasing spring N increased cleanout, total plant biomass, tissue N, Plant N uptake, spikelet number, floret number. Negative effects of increasing spring N were a decrease in harvest index and a decrease in floret site utilization. Increasing the potential seed number did not generally increase seed yield once 50 lb N was applied.

As with the other species, the residual NO_3-N (Table 7) was well under 10 PPM at the 70 lb N/a spring rate, thus there would be little potential for any leaching problems.

Table 6. Seed yield (lb/a) of fine fescue following varied rates of spring applied N, 1999-2002.

Main Factors	Sherman Farms	Taylor Farms	2-site average
Year			
1999	1679 a[1]	1491 a	1585
2000	1577 b	1377 b	1477
2001	1518 b	1295 b	1407
2002	1061 c	1146 c	1104
LSD 0.05	95	90	----
Spring N[2] (lb N/a)			
0	1016 d	1172 d	1094
30	1422 c	1392 a	1407
50	1600 a	1372 ab	1486
70	1618 a	1381 ab	1500
90	1562 ab	1337 bc	1450
110	1528 abc	1337 bc	1433
140	1467 bc	1299 c	1383
LSD 0.05	119	46	----

[1] Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values (p=0.05).
[2] Data is the four year average at each N rate.

Annual Ryegrass: The annual ryegrass trial was conducted for two simultaneous years at the same locations. Since the crop is planted anew each year, the differences in results between years is not from stand age, but from differences in the crop year due to weather, timing of planting and any other cultural practices that were different between years. The two locations reflect both volunteer and planted crop N management. Both years yielded well and were responsive to increased N up to 135-180 lb N/a range (Table 8). Seed yield responses to spring N in annual ryegrass was similar to first year perennial ryegrass reported in 1998 Seed Production Research. Harvest and yield components are reported in Tables AR-1 and AR-2. The only yield component affected by increasing N was an increase in floret number per spike, but only from the first increment of N (45 lb N/a) at the VanLeeuwen site. Thus, it is not apparent which yield component factor contributed to seed yield, however, use of excessive N rates lodged the crop heavily and did not promote good seed fill conditions. Yield responses were pretty level once the optimum rate of N was used. Residual soil N (Table 9) was higher in the annual ryegrass plots indicating less efficient uptake of the available N. Residual levels averaged over 10 PPM at one site with normal spring N rates and were over 20 PPM at both locations at the highest N rate of 270 lb N/a.

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 except for annual ryegrass had low to barely medium levels at normal rates of N fertilization. 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 8. Seed yield (lb/a) of annual ryegrass following varied rate of spring applied N, 2000-2001.

Main Factors	Michael Hayes Farms	Tim VanLeeuwen Farms	2-site average
Year			
2000	2272 a[1]	2883 a	2578
2001	2082 b	2401 b	2242
LSD 0.05	47	304	----
Spring N[2] (lb N/a)			
0	1554 c	1668 d	1611
45	2119 b	2558 c	2339
90	2249 ab	2614 bc	2432
135	2309 a	2836 abc	2573
180	2321 a	3024 a	2673
225	2398 a	2852 ab	2625
270	2289 a	2943 a	2616
LSD 0.05	165	291	----

[1] Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values (p=0.05).
[2] Data is the two year average at each N rate.

[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 7. Soil NO_3-N concentrations (ppm) at three soil depths of fine fescue following varied rates of spring applied N, 1999-2001 (3 year average).

Spring N Rate (lb/a)	Post harvest sample depth 0-12 in.	13-24 in.	25-36 in
	Sherman Farms		
0	2.6	0.9	1.6
70	5.3	1.9	1.9
140	14.1	6.3	5.0
	Taylor Farms		
0	2.3	0.6	1.5
70	3.5	1.3	1.7
140	6.9	2.9	3.1

Table 9. Soil NO_3-N concentrations (ppm) at three soil depths of annual ryegrass following varied rates of spring applied N, 2000-2001 (2 year average).

Spring N Rate (lb/a)	Post harvest sample depth 0-12 in.	13-24 in.	25-36 in
	Michael Hayes Farms		
0	11.8	4.1	2.4
135	18.3	5.0	2.8
270	24.1	6.5	5.0
	Tim VanLeeuwen Farms		
0	6.9	2.0	1.2
135	8.1	1.9	1.7
270	23.2	7.1	3.6

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 seed yield. Soil test results show efficient use of applied N and potential for leaching losses reported appear very low for recommended use rates.

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Table PR-1. Harvest component responses to spring nitrogen in perennial ryegrass (averages of 3 sites), 1998-2000.

Main Factors	Seed yield	Seed Cleanout	Total biomass	Veg. ratio	Harvest index	Plant tissue N	Plant N uptake
	(lb/a)	(%)	(tn/a)	(%)	(%)	(%)	(lb N/a)
CropYear							
1998	1913	9.6	6.2	16	16.4	176	197
1999	1371	12.0	5.1	22	14.0	114	128
2000	1406	12.7	5.4	27	13.7	132	148
Spring N[1] (lb N/a)							
0	962	11.2	3.4	28	15.0	54	61
45	1374	10.8	4.8	22	15.0	84	94
90	1570	11.0	5.7	21	14.0	117	131
135	1743	11.0	6.2	18	14.7	151	169
180	1780	11.1	6.0	21	15.3	166	186
225	1844	11.3	6.5	19	14.6	200	224
270	1808	12.6	6.3	19	15.2	219	246

[1] Data is the three year average at each N rate.

Table PR-2. Yield component responses to spring nitrogen in perennial ryegrass (averages of 3 sites), 1998-2000.

Main Factors	1000 seed weight	Spikelet number	Florets per spikelet	Fertile tiller density	Potential seed number	Actual seed number	Floret site utilization
	(g)	(no.)	(no.)	(no./sq. ft.)	(000's)	(000's)	(%)
CropYear							
1998	2.11	21.3	6.9	221	349	102	32
1999	1.90	20.9	7.0	230	374	81	24
2000	1.82	20.9	6.4	208	317	87	33
Spring N[1] (lb N/a)							
0	1.90	19.9	5.7	148	190	56	34
45	1.93	21.0	5.8	195	260	79	34
90	1.95	20.9	6.3	226	319	90	30
135	1.97	21.5	7.2	247	410	99	26
180	1.98	21.5	7.2	236	388	100	28
225	2.01	20.8	7.8	238	417	103	27
270	1.96	21.7	7.8	257	467	103	25

[1] Data is the three year average at each N rate.

Table TF-1. Harvest component responses to spring nitrogen in tall fescue (averages of three sites), 1998-2000.

Main Factors	Seed yield	Seed cleanout	Total biomass	Veg. ratio	Harvest index	Plant tissue N	Plant N uptake
	(lb/a)	(%)	(tn/a)	(%)	(%)	(%)	(lb N/a)
CropYear							
1998	1799	6.1	15.4	31	13.6	1.2	162
1999	1613	5.7	12.9	37	14.7	1.2	137
2000	1448	12.4	12.7	42	13.0	1.4	161
Spring N[1] (lb N/a)							
0	1260	7.8	10.0	35	14.2	0.9	77
45	1470	7.6	12.0	35	14.2	1.1	114
90	1646	7.9	13.5	38	13.8	1.2	139
135	1728	8.1	14.1	39	14.1	1.3	164
180	1703	8.3	15.7	37	12.5	1.4	187
225	1783	8.6	15.5	38	13.3	1.4	184
270	1750	8.2	14.6	38	14.1	1.6	203

[1] Data is the three year average at each N rate.

Table TF-2. Yield component responses to spring nitrogen in tall fescue (three site averages), 1998-2000.

Main Factors	1000 seed weight	Spikelet number	Florets per spikelet	Fertile tiller density	Potential seed number	Actual seed number	Floret site utilization
	(g)	(no.)	(no.)	(no./sq. ft.)	(000's)	(000's)	(%)
CropYear							
1998	2.53	71.5	5.2	76	307	80	30
1999	2.43	59.9	5.8	87	312	76	29
2000	2.23	55.5	5.3	69	220	74	38
Spring N[1] (lb N/a)							
0	2.46	50.5	4.9	67	173	58	36
45	2.46	57.3	5.2	72	221	68	35
90	2.40	58.9	5.4	74	241	78	35
135	2.39	65.0	5.6	80	303	82	31
180	2.36	65.9	5.7	81	327	81	29
225	2.35	69.4	5.6	90	365	86	28
270	2.35	69.2	5.7	78	329	84	32

[1] Data is the three year average at each N rate.

Table FF-1. Harvest component responses to spring nitrogen in fine fescue (average of 2 sites), 1999-2002.

Main Factors	Seed yield	Seed cleanout	Total biomass	Veg. ratio	Harvest index	Plant tissue N	Plant N uptake
	(lb/a)	(%)	(tn/a)	(%)	(%)	(%)	(lb N/a)
CropYear							
1999	1585	15.0	5.6	21	15.7	1.0	116
2000	1477	16.6	5.1	21	15.8	1.0	101
2001	1406	14.5	5.1	21	16.2	0.9	105
2002	1104	15.8	5.2	18	12.9	----	----
Spring N[1] (lb N/a)							
0	1050	14.7	2.8	13	21.0	0.7	43
30	1351	13.9	4.1	15	17.3	0.8	72
50	1427	14.7	4.8	20	15.2	1.0	99
70	1439	14.7	5.7	22	12.7	1.0	118
90	1392	14.6	5.3	19	13.3	0.9	104
110	1375	15.4	6.1	20	11.5	1.1	137
140	1327	16.1	6.4	27	10.8	1.4	178

[1] Data is the four year average at each N rate (Tissue N and N uptake are three year averages)

Table FF-2. Yield component responses to spring nitrogen in fine fescue (average of 2 sites), 1999-2002.

Main Factors	1000 seed weight	Spikelet number	Florets per spikelet	Fertile tiller density	Potential seed number	Actual seed number	Floret site utilization
	(g)	(no.)	(no.)	(no./sq. ft.)	(000's)	(000's)	(%)
CropYear							
1999	1.135	35.5	5.5	301	647	157	28
2000	1.128	29.1	5.4	314	540	148	32
2001	1.145	23.5	5.4	339	476	138	35
2002	0.974	25.0	4.5	352	433	129	34
Spring N[1] (lb N/a)							
0	1.060	23.4	4.5	228	297	106	42
30	1.050	24.8	5.0	294	420	139	35
50	1.034	27.4	4.9	309	470	149	34
70	1.049	27.1	5.1	348	553	148	29
90	1.044	27.6	4.9	328	516	144	29
110	1.061	29.3	5.1	338	594	140	25
140	1.063	30.5	5.5	349	674	134	21

[1] Data is the four year average at each N rate.

Table AR-1. Harvest component responses to spring nitrogen in Gulf annual ryegrass (averages of 2 sites), 2000-2001.

Main Factors	Seed yield	Seed cleanout	Total biomass	Harvest index	Plant tissue N	Plant N uptake
	(lb/a)	(%)	(tn/a)	(%)	(%)	(lb N/a)
CropYear						
2000	2578	4.5	5.0	27.4	1.0	95
2001	2242	3.6	4.3	26.9	1.1	99
Spring N[1] (lb N/a)						
0	1611	3.8	3.8	22.4	0.6	50
45	2339	3.9	4.9	24.7	0.7	71
90	2432	4.1	4.7	27.3	1.0	94
135	2572	3.9	4.6	29.5	1.1	99
180	2672	4.2	4.8	28.7	1.1	111
225	2625	4.2	5.1	27.3	1.2	117
270	2616	4.5	4.7	30.2	1.5	140

[1] Data is the two year average at each N rate.

Table AR-2. Yield component responses to spring nitrogen in Gulf annual ryegrass (averages of 2 sites), 2000-2001.

Main Factors	1000 seed weight	Spikelet number	Florets per spikelet	Fertile tiller density	Potential seed number	Actual seed number	Floret site utilization
	(g)	(no.)	(no.)	(no./sq. ft.)	(000's)	(000's)	(%)
CropYear							
2000	2.81	21.0	9.5	180	376	102	31
2001	2.73	20.9	8.5	163	313	92	32
Spring N[1] (lb N/a)							
0	2.76	21.8	7.6	174	304	65	25
45	2.84	21.2	8.9	174	355	92	29
90	2.79	21.1	9.3	182	379	98	28
135	2.78	21.0	8.5	169	321	104	35
180	2.79	20.6	9.7	166	351	107	33
225	2.73	20.0	9.5	173	351	108	34
270	2.74	21.3	9.5	162	349	107	34

[1] Data is the two year average at each N rate.

FALL NITROGEN ON TALL FESCUE

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

Beginning in 1998, we started on-farm spring N rate studies on several grass species (tall fescue, perennial ryegrass, fine fescue and annual ryegrass) with a goal of defining the optimum N level for seed crop yield (economic returns) and to assess the environmental fate of higher use rates (NO_3 leaching). These data have been reported in the annual Seed Production Research Reports (1998-2001). Specific to tall fescue, we have concluded that the optimum level of spring-applied N for seed production was 90-135 lb N/a.

In all of our spring N trials, fall-applied N was held constant at each grower site, as were other nutrients (phosphorous and potassium) normally applied in the management for cool-season seed crops. However, additional questions arose in regard to the effects of making adjustments to fall-applied N and the effect on spring N requirements.

The current OSU recommendation is for 30 to 40 lb N/a to be applied in the fall. However, there is no research available identifying the impact of fall N in combination or alone with spring N needs in tall fescue. Thus, our research proposed to measure wider ranges of fall applied N alone and in combination with spring N to determine how seed yield is impacted by these combinations.

To conduct these trials, three on-farm large plot experiments were established in tall fescue fields during the fall of 2001. Two fields were newer stands – one in the first year of seed production, the other a second year stand, and the third field was an 8-year-old stand. Both fall and spring combinations of N fertilizer management were used in order to determine the balance needed. We also established a trial at OSU's Hyslop Research Farm using a small plot trial to look at a wider range of fall and spring N treatments.

All grower sites received three fall N levels (0, 40, and 80 lb N/a) applied the last week of October and two spring N levels (grower rate and grower + 40 lb N/a). The extra 40 lb N/a treatment was applied the last week of March following the normal grower applications to determine if grower spring N rates were adequate with different fall N rates. At the Hyslop Research Farm a factorial arrangement of treatments was used, which included all combinations of four fall N levels (0, 40, 80, and 120 lb N/a) and five spring N levels (0, 40, 80, 120, and 160 lb N/a) for a total of 20 (four fall x five spring) different treatment combinations. Seed yield and components of yield have been measured in each of these trials.

Results

Spring tillering: Prior to the spring N applications, plots were sampled at two of the grower sites and at Hyslop to determine the effect of fall N treatments at the end of winter and prior to spring N applications. This factor is important as seed yield is directly related to the number of fertile tillers in the stand. Vegetative tillers in a tall fescue seed crop generally need vernalization prior to spring growth in order to produce seed heads. Therefore the development of mature tillers during this period is important in managing the crop for optimum seed production. Tiller populations were significantly increased at both Hyslop Farm and Roselawn Farms (Table 1). The fall treatment increased spring tillers 54% following 80 lb N/a at Roselawn Farms. At Kuehne Farms, there were no responses to fall N nor were there seed yield responses (discussed later). Treatments at Hyslop farm increased tiller densities up to 75% over the zero fall N treatment.

Table 1. Spring tiller density response to fall nitrogen prior to spring N applications in tall fescue, 2002.

	Hyslop Farm	Kuehne Farms	Roselawn Farms
	(tillers / sq. ft.)		
Fall N (lb N/a)			
0	329 c	396	480 b
40	455 b	434	652 a
80	537 a	416	741 a
120	576 a	---	---
LSD 0.05	56	NS	123

[1] Means in <u>columns</u> followed by the same letter are not significantly different at FPLSD = 0.05

Other effects from the fall N on spring tillers at Hyslop Farm are detailed in Tables 2, 3 and 4. Use of fall N at Hyslop Farm resulted in larger more robust tillers as shown by the dry weights of the tillers in Table 2. The mean dry weight per tiller increased from 38 mg to 52 mg. Not only were the tillers bigger but there were significant increases in the larger (3, 4 and 5 mm) tillers (Table 3). The larger tillers also became a larger portion of the tiller population (Table 4) so the result of fall fertilizer was more larger tillers thereby providing the basis for a higher yield. There were positive responses in these factors up to the highest rate of fall N used (120 lb N/a).

Table 2. Spring tiller dry weight responses to fall nitrogen prior to spring N applications in Velocity tall fescue, 2002.

	Dry weight per tiller by size class (basal tiller diameter in mm) 1	2	3	4	5+	Mean tiller dry wgt.	Total dry wgt.
	(mg/tiller)						(tn/a)
Fall N (lb N/a)							
0	4	19 b[1]	49 b	117	208	38 b	0.60 a
40	5	19 b	53 b	118	185	34 b	0.74 b
80	6	25 a	52 b	129	187	40 b	1.03 c
120	8	26 a	69 a	159	230	52 a	1.42 d
LSD 0.05 (0.10)	NS	(5.7)	13	NS	NS	7	0.14

[1] Means in columns followed by the same letter are not significantly different at FPLSD = 0.05

Table 3. Spring tiller density responses to fall nitrogen prior to spring N applications in Velocity tall fescue, 2002.

	Tiller density by mm size class (basal tiller diameter) 1	2	3	4	5+	Total tillers	Pct. of 0 Fall
	(tillers/sq. ft.)						(%)
Fall N (lb N/a)							
0	13	182 b[1]	125 c	8 b	2	329 c	100
40	23	281 a	143 c	5 b	3	455 b	138
80	32	280 a	209 b	12 ab	4	537 a	163
120	16	262 a	272 a	20 a	6	576 a	175
LSD 0.05 (0.10)	NS	(63)	48	8	NS	56	--

[1] Means in columns followed by the same letter are not significantly different at FPLSD = 0.05

Table 4. Spring tiller density distribution response to fall nitrogen prior to spring N applications in Velocity tall fescue, 2002.

Main Factors	Percent in size class 1 mm	2 mm	3mm	4 mm	5+ mm
	(%)				
Fall N (lb N/a)					
0	4	56 ab[1]	38 b	2	0
40	5	62 a	32 c	1	1
80	6	52 b	39 ab	2	1
120	3	48 b	45 a	3	1
LSD 0.05 (0.10)	NS	(8)	6	NS	NS

[1] Means in columns followed by the same letter are not significantly different at FPLSD = 0.05 (0.10)

Seed Yield: Seed yield responses to fall N are shown in Tables 5, 6 and 7. At Kuehne's, there was no significant seed yield difference due to season (fall or spring) of N application or rate. Thus, given the history of this field's crop rotation, soil type, mineralization, etc., the most economical approach would have been to not make a fall N application and applied no more than a normal amount in the spring. This site was is in a high organic matter soil and had rotated out of pasture and other cropping systems the enriched the soil with high levels of organic matter. However, at Smucker's there was a significant yield advantage to applying 40 lb N/a in the fall when compared to none. There was no advantage to applying more than 40 lb N/a in the fall, nor was there an advantage to using a rate greater than the normal amount in the spring.

Table 5. Clean seed yields for Fall N x Spring N factorial at three on-farm grower sites, 2002

Location Variety	Kuehne Farms (Yamhill Co) Rebel Exeda (1st yr)	Roselawn Farms (Marion Co) Tomahawk IIE (2nd yr)	Smucker Farms (Linn Co.) Titan II (8th yr)	Three site average
Fall N (lb/a)				
0	2234	2232	1511 b[3]	1992
40	2275	2501	1675 a	2150
80	2208	2506	1712 a	2142
LSD 0.05	NS	*[2]	126	----
Spring N				
Grower N rate[1]	2241	2370	1613	2075
Grower + 40 lb N/a	2237	2455	1653	2115
LSD 0.05	NS	*	NS	----

[1] Kuehne = 140 lb N/a, Roselawn = 110 lb N/a, Smucker = 120 lb N/a.
[2] = Significant interaction at P<0.05.
[3] Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values.

The interpretation of the data (see Table 6) from Roselawn's site is not so straight forward due to the interaction between fall and spring applied N. In this situation, the advantage of applying at least 40 lb N/a in the fall was seen only at the normal grower rate of spring-applied N (110 lb N/a). However, when an additional 40 lb N/a was spring-applied to the grower's normal rate (150 lb N/a total), there was no significant advantage from fall-applied N. This suggests that (at this site in this year) additional spring N was needed to compensate for not applying N in the fall.

Table 6. Fall x Spring N seed yield interactions in Tomahawk IIE tall fescue, 2002.

Main Factors	---------- **Spring** N (**lb N/A**) -------- Grower N	 Grower N + 40
Fall N **(lb N/a)**	------------- (lb/a)	----------------
0	2068 b[1]	2395 a
40	2534 a	2468 a
80	2509 a	2503 a
LSD 0.05	------------- 226	--------------

[1] Means in <u>columns</u> followed by the same letter are not significantly different at FPLSD = 0.05

Data from the trial at Hyslop Farm (a 3rd year stand) also found a significant interaction between fall and spring applied N. Within the interaction, the highest yielding spring N rate was dependent on the level of fall N applied. As the fall N rate increased, the spring N rate needed for maximum yield decreased in almost a pound for pound exchange once the yield plateau was reached (for this trial that was at 160 - 200 lb N/a total application range). In order to ensure attaining the highest yield, a minimum of 40 lb N/a of fall N needed to be applied. The 0 fall N responded positively to increased spring N rates up to the highest spring N rate (160 lb N/a) and was comparable to other treatments at the 160 lb/a total N rate. The best yields were with a total rate of 200 lb N/a applied on an annual basis and were effective with several combinations: 40 fall + 160 spring, 80 fall + 120 spring, 120 fall + 80 spring. These are the results of only one year and as this trial and the others are continued, the cumulative effect of several years will help in determining the N needs of this crop as the stand ages.

Table 7. Fall x Spring N seed yield interactions in Velocity tall fescue, 2002.

Main Factors	Fall N (lb N/a) 0	40	80	120
Spring N (lb N/a)	---------- (lb/a) ----------			
0	585 d[1]	934 c	1042 b	1206 b
40	826 c	1237 b	1290 a	1357 b
80	1172 ab	1343 ab	1314 a	1571 a
120	1094 b	1202 b	1485 a	1560 a
160	1332 a	1541 a	1390 a	1383 ab
LSD 0.05	---------- 198 ----------			

[1] Means in columns followed by the same letter are not significantly different at FPLSD = 0.05

Highest yields at Hyslop were at a higher total N (200 lb) than at the grower sites. This can be seen by the data which shows a maximum yield attained at the 150 - 160 lb total N (fall+spring) for the Roselawn and Smucker sites. The Kuehne site yield was maximized by the lowest treatment of 140 lb total N.

Yield components: Figures 1 and 2 show graphically a representation of how fall or spring fertilizer affected the major yield components related to seed yield. In Figure 1 each fall N rate variable is the averaged value across all spring N rates, and in Figure 2 each spring N rate variable is the averaged value across all fall N rates, thus 0 lb fall N value for fertile tillers is the average of all five spring N rates that received 0 lb fall N, and the 0 lb spring N value for fertile tillers is the average of all four fall N rates that received 0 lb spring N. Fall N substantially increased fertile tiller numbers and some increases in spikelet numbers. There were some small negative effects on floret number and 1000 seed weight. Spring N had a lesser but still positive effect on fertile tiller densities and a large effect on the number of florets per spikelet. Potential seed number was significantly increased by both fall and spring N but, as indicated, by differing yield components. Both fall and spring N increased actual seed number, but the level of increase depended on the fall and spring combination as was previously discussed with the seed yield. Harvest efficiency, as measured by the FSU (floret site utilization), is the ratio of the actual seed number harvested compared to the potential seed number calculated. The decrease in FSU indicates that the crop was not able to convert all the improvements in yield components into harvested seed. As the level of N reached an optimum level (160-200 lb N/a) the seed yield reached a maximum plateau and did not go up any more indicating that N was no longer a limiting factor to yield and that other factors may be affecting the crop (genetics, weather, etc.,)

These results are encouraging in that they are consistent with the current OSU recommendations. It should be noted that these results are only from one year of data and if we are able to continue this research over several years, we will be able to provide more thorough recommendations.

Acknowledgement:
This project was supported by a grant from the Oregon Tall Fescue Commission.

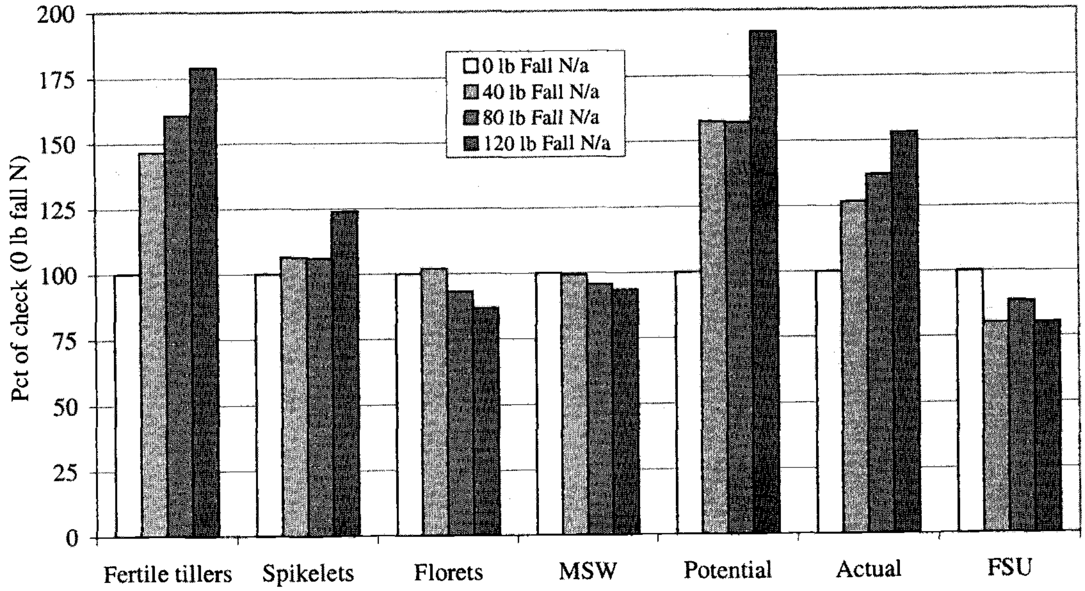


Figure 1. Seed yield components as influenced by rate of fall-applied N in Velocity tall fescue, 2002

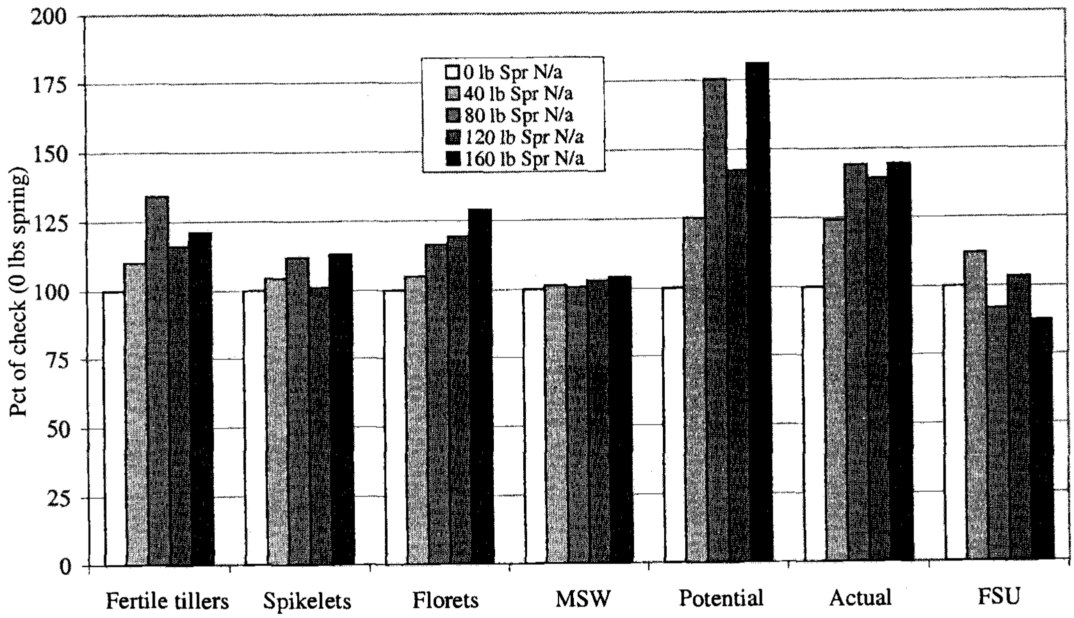


Figure 2. Seed yield components as influenced by rate of spring-applied N in Velocity tall fescue, 2002

RESPONSE OF PERENNIAL RYEGRASS TO SPRING NITROGEN FERTILITY AND PLANT GROWTH REGULATOR APPLICATIONS, 2002

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 nitrogen (N) fertility rates used to maximize seed production. Lodging of the crop can cause increased problems from disease and can decrease pollination, seed set and seed yield. Use of recently registered plant growth regulators (PGRs) Palisade® (trinexapac-ethyl) and Apogee® (Prohexadione-Calcium) have given excellent control of stem elongation resulting in seed yields increases. Previous research detailed in the annual Seed Production Research Reports (1999-2001) also determined that timing applications in relation to crop development affected differences in seed yield and the level of lodging. Being able to control the "leggy" growth caused by high levels of spring applied N may encourage growers to use higher than recommended N applications with the desire to further increase seed yields.

The objective of this research was to determine if controlling lodging can allow for more spring N to be applied in order to further increase seed yield.

Procedure

This trial was conducted on an established stand of Cutter perennial ryegrass in the fourth crop year at Hyslop Research Farm, Corvallis Oregon. A factorial experimental design with N rate and PGRs as main factors was used. PGR treatments were applied at walking speed using a bicycle-type 10-foot wide boom sprayer with nozzles at 18 inch spacing. The sprayer operated at 20 psi with XR TEEJET 8003VS nozzles (approx. 20 gal/a water). PGR Treatments were applied at a single rate of 0.36 lb a.i./a (Apogee at 21 oz/a and Palisade at 2.9 pt/a) at what is considered in an optimum timing for application (2 node stage of plant development). Nitrogen was split-applied with treatments at 90, 145, 180 and 225 lb N/a to cover a range of treatments from less than optimum to above optimum. Recommended rates are in the range of 135 to 180 lb N in the spring. Plots were 10 ft x 50 ft and treatments were applied in a factorial design with N rates (four rates) and type of PGR (Apogee®, Palisade® and untreated) as main factors. The resulting 12 treatments (4 N rates x PGRs) were replicated four times. 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.

Table 1. Calendar dates for Spring N, PGR application, swathing and combining, 2002.

1st Spring N (80 lb N)	March 4
2nd Spring N (rest)	April 8
PGR applied at 2 node stage	April 23
Swathed	July 8
Combined	July 18-19

Plots were sampled at early bloom to determine fertile tiller density, stem length measurements, and above ground biomass. Inflorescences were also randomly sampled for yield component analysis and inflorescence 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 a M2-B clipper cleaner for final cleanout; subsamples of combined seed were taken for 1000 seed weights.

Results

Data presented in Table 2, 3 and 4 are shown with two factors: N rate factor averages all treatments receiving the indicated N rate, and the PGR factor averages each PGR compound across all N rates. When there is no N rate x PGR interaction, the response to the main factors (either N rate or PGR) is essentially the same.

Seed yield increased as N rates increased from 90 to 145 lb N/a, but did not statistically increase as the N rate went up to 225 lb N/a (Table 2) indicating that N was not the factor limiting seed yield once the recommended range (135-180 lb N/a) was reached. PGR treated plots averaged 410 lb/a above the untreated (Table 2). Seed yields were optimized with or without the PGR at the same N rate. Harvest index (a measure of seed yield to total biomass) increased with PGR applications. Seed size (1000 seed weight) was not affected by any of the treatments. Lodging increased as the N rate increased, but was effectively controlled at all N rates by the PGR applications.

Within the spike, the number of spikelets was not affected by any treatment combination. Increased N rates and the application of PGRs both improved floret number. The floret number reached the maximum at 180 lb N/a. Spike length was increased by higher N rates and decreased with PGR applications, as would be expected. Fertile tiller densities were not affected by N rates or PGR treatments. The actual seed number harvested increased from both N and PGR applications (Table 4). However, only the potential seed number was improved by N application. Seed set (floret site utilization) was improved by the use of PGRs but not by using more N. Seed yield improvements appear to have come from more than one cause – a general increase in actual seed number and, for the PGR treatments, a higher seed set (floret site utilization).

These results show that the N requirement for optimum seed production is the same with or without the use of PGRs.

Results from other studies in fine fescue gave the same results. The use of these PGRs does not justify changing spring-applied N rates. The effect of PGR applications are best at optimum N rates.

Acknowledgments: This research was supported in part through funds from Syngenta Crop Protection, Inc. and BASF Corporation.

Table 2a. Statistical summary of harvest component responses to PGR's and Spring N in Cutter perennial ryegrass, 2002.

Main Factors	Seed yield	Total biomass	Harvest index	1000 seed weight	Plant height	Lodging. score
N rate	***[1]	NS	NS	NS	NS	***
PGR	***	NS	***	NS	***	***
N rate x PGR	NS	NS	NS	NS	NS	(*)

[1] NS = not significant P value 0.05, (*) = 0.05 ≤ P value ≤0.10,* = P value ≤0.05, ** = P value ≤0.01, *** = P value ≤0.001

Table 2b. Harvest component responses to PGR's and Spring N in Cutter perennial ryegrass, 2002.

Main Factors	Seed yield	Total biomass	Harvest index	1000 seed weight	Plant height	Lodging. score
	(lb/a)	(tn/a)	(%)	(g)	(cm)	(1-5)
<u>N rate (lb/a)</u>						
90	1184 b[1]	4.3	15.5	1.59	54.3	2.3 c
145	1375 a	5.1	14.0	1.61	57.1	2.6 b
180	1418 a	4.9	15.0	1.64	56.0	3.0 a
225	1437 a	5.2	14.3	1.63	56.7	3.2 a
LSD 0.05	88	NS	NS	NS	NS	0.2
<u>PGR</u>						
Untreated	1080 b	5.3	10.5 b	1.61	65.4 a	4.6 b
Palisade	1490 a	4.7	16.8 a	1.64	51.8 b	1.8 a
Apogee	1491 a	4.6	16.8 a	1.61	50.9 b	1.8 a
LSD 0.05	77	NS	2.8	NS	4.0	0.2

[1] Means in <u>columns</u> for each main factor followed by the same letter are not significantly different at FPLSD = 0.05

Table 3a. Statistical summary of inflorescence yield component responses to PGR's and Spring N in Cutter perennial ryegrass, 2002.

Main Factors	Spikelets per infl.	Florets per spikelet by position on inflorescence: bottom	2	3	4	top	mean	Spike length
N rate	NS[1]	**	***	**	**	**	***	*
PGR	NS	*	**	**	**	*	**	***
N rate x PGR	NS	NS	NS	NS	NS	NS	NS	NS

[1] NS = not significant P value 0.05, (*) = 0.05 ≤ P value ≤0.10, * = P value ≤0.05, ** = P value ≤0.01, *** = P value ≤0.001

Table 3b. Inflorescence yield component responses to PGR's and Spring N in Cutter perennial ryegrass, 2002.

Main Factors	Spikelets per infl.	Florets per spikelet by position on inflorescence: bottom	2	3	4	top	mean	Spike length
	(no.)	----------------(no.)					----------------	(cm)
N rate (lb/a)								
90	21.0	4.5 c[1]	5.2 c	5.5 b	5.8 c	4.9 b	5.2 c	14.0 b
145	21.5	5.2 ab	5.9 bc	6.3 ab	6.3 bc	5.5 ab	5.8 bc	14.6 ab
180	21.6	6.3 a	6.7 ab	7.0 a	7.0 ab	6.0 a	6.6 ab	15.6 a
225	21.1	6.2 a	7.0 a	7.2 a	7.3 a	6.1 a	6.7 a	15.2 a
LSD 0.05	NS	0.9	0.9	0.9	0.8	0.7	0.8	1.1
PGR								
Untreated	21.5	4.8 b	5.5 b	5.8 b	5.9 b	5.1 b	5.4 b	17.1 a
Palisade	21.5	6.0 a	6.8 b	7.0 a	7.1 a	6.1 a	6.6 a	13.6 b
Apogee	20.9	5.8 a	6.3 b	6.7 a	6.8 a	5.7 ab	6.3 a	13.8 b
LSD 0.05	NS	0.8	0.8	0.8	0.7	0.6	0.7	0.9

[1] Means in columns for each main factor followed by the same letter are not significantly different at FPLSD = 0.05

Table 4a. Statistical summary of tiller density and harvest efficiency responses to PGR's and Spring N in Cutter perennial ryegrass, 2002.

Main Factors	Fertile tillers Density	Fertile tillers Specific dry wgt.	Actual seed number	Potential seed number	Floret site utilization
N rate	NS[1]	NS	***	*	NS
PGR	NS	NS	***	NS	*
N rate x PGR	NS	NS	NS	NS	NS

[1] NS = not significant P value 0.05, (*) = 0.05 ≤ P value ≤0.10, * = P value ≤0.05, ** = P value ≤0.01, *** = P value ≤0.001

Table 4b. Tiller density and harvest efficiency responses to PGR's and Spring N in Cutter perennial ryegrass, 2002.

Main Factors	Fertile tillers Density	Fertile tillers Specific dry wgt.	Actual seed number	Potential seed number	Floret site utilization
	(no/sq. ft.)	(mg/tiller)	---------- (000/sq. m.)	------------	(%)
N rate (lb/a)					
90	211	435	7.8 b[1]	22.9 b	37.7
145	229	464	8.9 a	28.2 ab	32.8
180	227	456	9.0 a	32.5 a	29.9
225	232	477	9.2 a	33.1 a	29.7
LSD 0.05	NS	NS	0.6	6.9	NS
PGR					
Untreated	243	464	7.0 b	28.6	27.2 b
Palisade	211	472	9.5 a	29.6	34.4 a
Apogee	221	438	9.7 a	29.3	35.9 a
LSD 0.05	NS	NS	0.5	NS	6.6

[1] Means in columns within each main factor followed by the same letter are not significantly different at FPLSD = 0.05

RESPONSE OF PERENNIAL RYEGRASS TO TIMING OF PLANT GROWTH REGULATOR APPLICATIONS, 2002

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 cause increased problems from disease and can decrease pollination, seed set, and seed yield. Use of recently registered plant growth regulators (PGRs) Palisade® (trinexapac-ethyl) and Apogee® (Prohexadione-Calcium) have given excellent control of stem elongation resulting in seed yields increases. Previous research detailed in the annual Seed Production Research Reports (1999-2001) also determined that timing applications in relation to crop development affected differences in seed yield and the level of lodging. Seed yield increases were not solely attributed to lodging control, but also to physiological changes in the potential seed yield. The greatest impact on yield potential and seed yield were from applications prior to seed head emergence.

Palisade® and Apogee® both function in the plant the same way but are not identical compounds and are different formulations. Apogee® is available as a water dispersible granule (WDG) and Palisade® is available as an emulsifiable concentrate (EC). Prior research had indicated responses were similar with both compounds but equal active ingredients were not always used.. This trial was set up to determine if both compounds gave the same crop responses at the same active ingredients across the full range of timings used in seed production. Much of the earlier timing research was done using Palisade® so it was not known if Apogee® gave similar responses. The research reported here was designed to determine the impact of both compounds at the same active ingredient levels and timings.

Procedure

This trial was conducted on an established stand of Cutter perennial ryegrass in the fourth crop year at Hyslop Research Farm, Corvallis Oregon. A factorial experimental design with rate and date as main factors was used. PGR treatments were applied at walking speed using a bicycle-type 10-foot wide boom sprayer with nozzles at 18 inch spacing. The sprayer operated at 20 psi with XR TEEJET 8003VS nozzles (approx. 20 gal/a water). Treatments were applied at a single rate of 0.36 lb a.i./a (Apogee at 21 oz/a and Palisade at 2.9 pt/a). Treatment timings were selected to coincide with defined plant growth stages (see Table 1). Applications with each PGR were done at the onset of internode expansion (1st date), 2 node stage (2nd date), flag leaf emerging (3rd date), 10% heading (4th date) and at full heading prior to bloom (5th date). Plots were 10 ft x 50 ft and treatments were applied in a factorial design with timing (five dates) and type of PGR (Apogee®, Palisade®) as main factors. The resulting 11 treatments (5 timings x 2 PGRs + 1 untreated check) were replicated four times. 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.

Table 1. Calendar dates for PGR application, swathing and combining, 2002.

Onset of internode expansion	April 12
2 node stage	April 23
Flag leaf emergence	May 3
Early heading (10%)	May 13
Full heading	May 22
Swathed	July 8
Combined	July 18-19

Plots were sampled at early bloom to determine fertile tiller density, stem length measurements, and above ground biomass dry weights. Inflorescences were also randomly sampled for yield component analysis and inflorescence 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). Combine-harvested seed samples were cleaned using a M2-B clipper cleaner for final cleanout; sub-samples of combined seed were taken for determining 1000 seed weight.

Results

Data presented in Table 2, 3 and 4 are shown with three factors: the Check vs treated compares the check (untreated) with the average of all PGR treatments, the Timing factor averages both PGRs at each stage of growth, and the PGR factor averages each PGR compound across all timings. When there is no Time x PGR interaction, the response to the PGRs is essentially the same.

Seed yield increases from all PGR treated plots averaged 345 lb/a above the untreated check (Table 2 – Check vs treated). Yields were optimized with application up to and including flag leaf emergence. PGR applications made after flag leaf emergence resulted in considerable yield decline. Harvest index (a measure of seed yield to total biomass) was increased by PGR use, with the greatest improvement occurring from the earliest timing. Seed size (1000 seed weight) was improved by the PGR treatments. Crop height and subsequent lodging was maximized by the earliest timings.

Within the spike, the number of spikelets was generally unchanged except for a minor (10%) reduction by the earliest and latest PGR applications (Table 3). Floret numbers were improved by all PGR treatments with an average increase of 1.2 florets per spikelet (25% increase). There was a different response in floret numbers to the two PGRs used resulting in the interaction shown in Table 5. Palisade® maximized the floret count with the earlier treatments (onset and 2-node) and Apogee® maximized the floret counts a little later (Flag and Early heading timings). Fertile tiller densities were affected some by the timing of the PGR treatments. The earliest treatment had a small decrease in the total number of fertile tillers at harvest (Table 4) but the resulting seed yields seemed unaffected by this. Seed yield improvements appear to have come from several sources – increased seed weight, a general increase in potential seed numbers (more florets) and a higher seed set (floret site utilization) resulting in an average 33% seed yield increase over the untreated plots.

Table 5. Perennial ryegrass PGR x Growth stage interaction on floret development, 2002.

Growth Stage	PGR		Average
	Apogee®	Palisade®	
	- (Florets per spikelet) -		
Onset	5.6 b[1]	6.6 ab	6.1
2 node	5.7 b	6.9 a	6.3
Flag leaf	6.9 a	5.9 bc	6.4
Early heading	6.3 ab	5.4 c	5.9
Full heading	5.9 b	5.9 bc	5.9
LSD 0.05	0.8	0.8	---

[1]Means in columns within each main factor followed by the same letter are not significantly different at FPLSD = 0.05

These results show that both compounds provide the same yield improvements and give the best yields when applied prior to seed head emergence. Results for previous years gave similar responses and also indicate that lower rates have less dramatic changes in yield, but are still very effective at improving the overall efficiency of perennial ryegrass without any other inputs except the PGR application.

Acknowledgments: This research was supported in part through funds from Syngenta Crop Protection, Inc. and BASF Corporation.

Table 2a. Statistical summary of harvest component responses to PGR application time and type in Cutter perennial ryegrass, 2002.

Main Factors	Seed yield	Total biomass	Harvest index	1000 seed weight	Height reduction	Lodging score
Check vs treated	***[1]	NS	*	(*)	***	***
Time	***	*	***	NS	NS	***
PGR	NS	NS	NS	NS	NS	NS
Time x PGR	NS	NS	NS	NS	NS	NS

[1] NS = not significant P value 0.05, (*) = 0.05 ≤ P value ≤0.10, * = P value ≤0.05, ** = P value ≤0.01, *** = P value ≤0.001

Table 2b. Harvest component responses to PGR application time and type in Cutter perennial ryegrass, 2002.

Main Factors	Seed yield	Total biomass	Harvest index	1000 seed weight	Height reduction	Lodging score
	(lb/a)	(tn/a)	(%)	(g)	(%)	(1-5)
<u>Check vs treated</u>						
Check	1060 b[1]	5.0	11 b	1.57 b	0	4.6 b
All treated	1405 a	5.1	15 a	1.62 a	19	2.4 a
LSD 0.05 (0.10)	105	NS	4	(0.05)	6	0.5
<u>Timing</u>						
Onset	1455 a	4.0	19 a	1.59	18	1.9 ab
2 Node	1483 a	5.2	15 bc	1.62	21	1.6 a
Flag	1531 a	5.1	16 ab	1.63	20	2.1 ab
Early heading	1314 b	5.6	12 cd	1.63	20	3.2 c
Full heading	1244 b	5.7	11 d	1.65	14	3.4 c
LSD 0.05	100	1.0	3	NS	NS	0.5
<u>PGR</u>						
Palisade®	1384	5.2	14	1.62	19	2.4
Apogee®	1427	5.0	15	1.63	18	2.5
LSD 0.05	NS	NS	NS	NS	NS	NS

[1] Means in <u>columns</u> within each main factor followed by the same letter are not significantly different at FPLSD = 0.05

Table 3a. Statistical summary of inflorescence yield component responses to PGR application time and type in Cutter perennial ryegrass, 2002.

Main Factors	Spikelets per infl.	Florets per spikelet by position on inflorescence: bottom	2	3	4	top	mean	Spike length
Check vs treated	NS[1]	**	***	**	***	**	***	***
Time	(*)	NS	NS	NS	NS	NS	NS	***
PGR	NS	NS	NS	NS	NS	NS	NS	NS
Time x PGR	NS	**	***	**	**	*	***	(*)

[1]NS = not significant P value 0.05, (*) = 0.05 ≤ P value ≤0.10,* = P value ≤0.05, ** = P value ≤0.01, *** = P value ≤0.001

Table 3b. Inflorescence yield component responses to PGR application time and type in Cutter perennial ryegrass, 2002.

Main Factors	Spikelets per infl.	Florets per spikelet by position on inflorescence: bottom	2	3	4	top	mean	Spike length
	(no.)	----------(no.)----------						(cm)
Check vs treated								
Check	21.2	4.1 b[1]	4.9 b	5.5 b	5.2 b	4.9 b	4.9 b	16.8 a
All treated	20.5	5.5 a	6.3 a	6.5 a	6.6 a	5.7 a	6.1 a	14.2 b
LSD 0.05	NS	0.8	0.7	0.7	0.6	0.6	0.6	1.1
Timing								
Onset	19.5 c	5.7	6.2	6.6	6.5	5.7	6.1	13.3 b
2 Node	21.4 a	5.7	6.4	6.7	6.8	6.0	6.3	13.3 b
Flag	20.9 ab	5.8	6.7	6.6	7.0	5.9	6.4	13.4 b
Early heading	20.8 ab	5.3	6.0	6.5	6.3	5.4	5.9	15.0 a
Full heading	19.8 bc	5.3	6.1	6.2	6.4	5.6	5.9	15.9 a
LSD 0.05 (0.10)	(1.3)	*[2]	*	*	*	*	*	1.0
PGR								
Palisade®	20.6	5.6	6.3	6.4	6.6	5.8	6.1	14.1
Apogee®	20.4	5.4	6.2	6.6	6.6	5.6	6.1	14.3
LSD 0.05	NS	*	*	*	*	*	*	NS

[1] Means in columns within each main factor followed by the same letter are not significantly different at FPLSD = 0.05
[2] * = significant timing x PGR interaction.

Table 4a. Statistical summary of tiller density and harvest efficiency responses to PGR application time and type in Cutter perennial ryegrass, 2002.

Main Factors	Fertile tillers: Density	Fertile tillers: Specific dry wgt.	Actual seed number	Potential seed number	Floret site utilization
Check vs treated	NS[1]	NS	***	NS	NS
Time	*	NS	***	*	***
PGR	NS	NS	NS	NS	NS
Time x PGR	NS	NS	NS	NS	NS

[1]NS = not significant P value 0.05, (*) = 0.05 ≤ P value ≤0.10,* = P value ≤0.05, ** = P value ≤0.01, *** = P value ≤0.001

Table 4b. Tiller density and harvest efficiency responses to PGR application time and type in Cutter perennial ryegrass, 2002.

Main Factors	Fertile tillers: Density	Fertile tillers: Specific dry wgt.	Actual seed number	Potential seed number	Floret site utilization
	(no/sq. ft.)	(mg/tiller)	---------- (000/sq. m.)	------------	(%)
Check vs treated					
Check	253	418	7.0 b	25.8	29.3 b
All treated	241	445	9.0 a	30.0	31.9 a
LSD 0.05	NS	NS	0.6	NS	3.9
Timing					
Onset	194 b[1]	431	9.5 a	22.9 b	43.1 a
2 Node	252 a	433	9.5 a	33.7 a	29.0 b
Flag	234 ab	450	9.8 a	30.6 a	32.6 b
Early heading	252 a	475	8.4 b	30.3 a	28.7 b
Full heading	275 a	435	7.9 b	32.6 a	26.3 b
LSD 0.05	47	NS	0.6	7.2	7.3
PGR					
Palisade®	246	449	8.9	30.6	30.8
Apogee®	237	440	9.2	29.4	33.0
LSD 0.05	NS	NS	NS	NS	NS

[1] Means in columns within each main factor followed by the same letter are not significantly different at FPLSD = 0.05

PALISADE AND FIELD BURNING IN CREEPING RED FESCUE

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

Introduction

Application of plant growth regulators such as Palisade can reduce or delay lodging in grass seed crops. It may also be possible to lessen the need for field burning in creeping red fescue and other grasses by the use of plant growth regulators. Field burning increases seed yield in some species by reducing autumn plant height and rhizome production, and by increasing panicle production. Autumn application of these plant growth regulators might enhance seed yield without field burning, especially as the stand ages. Spring application may further increase yield by stimulating greater panicle production and by reducing lodging.

Methods

Field trials were conducted to compare autumn application of Palisade in burned vs. nonburned stands of Shademaster creeping red fescue. Twelve combinations of autumn and spring applications of Palisade were investigated. Two rates of Palisade (1.4 pt/acre and 2.9 pt/acre) and two dates of application are being tested in the autumn and one rate (2.9 pt/acre) and two application dates in the spring. Early autumn applications were made on October 10, 2001 and October 9, 2002, while late autumn applications were made on November 6, 2001 and 2002. Early spring applications were made on April 16, 2001, and April 11, 2002, and late applications were made May 3, 2001, and April 30, 2002.

Samples were taken in late autumn to determine treatment effects on tiller height, and shoot, root, and rhizome biomass. Seed yield components (panicle number, spikelets/panicle, and florets/spikelet) were determined on samples taken prior to peak anthesis. The plots were harvested with a specially-designed small-plot swather and threshed with a small-plot combine. Seed yield was determined on cleaned seed obtained from the plots.

Results

Some characteristics of the growth and development of the creeping red fescue plant responded to field burning while others responded to Palisade treatment. Seed yield differences were very small between burned and flailed crops in the first-year (2001) but yield was much greater when burned in the second-year (2002). The differential response to field burning in the two crops years is typical for creeping red fescue and can be explained by the yield components (Table 1). No statistically significant differences were observed in 2001, but spikelets/panicle and panicle length were greater for burning than for the flailed crop in 2002. Even though many of these yield components were not individually significant in either year, the mathematical product of three of these yield components that together form the crop's yield potential; panicle number, spikelets/panicle, and florets/spikelet, was consistently greater in both years.

Table 1. Effect of residue management on yield components in Shademaster creeping red fescue.

Year	Characteristic	Burn	Flail
2001	Panicles/ft^2	365	349
	Spikelets/panicle	33	32
	Florets/spikelet	4.8	4.8
	Panicle length (cm)	13.4	12.9
	Above-ground dry weight (g/ft^2)	185	143
2002	Panicles/ft^2	403	377
	Spikelets/panicle	28b	23a
	Florets/spikelet	4.6	4.7
	Panicle length (cm)	11.9b	10.4a
	Above-ground dry weight (g/ft^2)	165	139

Seed yield was governed by an interaction of Palisade treatment and residue management in each year (Figures 1 and 2). Spring applications of Palisade increased seed yield of creeping red fescue to the same extent whether or not the crop residue had been burned after the previous harvest in 2001 (Figure 1). Spring applications increased seed yield by up to 40% over the burned or non-burned controls (without Palisade) in 2001, and nearly by 50% in 2002. Early spring application produced similar seed yield to late spring application in both years. Increases in yield in the early spring application was attributable to a combination of increased flowering (floret number) and seed set (Table 2) in 2001. In 2002, seed yield was increased in spring applications of Palisade by the same extent over the untreated controls, but the burned and treated plots out-yielded the flailed and treated plots. Late spring application did not improve flowering, but markedly increased the seed set observed from the early spring application in 2001. Seed set was very high for both spring application timings in 2002.

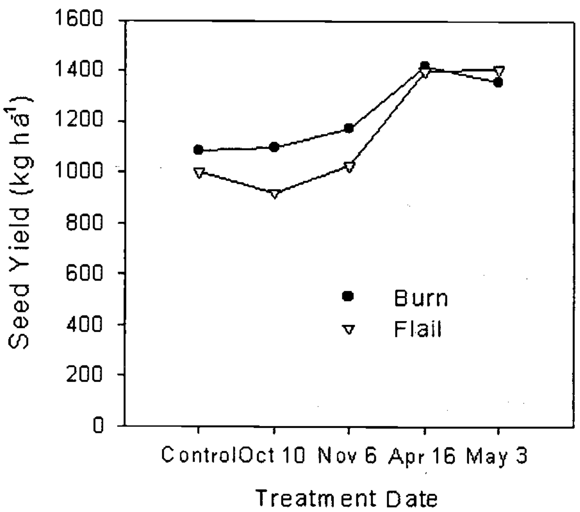


Figure 1. Interaction of Palisade treatment date and residue management on seed yield of first-year creeping red fescue in 2001.

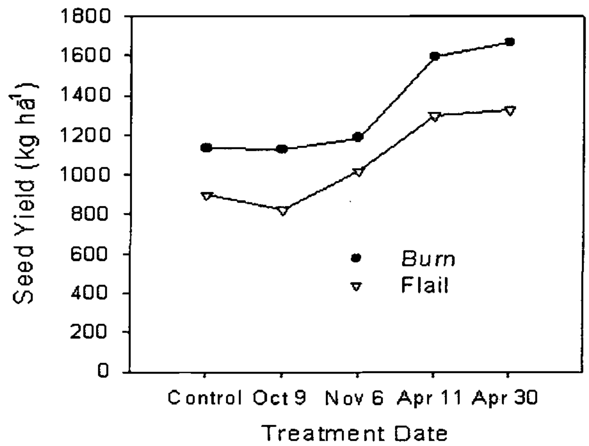


Figure 2. Interaction of Palisade treatment date and residue management on seed yield of second-year creeping red fescue in 2002.

The rate of autumn application had no consistent effect on seed yield, however, panicle number tended to be reduced and floret number increased with increasing rate of Palisade in 2002. Plots that were field burned out-yielded those that were not burned with or without autumn Palisade application. Autumn applications of Palisade did not significantly improve seed yield of the 1st year crop, but Palisade caused a modest increase in seed yield in the non-burned crop when applied in late autumn.

Inconsistent effects on autumn shoot biomass and tiller height were noted in response to Palisade application (data not shown). Rhizome biomass was reduced by 15 to 35% by both autumn and spring applications of Palisade (data not shown).

Plant growth regulators such as Palisade are beneficial management tools that provide seed producers with the opportunity to improve the reproductive efficiency of grass seed crops and to improve production cost efficiencies. Furthermore, this tool might be used by seed growers to lessen the need for field burning in creeping red fescue. Spring applications of Palisade on unburned creeping red fescue consistently increased seed yield over the untreated, burned control in each year.

Table 2. Palisade treatment and date of application effects on florets/spikelet and seed set in Shademaster creeping red fescue.

	Florets/spikelet		Seed set (%)	
Treatment Date 2001/2002	2001	2002	2001	2002
Untreated	4.8	4.4	16.4	22.1
October 10/9	4.9	4.7	18.9	23.9
November 6	4.4	4.5	18.0	24.3
April 16/11	5.4	4.9	19.6	32.8
May 3/April 30	4.9	4.8	23.4	31.9

ANNUAL BLUEGRASS CONTROL IN CARBON-SEEDED PERENNIAL RYEGRASS

C.M. Cole, R.P. Affeldt, B.D. Brewster, J.B. Colquhoun and C.A. Mallory-Smith

Introduction

The application of activated charcoal (carbon) over the seed row to safen a perennial ryegrass crop to preemergence herbicides has been a common practice in grass seed production in Oregon for over three decades. During that time annual bluegrass (*Poa annua*) developed resistance to diuron (Karmex, Direx) in some fields. Stand establishment in these fields would benefit from an alternative to diuron.

Four trials were conducted to assess the merits of applying norflurazon (Solicam), pronamide (Kerb), flumioxazin (Valor), pyrithiobac (Staple), and azafeniden (Milestone) as preemergence broadcast treatments over activated carbon.

Methods

The experimental design for each trial was a randomized complete block with four replications. Individual plots were 8 ft by 35 ft. Soil at the OSU Hyslop Research Farm was a Woodburn silt loam with an organic matter content of 2.6% and a pH of 5.6; soil at the Tangent site was a Dayton silt loam with an organic matter content of 3.0% and a pH of 6.0; soil at the Shedd site was an Amity silt loam with an organic matter content of 4.2% and a pH of 6.1; and soil at the Crabtree location was a Holcomb silt loam with an organic matter content of 6.0% and a pH of 6.1. The Hyslop site was infested with non-resistant annual bluegrass. The three sites in growers' fields were infested with suspected diuron-resistant annual bluegrass. 'Linn' perennial ryegrass was seeded October 3, 2001 in the Hyslop trial. 'Prelude' perennial ryegrass was seeded on October 8, 2001, in both the Tangent and Shedd trials, and on October 10, 2001, in the Crabtree trial. Activated carbon was applied over the seed row in a 1-inch band at 300 lb/a during the planting process at all sites. Herbicide timing was October 7, 2001 for the Hyslop trial, October 9, 2001 for the Tangent and Shedd trials, and October 12, 2001 for the Crabtree trial. Herbicides were applied in water at 20 gallons per acre at 20 psi. Visual evaluations were conducted periodically to assess annual bluegrass and volunteer perennial ryegrass control and perennial ryegrass injury. The crop was swathed prior to threshing with a small-plot combine in July. The seed was cleaned prior to weighing.

Results

Annual bluegrass control was less effective in growers' fields that at the Hyslop site (Table 1). Pyrithiobac and the lower rate of flumioxazin were the least effective on annual bluegrass. The pronamide and norflurazon treatments were most consistent in controlling annual bluegrass between rows. Annual bluegrass control within the seed row was most consistent where norflurazon was applied. Control of volunteer perennial ryegrass between rows was slightly improved with the norflurazon and pronamide treatments compared to diuron applied alone.

Crop protection with activated carbon was adequate in all herbicide treatments and at all locations. The norflurazon treatments at the Tangent site caused considerable chlorosis at the December evaluation, but symptoms had mostly subsided by January (Table 2).

Ryegrass yield was not influenced statistically by any herbicide treatment at the two harvested off-station locations. Seed yields at the Hyslop site were the lowest in the untreated check.

Pronamide is legal for use at a lower rate than that tested. Norflurazon, flumioxazin, pyrithiobac and azafeniden are not labeled for any application in grass seed production.

Table 1. Annual bluegrass control in carbon-seeded perennial ryegrass between and within the seed row three months after treatment in four locations.

		Annual bluegrass control							
		Hyslop		Tangent		Shedd		Crabtree	
Treatment	Rate	Between row	In row	Between row	In row	Between row	In row	Between row	In row
	(lb a.i./a)	(%)							
Diuron	2.4	93.5	66.3	12.5	5.0	33.8	47.5	50.0	45.0
Diuron + norflurazon	1.6 + 0.98	97.5	82.5	80.0	20.0	75.0	78.8	81.3	75.0
Diuron + norflurazon	1.6 + 1.96	98.0	93.8	84.9	58.9	85.0	90.0	92.5	85.0
Diuron + pronamide	1.6 + 0.375	96.0	50.0	95.0	77.5	93.8	98.0	96.0	95.0
Diuron + flumioxazin	1.6 + 0.05	85.0	50.0	50.0	2.5	52.5	25.0	57.5	32.5
Diuron + flumioxazin	1.6 + 0.1	90.0	58.8	81.3	20.0	76.3	62.5	88.8	72.5
Diuron + pyrithiobac	1.6 + 0.1	90.0	72.5	15.0	0.0	43.8	50.0	47.5	0.0
Diuron + azafeniden	1.6 + 0.1	96.3	50.0	62.5	11.3	62.5	56.3	71.3	50.0
Check	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSD 0.05		7.58	18.47	10.17	17.62	12.26	9.32	4.46	8.80

Table 2. Perennial ryegrass injury in four trial locations evaluated approximately two and three months after herbicide application.

		Perennial ryegrass injury							
		Hyslop		Tangent		Shedd		Crabtree	
Treatment	Rate	Nov. 13	Dec. 18	Dec. 18	Jan. 23	Nov. 30	Dec. 18	Dec. 18	Jan. 23
	(lb a.i./a)	(%)							
Diuron	2.4	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0
Diuron + norflurazon	1.6 + 0.98	2.5	0.0	35.0	17.5	0.0	0.0	35.0	18.8
Diuron + norflurazon	1.6 + 1.96	21.3	13.8	52.9	16.5	7.5	0.0	45.0	22.5
Diuron + pronamide	1.6 + 0.375	17.5	21.3	15.0	10.0	2.5	0.0	7.5	2.5
Diuron + flumioxazin	1.6 + 0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diuron + flumioxazin	1.6 + 0.1	0.0	0.0	0.0	0.0	0.0	0.0	2.5	2.5
Diuron + pyrithiobac	1.6 + 0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diuron + azafeniden	1.6 + 0.1	0.0	17.5	37.5	17.5	0.0	0.0	10.0	2.5
Check	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSD 0.05		5.70	5.34	5.99	4.13	3.65	0.0	12.54	6.81

TOLERANCE OF SEEDLING GRASSES AND CONTROL OF BROADLEAF WEEDS WITH CARFENTRAZONE

R.P. Affeldt, C.M. Cole, B.D. Brewster, J.B. Colquhoun and C.A. Mallory-Smith

Introduction

Carfentrazone (Aim) is a broadleaf herbicide that is very effective for control of several problem weeds in western Oregon, such as catchweed bedstraw (*Galium aparine*) and ivyleaf speedwell (*Veronica hederaefolia*). Carfentrazone is often tank-mixed with a broad-spectrum broadleaf herbicide, because it provides little control of some weeds such as mayweed chamomile (*Anthemis cotula*) and common groundsel (*Senecio vulgaris*). Carfentrazone has been reformulated as an emulsifiable concentrate (EC), which poses a potential for increased phytotoxicity compared to the dry granule formulation (DG). Tank-mixing carfentrazone with other broadleaf herbicides may further increase this phytotoxicity. We evaluated the tolerance of seedling grasses and weed control with the liquid carfentrazone formulation alone and tank-mixed with 2,4-D, MCPA, dicamba (Banvel, Clarity), tribenuron (Express), clopyralid with MCPA (Curtail M), and bromoxynil (Buctril).

Methods

The trial was conducted at the OSU Hyslop research farm near Corvallis on five seedling grass species. Six rows each of 'Highland' bentgrass, 'Pennlate' orchardgrass, 'Top Hat' perennial ryegrass, 'Velocity' tall fescue, and 'Shademaster' creeping red fescue were seeded on 12 inch row spacing across each plot with Planet Jr. seeders on April 25, 2002. The trial site was irrigated. A randomized complete block experimental design with four replications and 8 ft by 35 ft plots was used in this study. The soil was a Woodburn silt loam with an organic matter content of 2.6% and a pH of 5.1. The herbicide treatments were applied on May 22 with a single-wheel compressed-air plot sprayer, which delivered 20 gallons per acre at 20 psi. At the time of treatment the bentgrass and orchardgrass had 2 to 3 leaves, the tall fescue and creeping red fescue had 2 to 4 leaves with 0 or 1 tiller, and the perennial ryegrass had 3 to 5 leaves with 1 tiller.

Results

Perennial ryegrass and tall fescue were more sensitive to the liquid formulation of carfentrazone than the dry formulation at the 0.025 lb a.i./a rate (Table 1). For the other three species there was little difference in tolerance between the two formulations of carfentrazone. Orchardgrass was the most sensitive grass to carfentrazone, followed by bentgrass in the initial evaluation. The addition of other herbicides increased injury on all species. For most additional herbicides, bentgrass and orchardgrass were most sensitive, but tribenuron dramatically increased early injury on perennial ryegrass and tall fescue. Later evaluations indicated the grasses were recovering, but the bentgrass was still stunted more than the other species. Orchardgrass was especially sensitive to treatment with bromoxynil and carfentrazone, having 76% injury 1 week after application, and resulting in a diminished stand.

Both formulations of carfentrazone provided excellent control of hairy nightshade and shepherdspurse (Table 2). The addition of other herbicides was necessary for adequate control of mayweed chamomile and common groundsel. Treatments containing MCPA and dicamba were not as effective on mayweed chamomile and common groundsel, however the higher rate of carfentrazone improved control.

Table 1. Crop injury evaluations 1 and 5 weeks after herbicide application to seedling grasses on May 22, 2002, Hyslop Farm, Corvallis, OR.

		Crop Injury									
		Bentgrass		Orchardgrass		Perennial ryegrass		Tall fescue		Red fescue	
Treatment	Rate	1 wk	5 wk	1 wk	5 wk	1 wk	5 wk	1 wk	5 wk	1 wk	5 wk
	(lb a.i./a)	(%)									
Carfentrazone DG	0.016	31	21	39	24	26	23	23	21	21	18
Carfentrazone DG	0.025	31	16	51	23	28	20	25	20	30	15
Carfentrazone EC	0.016	30	15	39	18	25	15	23	18	25	16
Carfentrazone EC	0.025	38	23	41	23	38	29	41	23	34	16
Carfentrazone EC + 2,4-D	0.016 + 0.25	55	49	53	38	25	20	28	29	31	28
Carfentrazone EC + 2,4-D	0.025 + 0.25	58	46	61	46	35	29	35	31	44	31
Carfentrazone EC + MCPA	0.016 + 0.375	65	44	54	35	31	30	41	31	35	33
Carfentrazone EC + MCPA	0.025 + 0.375	75	50	61	44	39	26	48	31	45	35
Carfentrazone EC + dicamba	0.016 +0.25	56	48	60	28	29	26	45	29	35	33
Carfentrazone EC + dicamba	0.025 + 0.25	65	45	68	45	39	26	54	31	46	39
Carfentrazone EC + tribenuron	0.016 + 0.0156	51	21	34	18	53	34	53	38	31	23
Carfentrazone EC + tribenuron	0.025 + 0.0156	58	28	48	31	61	43	64	41	50	35
Carfentrazone EC + clopyralid & MCPA	0.016 + 0.3	63	38	54	38	30	24	35	34	26	33
Carfentrazone EC + clopyralid & MCPA	0.025 + 0.3	65	35	69	38	39	21	38	39	34	30
Carfentrazone EC + bromoxynil	0.016 + 0.375	60	30	76	45	40	28	41	29	43	38
Carfentrazone EC + bromoxynil	0.025 + 0.375	71	33	76	46	55	29	53	30	50	33
check	0	0	0	0	0	0	0	0	0	0	0
LSD 0.05	---	14	11	15	14	12	14	12	13	13	12

Table 2. Broadleaf weed control 5 weeks after herbicide application to seedling grasses on May 22, 2002, Hyslop Farm, Corvallis, OR.

Treatment	Rate	Weed control			
		Mayweed chamomile	Common groundsel	Hairy nightshade	Shepherdspurse
	(lb a.i./a)	(%)			
Carfentrazone DG	0.016	65	31	99	99
Carfentrazone DG	0.025	74	44	100	99
Carfentrazone EC	0.016	69	51	100	99
Carfentrazone EC	0.025	68	68	100	99
Carfentrazone EC + 2,4-D	0.016 + 0.25	81	96	100	100
Carfentrazone EC + 2,4-D	0.025 + 0.25	91	97	100	100
Carfentrazone EC + MCPA	0.016 + 0.375	75	84	100	100
Carfentrazone EC + MCPA	0.025 + 0.375	80	94	100	99
Carfentrazone EC + dicamba	0.016 + 0.25	81	80	100	100
Carfentrazone EC + dicamba	0.025 + 0.25	89	94	100	100
Carfentrazone EC + tribenuron	0.016 + 0.0156	95	100	100	99
Carfentrazone EC + tribenuron	0.025 + 0.0156	93	100	99	100
Carfentrazone EC + clopyralid & MCPA	0.016 + 0.3	98	99	100	100
Carfentrazone EC + clopyralid & MCPA	0.025 + 0.3	97	98	100	100
Carfentrazone EC + bromoxynil	0.016 + 0.375	100	100	100	100
Carfentrazone EC + bromoxynil	0.025 + 0.375	100	100	100	100
check	0	0	0	0	0
LSD 0.05	---	15	10	1	1

RESPONSE OF SPACE-PLANTED BENTGRASS TO GRASS-CONTROL HERBICIDES

G.W. Mueller-Warrant

Four hundred acres of Roundup-Ready creeping bentgrass are currently under production in a control district north of Madras, Oregon. Concerns voiced by the grass seed industry during discussions leading to the creation of this control district included anticipated difficulty in removing old stands, controlling volunteer seedlings, limiting movement of pollen, seed, and vegetative propagules, detecting outcrosses, and controlling bentgrass plants containing the Roundup resistance gene whenever and wherever they might appear. Many plans are under development for meeting these concerns, evaluating the consequences of failure to contain this gene, or predicting the likelihood of such failure. One key aspect of informed discussion and decision-making on these topics is knowledge of weed control problems currently posed to the grass seed industry by non-transgenic bentgrass. While many details on the biology, distribution, and control of bentgrass might provide valuable knowledge, the image of an individual, well-established bentgrass plant recovering from a spot-spray herbicide treatment applied explicitly for its control is helpful in defining the most urgently needed research. The isolated plant is primarily competing against other species rather than against itself, it is undergoing rapid vegetative spread, it is hidden from easy detection, and regrowth by a single node or tiller can threaten to reestablish an entire clump following herbicide treatment. Knowledge of the performance of Roundup and alternative herbicides against space-planted bentgrass plants is critically needed, especially on the question of whether or not the plant recovers from injury.

The primary objective of this research was to identify effective herbicide treatments for suppression/control of well-established bentgrass plants, and determine the number of sequential applications of each of these treatments required to achieve lasting control (i.e., no further regrowth). A secondary objective was to quantify possible differences among common bentgrass species in number of herbicide applications required to achieve lasting control of initially well-established plants. Due to concerns over possible escape of herbicide resistance, none of the resistant types developed through genetic engineering or conventional breeding were included in these trials.

Three cycles of tests are being conducted. The first test cycle commenced with transplanting five bentgrass species (dryland, redtop, Colonial, creeping, and velvet) in January 2000 into an old orchardgrass stand, followed by initiation of herbicide treatments in two timing sequences in October and November 2000. The first application in the early timing sequence was made soon after the initiation of vigorous fall regrowth, and treatments were reapplied in early spring and again in early summer after plants had recovered from herbicide damage and initiated new tiller growth. Treatments in the later timing sequence were applied approximately one month after those in the early sequence. The eight herbicide treatments were Roundup 1.5 lb a.i./a, Rely 1.0 lb a.i./a, Gramoxone 0.625 lb a.i./a, Fusilade DX 0.375 lb a.i./a, Kerb 0.375 lb a.i./a (rate increased to 1.0 lb a.i./a for all subsequent applications), Select 0.125 lb a.i./a, Raptor 0.039 lb a.i./a, and a tank-mix of Roundup 1.5 lb a.i./a plus Fusilade DX 0.375 lb a.i./a. Treatments were initially applied to all plots, and subsequently reapplied only to those plots in which surviving bentgrass plants were found. All herbicides achieved fair to good initial "burndown" of bentgrass except for Kerb. The second test cycle commenced with transplanting seven bentgrass species or varieties (Seaside creeping, Penncross 'F1' creeping, SRX7100 Colonial, dryland, velvet, redtop, and a not-yet-identified weedy species collected from a perennial ryegrass field on OR Hwy. 34) in January 2001 into an old orchardgrass stand, followed by initiation of herbicide treatments in two timing sequences in November and December 2001. The ten herbicide treatments in the second cycle included all eight treatments from the first cycle plus Assure II at 0.0825 lb a.i./a and a tank-mix of Roundup at 1.5 lb a.i./a plus Assure II at 0.0825 lb a.i./a. The third test cycle commenced after transplanting seven bentgrass species or varieties (repeating those used in the second test cycle) in late fall 2001 into an old perennial ryegrass stand, followed by initiation of herbicide treatments in October and November 2002. Herbicide treatments used in the second cycle were repeated in the third.

Data being collected includes monthly to bimonthly observations of whether regrowth occurred on each individual plant. Regrowth status was rated into one of four categories: *Dead* = no signs of any new growth or survival of treated shoots; *Unclear* = any regrowth present too small to identify, or some treated shoots injured but tissue not quite dead; *Alive* = one or more healthy tillers present, but tillers smaller in size and fewer in number than before treatment; *Robust* = many tillers present, plant nearing pre-treatment size. Repeat herbicide applications were generally not made until none of the plants fell into the *unclear* response category. Individual plots are being retreated until all bentgrass plants present in them have been killed. Primary result of the research is information on the number of times each of the herbicide treatments in the early and later timing sequence (16 treatments in cycle one, 20 in cycles two and three) must be applied in order to kill the bentgrass plants.

None of the treatments in the first, second, or third testing cycle succeeded in completely destroying space-planted, well-established bentgrass plants in a single application. Indeed, some individual bentgrass plants have survived up to seven applications of the least successful treatments in the first cycle. The most effective treatment was a tank-mix of 1.5 lb a.i./a Roundup plus 0.375 lb a.i./a Fusilade, requiring an average of 2.3 applications to kill all bentgrass for the early timing sequence and 2.1 applications for the later timing sequence in the first cycle, while 1.4 and 1.5 applications appear, at the present, to have been sufficient in the second cycle. Fusilade by itself was almost as effective as this tank-mix in the first cycle (requiring an average of 2.35 applications), while Roundup by itself required an average of 0.5 more applications per plant to kill bentgrass than the Roundup plus Fusilade tank-mix. Select at 0.125 lb a.i./a was the next most effective treatment, requiring an average of 3.1 applications to kill bentgrass in the first cycle. In decreasing order of effectiveness, Rely at 1.0 lb a.i./a required an average of 3.35 applications to kill bentgrass, Gramoxone at 0.625 lb a.i./a required 3.77 applications, Raptor at 0.039 lb a.i./a required 3.97 applications, while Kerb has required 6.3 applications to date, with some bentgrass plants still alive. The later timing sequence of the first cycle was more effective than the earlier timing, requiring an average of 0.42 fewer applications to kill all bentgrass. Much of the difference between the two timing sequences has been the result of conditions during the fall applications. Rains arrived relatively late in the falls of both 2000 and 2002, and although herbicide applications for the early timing sequence were delayed until new shoot growth was visible, it is likely that additional tillers arose from dormant buds during the month between the early and late application timings.

Many of treatments in the first cycle had appeared to achieve complete control by spring or summer of 2002, and no bentgrass regrowth could be found in fall 2002 except for some of the Raptor plots, most of the Kerb plots, and a very few plots of the other herbicides. By April 2003, however, bentgrass was once again present in a surprisingly large number of plots. Some of these bentgrass plants were clearly seedlings that had emerged at random locations throughout the plots, and herbicide treatments in spring 2003 to control any obvious seedlings were not included in the total count of applications required to kill the original plants. Many of the bentgrass plants found in April 2003, however, were growing at or very near to the original planting sites and were larger in size than the obvious seedlings. A likely source for many of these plants would be vegetative propagules from the original plants scattered by a rotary mowing conducted in late summer. Attempts will be made in future years to control seedlings in the third and later years of each cycle with early fall broadcast applications of Prowl and/or Axiom combined with physical shielding of any surviving bentgrass plants remaining from the original planting. Using the same application timing sequences for all herbicide treatments may have worked to the disadvantage of the less effective, contact herbicides (Rely and Gramoxone) because bentgrass regrowth tended to be initiated sooner in these treatments than in the more effective, systemic herbicides (Roundup, Fusilade, Select, and Assure). Bentgrass plants initiating regrowth earlier were more likely to recover to *Robust* growth status by time of the next application, and hence were much less likely to die from that next herbicide application.

There were interesting differences among the bentgrass species in their probability of recovering from herbicide treatment. In the first cycle, dryland bentgrass and redtop were harder to kill, requiring an average of 0.5 more applications than Colonial and creeping bentgrass. In the second cycle, dryland bentgrass and redtop were once again the hardiest types, requiring an average of 3.3 treatments, whereas creeping, Colonial, and velvet bentgrass only needed an average of 2.1 applications. The not-yet-identified type from Hwy 34 perennial ryegrass was intermediate, requiring an average of 2.7 applications. Treatment of all three cycles will continue until no surviving bentgrass plants are present for all herbicides, or until no further progress is achieved by additional applications of Kerb while all other herbicides have eliminated bentgrass.

Table 1. Third-year results from first cycle bentgrass control study, spring 2003.

Sequence start date†	Herbicide trade name	Rate	Bentgrass status before 2nd application (Mar/Apr 2001) *Robust*	*Alive*	*Dead*	Bentgrass status before 8th application (Mar/Apr 2003) *Robust*	*Alive*	*Dead*	Total number of times each plant treated to present date
		(lb a.i./a)	---------------- (% of plants in each category)					---------------	(applications)
Oct 2000	Roundup	1.5	0	90	10	0	40	60	2.95
Nov 2000	Roundup	1.5	0	60	40	0	55	45	2.45
Oct 2000	Rely	1.0	65	30	5	0	45	55	4.00
Nov 2000	Rely	1.0	35	65	0	0	40	60	2.70
Oct 2000	Gramoxone Extra	0.625	45	50	5	0	55	45	3.95
Nov 2000	Gramoxone Extra	0.625	10	80	10	0	30	70	3.60
Oct 2000	Fusilade DX	0.375	0	95	5	0	20	80	2.45
Nov 2000	Fusilade DX	0.375	0	65	35	0	5	95	2.25
Oct 2000	Kerb	0.375* ->1*	95	5	0	30	40	30	6.45
Nov 2000	Kerb	0.375* ->1*	80	15	5	10	45	45	6.15
Oct 2000	Select	0.125	0	95	5	0	50	50	3.15
Nov 2000	Select	0.125	0	80	20	0	55	45	3.05
Oct 2000	Raptor	0.039	50	45	5	0	40	60	4.20
Nov 2000	Raptor	0.039	45	45	10	0	35	65	3.75
Oct 2000	Roundup + Fusilade	1.5 + 0.375	0	95	5	0	15	85	2.30
Nov 2000	Roundup + Fusilade	1.5 + 0.375	0	45	55	0	50	50	2.10
Species means avg. over herbicides		No. plants							
Dryland bentgrass		154	26	60	14	2	40	58	3.62
Redtop		84	21	73	6	0	42	58	3.56
Colonial bentgrass		37	27	54	19	0	38	62	3.11
Creeping bentgrass		30	17	66	17	0	40	60	3.07
Velvet bentgrass		2	0	100	0	0	50	50	3.50
Unidentified spp.		13	23	54	23	0	38	62	3.00
Timing means avg. over herbicides									
Early application sequence		---	32	63	5	1	41	58	3.68
Late application sequence		---	16	63	21	1	40	59	3.26

*Kerb applied at 0.375 lb a.i./a in first application of both timing sequences. Rate was then increased to 1.0 lb a.i./a for all subsequent applications.

†Early sequence: Oct. 26, 2000; Mar. 20, 2001; June 12, 2001; Nov. 6, 2001; Apr. 2, 2002; June 14, 2002; Oct. 29, 2002; Mar. 24, 2003. Late sequence: Nov. 17, 2000; Apr. 19, 2001; July 10; Dec. 21, 2001; Apr. 30, 2002; July 19, 2002; Nov. 26, 2002; Apr. 25, 2003. Treatments only reapplied to plots with live bentgrass present. Bentgrass species included dryland, redtop, Colonial, creeping, velvet and unidentified.

Table 2. Second-year results from second cycle bentgrass control study, spring 2003.

Sequence start date†	Herbicide trade name	Rate	Bentgrass status before 2nd application (Mar/Apr 2002) *Robust*	*Alive*	*Dead*	Bentgrass status before 5th application (Mar/Apr 2003) *Robust*	*Alive*	*Dead*	Total number of times each plant treated to present date
		(lb a.i./a)	---------------- (% of plants in each category)					----------------	(applications)
Oct 2001	Roundup	1.5	0	32	68	0	7	93	1.96
Nov 2001	Roundup	1.5	7	72	21	0	64	36	2.50
Oct 2001	Rely	1.0	39	57	4	18	39	43	3.61
Nov 2001	Rely	1.0	33	67	0	0	44	56	2.63
Oct 2001	Gramoxone Extra	0.625	33	48	19	4	11	85	3.00
Nov 2001	Gramoxone Extra	0.625	43	53	4	4	21	75	3.04
Oct 2001	Fusilade DX	0.375	4	66	30	0	7	93	2.04
Nov 2001	Fusilade DX	0.375	0	61	39	0	7	93	1.79
Oct 2001	Kerb	1.0	39	61	0	32	25	43	4.07
Nov 2001	Kerb	1.0	25	68	7	29	36	35	4.14
Oct 2001	Select	0.125	4	50	46	0	21	79	2.61
Nov 2001	Select	0.125	0	71	29	0	14	86	2.25
Oct 2001	Raptor	0.039	25	54	21	14	25	61	3.11
Nov 2001	Raptor	0.039	54	46	0	11	7	82	2.61
Oct 2001	Roundup + Fusilade	1.5 + 0.375	0	18	82	0	7	93	1.37
Nov 2001	Roundup + Fusilade	1.5 + 0.375	0	39	61	0	7	93	1.46
Oct 2001	Assure II	0.082	4	73	23	0	12	88	2.81
Nov 2001	Assure II	0.082	7	67	26	0	11	89	2.22
Oct 2001	Roundup + Assure II	1.5 + 0.082	0	39	61	0	11	89	1.57
Nov 2001	Roundup + Assure II	1.5 + 0.082	0	4	96	0	8	92	1.65
Species means avg. over herbicides		No. plants							
Unidentified Hwy 34 grass seed		80	16	42	42	7	23	70	2.69
Seaside creeping bentgrass		79	6	45	49	0	13	87	2.14
Penncross 'F1' creeping bent.		77	17	38	45	0	14	86	2.25
Colonial bentgrass		77	7	39	54	0	9	91	2.03
Dryland bentgrass		80	20	51	29	17	22	60	3.31
Velvet bentgrass		78	9	35	56	0	10	90	1.95
Redtop		80	18	52	30	9	30	61	3.28
Timing means avg. over herbicides									
Early application sequence		---	15	50	35	7	17	76	2.62
Late application sequence		---	3	43	54	3	11	86	2.43

†Early sequence: Nov. 6, 2001; Apr. 2, 2002; June 14, 2002; Oct. 29, 2002; Mar. 24, 2003. Late sequence: Dec. 21, 2001; Apr. 30, 2002; July 19, 2002; Nov. 26, 2002; Apr. 25, 2003. Treatments only reapplied to plots with live bentgrass present. Bentgrass species included unidentified weedy type from Hwy 34 perennial ryegrass field, Seaside creeping, Penncross 'F1' creeping, Colonial, dryland, velvet, and redtop.

GEOGRAPHIC DISTRIBUTION OF PROMINENT WEEDS OF GRASS SEED PRODUCTION

G.W. Mueller-Warrant, L.R. Schweitzer, R.L. Cook, and A.E. Garay

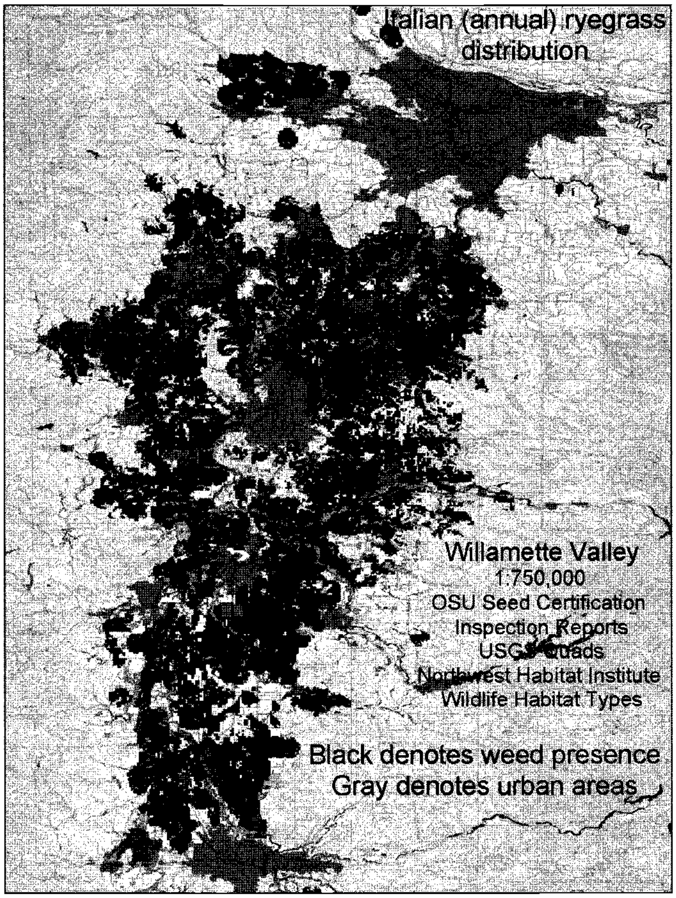
The OSU Seed Certification database was queried for the presence of grass and broadleaf weeds in pre-harvest field inspection reports from 1994 through 2002. A total of 66 grasses and 131 other weeds (broadleaves, sedges, etc.) were found over this nine-year period, with 23 grasses and 18 other weeds occurring in more than 1% of all fields inspected. Tabular summaries of data through the 2001 harvest were presented in last year's OSU Seed Production Research Report. This year's report incorporates the use of Geographic Information System (GIS) tools to produce maps displaying the geographic distribution of 12 of the most common weeds occurring in Oregon grass seed fields: annual (Italian) ryegrass, annual bluegrass, roughstalk bluegrass, bentgrass species, quackgrass, German velvetgrass, tame and wild oat, rattail fescue, Canada thistle, field bindweed, wild carrot, and wild cucumber.

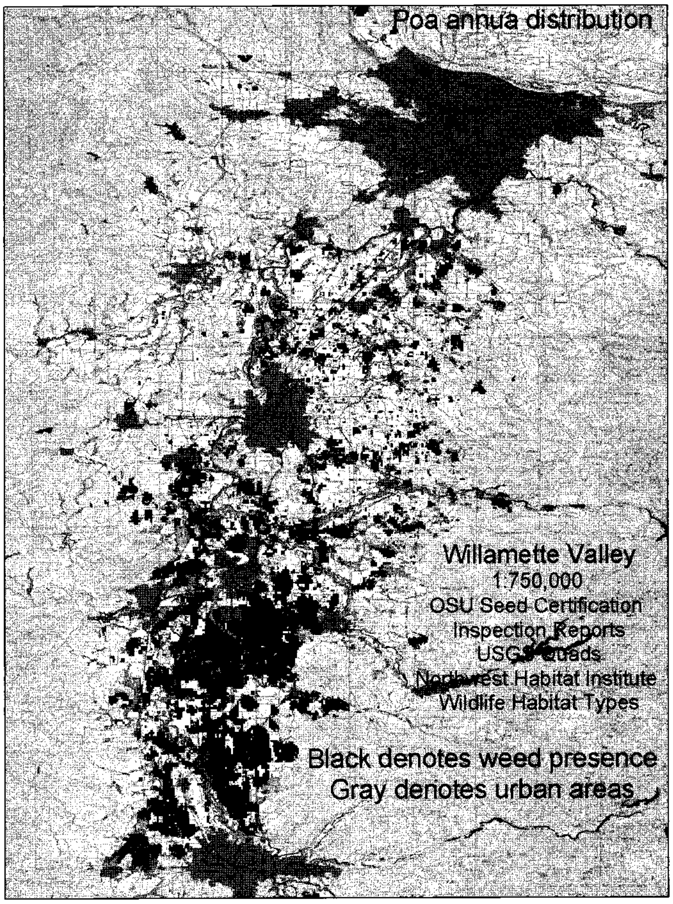
To produce these maps, fields in the seed certification system were first sorted by township-range-section location, then assigned longitude/latitude coordinates for the centers of each section, and finally systematically scattered throughout 640-acre sections to generate unique, albeit somewhat arbitrary, positions for each field. The density of specific weeds at these points was obtained from the pre-harvest field inspection reports (weeds either not found or present at *trace*, *many*, or *excessive* levels). Numeric values (0, 1, 10, or 100) were assigned to these four categories, and then used in an inverse distance weighted (IDW) algorithm to estimate weed density in 35-acre-sized cells within one mile of each assigned field position. Cells in which specific weeds occurred were coded as black on the maps, urban areas were coded as gray, and the remaining background was a faded version of USGS Quads and Northwest Habitat Institute landcover types. Because of the methods used to assign field positions and interpolate weed density between field positions, accuracy of weed locations on these maps is limited to approximately one mile.

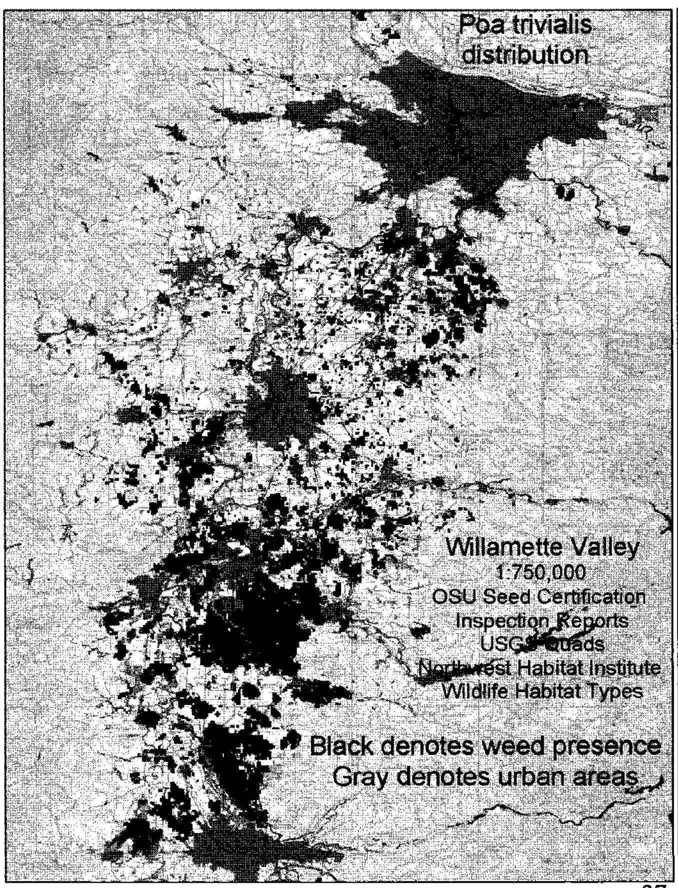
The cosmopolitan distribution of annual ryegrass throughout the Willamette Valley is a reminder of just how bad weeds can be. If actual densities of annual ryegrass were displayed on color-coded maps rather the binary present/absent values used on these black and white maps, the northeastern section of the Willamette Valley would be seen to have a much less serious annual ryegrass problem than the rest of the valley. Annual bluegrass and roughstalk bluegrass are clearly concentrated in the southern Willamette Valley, but are by no means limited to just that region. Lowest frequency of annual bluegrass occurs in the Silverton Hills and in the northwestern section of the valley. Roughstalk bluegrass is slightly clumpier in its distribution than annual bluegrass, and a high frequency of fields in the extreme northeast corner of the valley are infested with roughstalk bluegrass, in addition to those infested in the southern valley. Bentgrasses (*Agrostis* spp.) are widely distributed in the Willamette Valley, although the northwest section is relatively free. Quackgrass occurs less commonly than bluegrasses and bentgrasses, particularly in the southern valley and in the Silverton Hills. One likely cause for its absence from the Silverton Hills is the prolonged history of Poast and Fusilade use in the fine fescues, herbicides relatively effective on this weed. German velvetgrass is found almost exclusively in the Silverton Hills, where it thrives despite repeated use of Poast and Fusilade. Rattail fescue also occurs primarily in the Silverton Hills, although it is present in scattered fields throughout the valley. Tame and wild oats occur almost as commonly as annual ryegrass. Oats are present throughout the valley, but unlike many of the other grassy weeds, are particularly abundant in the western and northern edges of the valley, and may correspond to past cereal production.

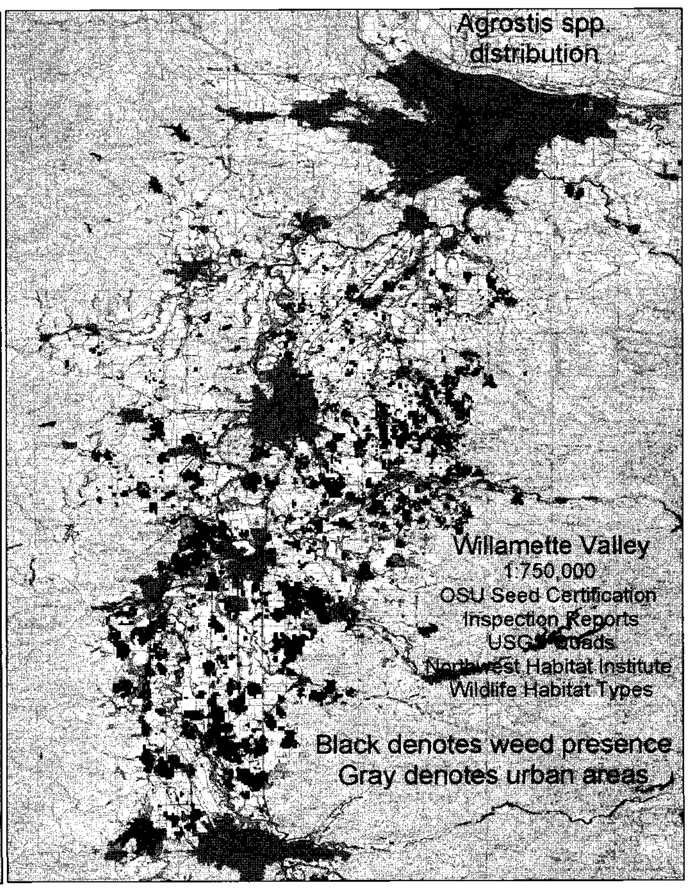
Canada thistle is a threat to grass seed production throughout the entire Willamette Valley. Although it is not quite as ubiquitous as annual ryegrass, few fields are more than a mile or two away from known infestations. A particularly troubling feature of Canada thistle is that the percentage of fields in which it is found has grown by over 50% in the past nine years, from 8.2% of fields in 1994 to 12.5% in 2002. Field bindweed, another federal noxious weed, occurs primarily in an arc east, north, and west of Albany, but it is also common northwest of Eugene and in numerous locations scattered throughout the north valley. The distribution of wild carrot is interesting, and infested fields are scattered throughout the valley. It is not yet as commonly present as many of the other weeds on these maps, but it has increased in prevalence over the past nine years, and appears to have the potential to rival the worst of the weeds in the future. In contrast to wild carrot, wild cucumber infestations are primarily clustered in particular geographic locations, suggesting a strong influence of factors such as soil type, slope, elevation and/or drainage on distribution of this weed.

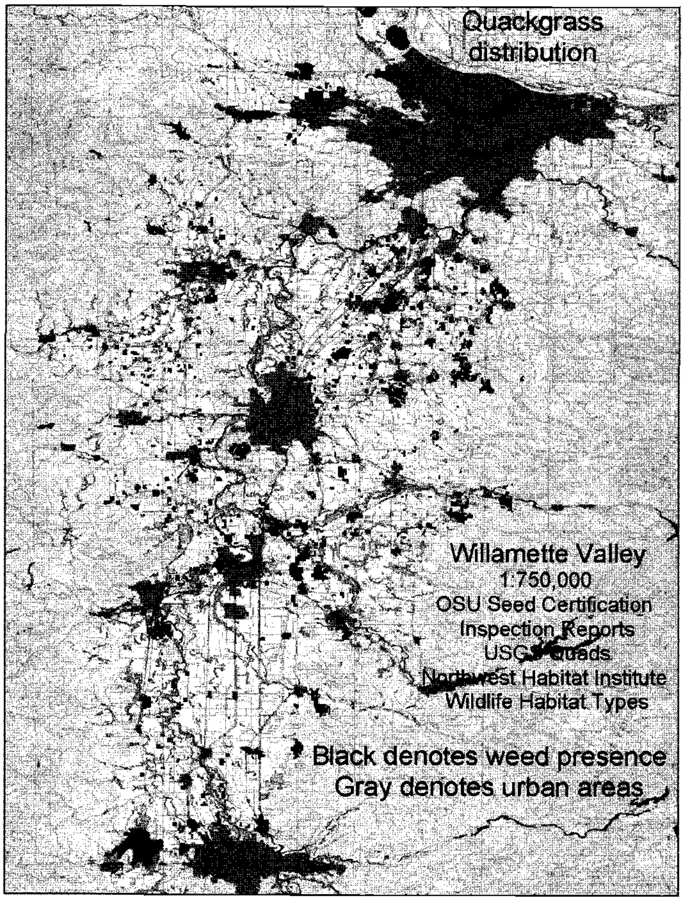
GIS research efforts are currently focused on improving the spatial resolution of the data by converting point locations of certified seed fields used in these maps into actual boundaries corresponding to true positions and shapes of fields. When completed, this change will allow accurate year-to-year comparisons in weed infestations, better correlations with soil factors, and improved linkage with agronomic practices. To protect grower confidentiality, data resolution in publicly released maps will be degraded back to the plus or minus one mile accuracy of the current maps. Procedures will also be developed to provide high resolutions maps of their own operations to individual growers.

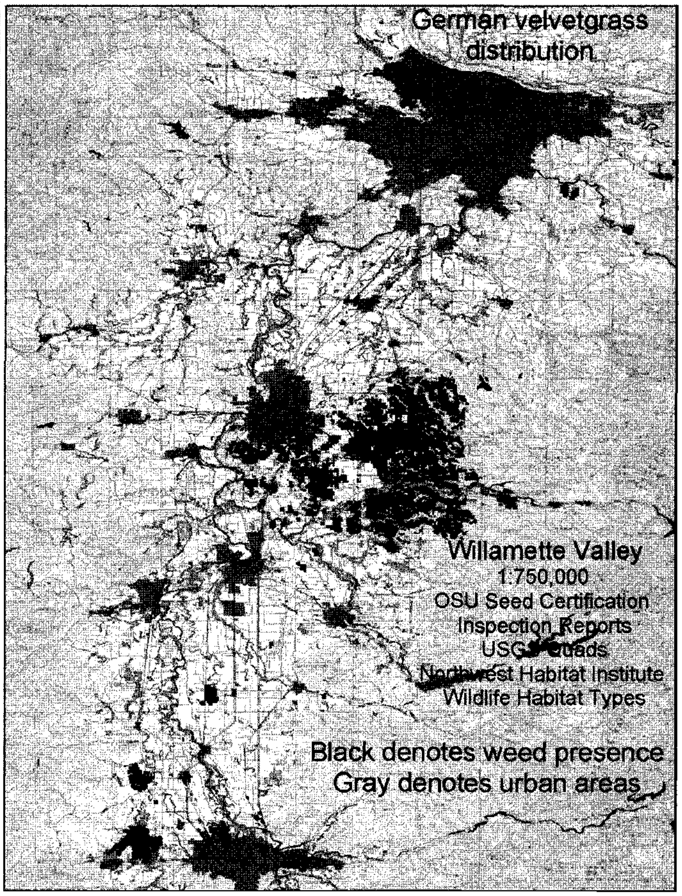

Italian (annual) ryegrass distribution
Willamette Valley
1:750,000
OSU Seed Certification
Inspection Reports
USGS Quads
Northwest Habitat Institute
Wildlife Habitat Types
Black denotes weed presence
Gray denotes urban areas

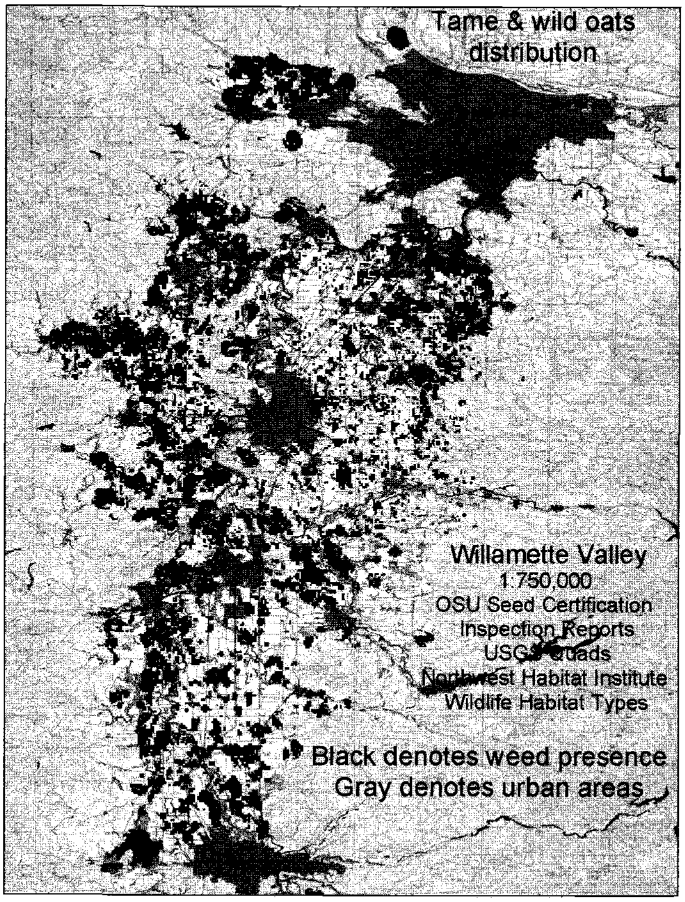

Poa annua distribution
Willamette Valley
1:750,000
OSU Seed Certification
Inspection Reports
USGS Quads
Northwest Habitat Institute
Wildlife Habitat Types
Black denotes weed presence
Gray denotes urban areas

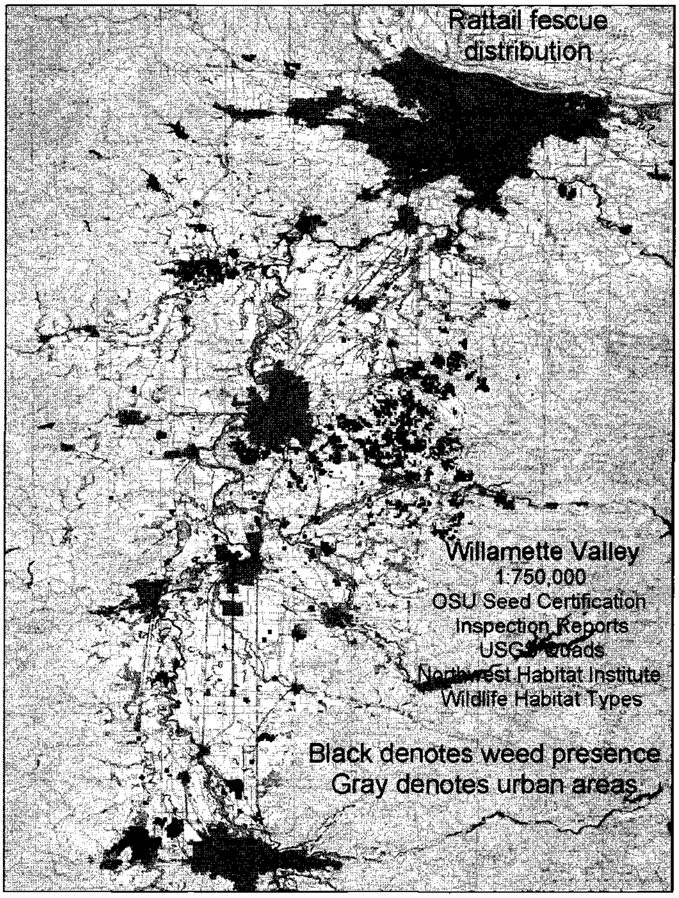

Poa trivialis distribution
Willamette Valley
1:750,000
OSU Seed Certification
Inspection Reports
USGS Quads
Northwest Habitat Institute
Wildlife Habitat Types
Black denotes weed presence
Gray denotes urban areas

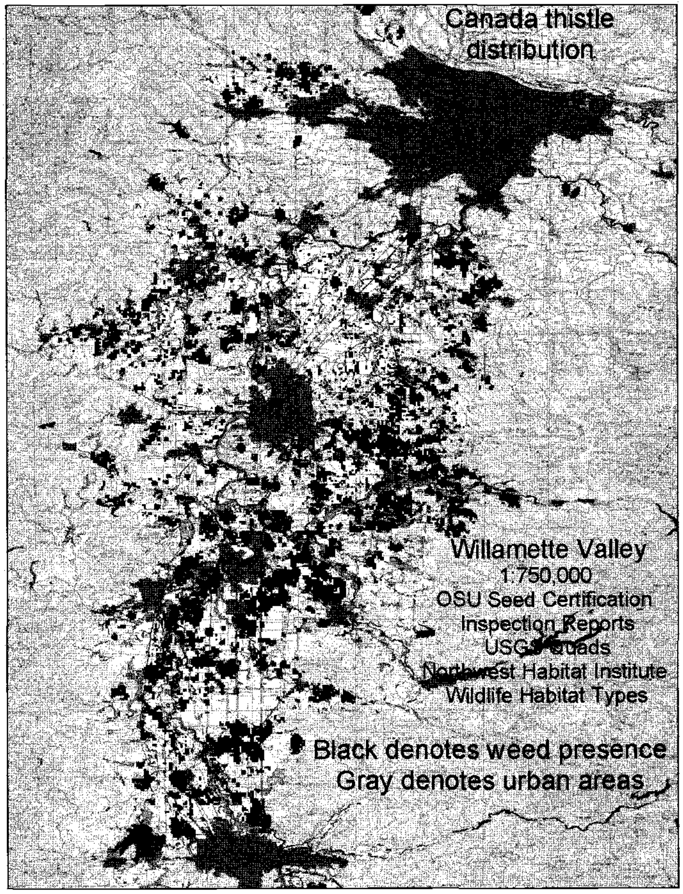

Agrostis spp. distribution
Willamette Valley
1:750,000
OSU Seed Certification
Inspection Reports
USGS Quads
Northwest Habitat Institute
Wildlife Habitat Types
Black denotes weed presence
Gray denotes urban areas

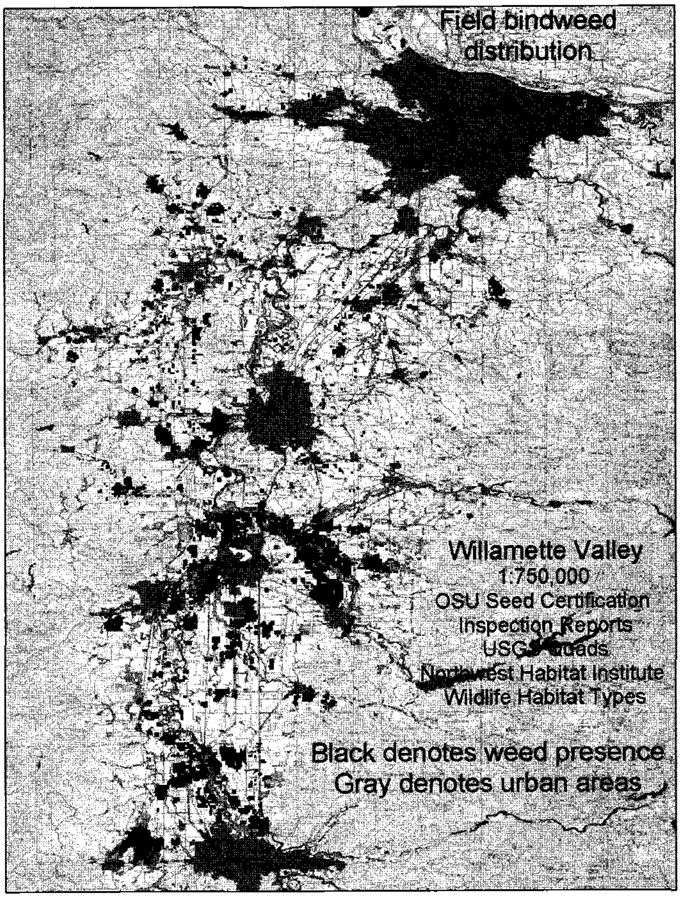

Quackgrass distribution
Willamette Valley
1:750,000
OSU Seed Certification
Inspection Reports
USGS Quads
Northwest Habitat Institute
Wildlife Habitat Types
Black denotes weed presence
Gray denotes urban areas


German velvetgrass distribution
Willamette Valley
1:750,000
OSU Seed Certification
Inspection Reports
USGS Quads
Northwest Habitat Institute
Wildlife Habitat Types
Black denotes weed presence
Gray denotes urban areas


Tame & wild oats distribution
Willamette Valley
1:750,000
OSU Seed Certification
Inspection Reports
USGS Quads
Northwest Habitat Institute
Wildlife Habitat Types
Black denotes weed presence
Gray denotes urban areas


Rattail fescue distribution
Willamette Valley
1:750,000
OSU Seed Certification
Inspection Reports
USGS Quads
Northwest Habitat Institute
Wildlife Habitat Types
Black denotes weed presence
Gray denotes urban areas


Canada thistle
distribution
Willamette Valley
1:750,000
OSU Seed Certification
Inspection Reports
USGS Quads
Northwest Habitat Institute
Wildlife Habitat Types
Black denotes weed presence
Gray denotes urban areas


Field bindweed
distribution
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OSU Seed Certification
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USGS Quads
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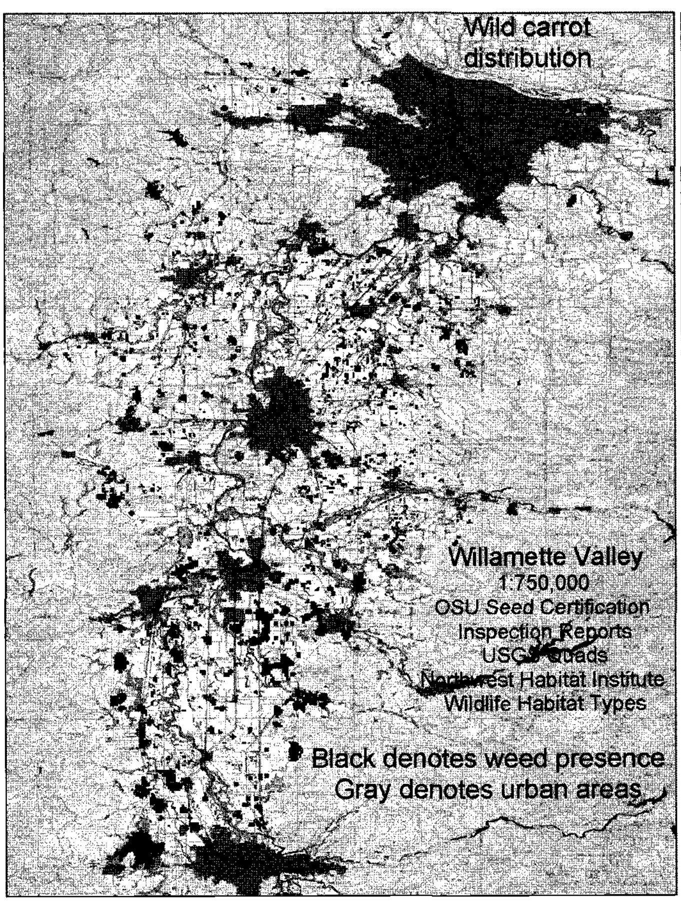
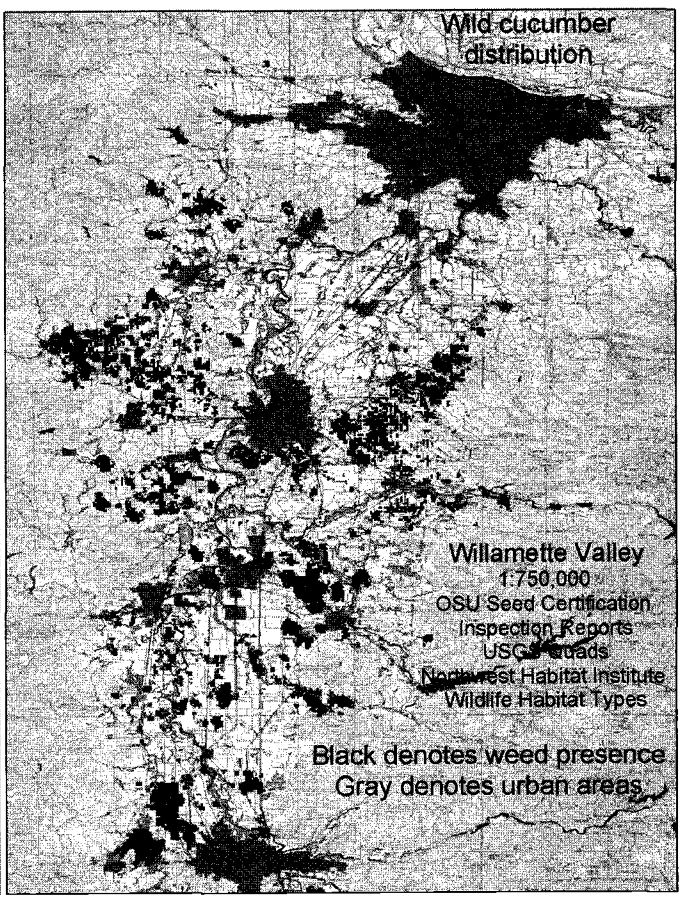
Wildlife Habitat Types
Black denotes weed presence
Gray denotes urban areas


Wild carrot
distribution
Willamette Valley
1:750,000
OSU Seed Certification
Inspection Reports
USGS Quads
Northwest Habitat Institute
Wildlife Habitat Types
Black denotes weed presence
Gray denotes urban areas


Wild cucumber
distribution
Willamette Valley
1:750,000
OSU Seed Certification
Inspection Reports
USGS Quads
Northwest Habitat Institute
Wildlife Habitat Types
Black denotes weed presence
Gray denotes urban areas

EVALUATION OF PAIRED PLOTS VS. ONE SAMPLE T-TEST TO DETERMINE YIELD DIFFERENCES IN PERENNIAL RYEGRASS FIELDS

M. Louhaichi, D.E. Johnson, M.M. Borman and D.R. Thomas

Introduction

Farm fields are characterized by areas with varying potential to produce crop output. Across a given field, one could find variability with respect to soil type, nutrient status, catena position, organic matter content, water holding capacity, and so on. Variation in these factors leads to variation in the potential of different areas to utilize applied inputs and produce crop output (Carr *et al.*, 1991; Sawyer, 1994; Wibawa *et al.*, 1993). Techniques are now available to account for the multiple factors that influence production. In particular Geographical Information Systems (GIS) and Global Positioning Systems (GPS) provide new opportunities to spatially register measurement of 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.

A common form of scientific experimentation is the comparison of two groups. This comparison could be of two different treatments, the comparison of a treatment to a control, or a before and after comparison. Typically, if the probability of occurrence or p-value is below a certain level (such as 0.10 or 0.05), the conclusion is that there is a difference between the two group means. The lower the p-value, the greater "evidence" that the two group means are different (Ramsey and Schafer, 1997).

Our objectives were to:

1. Assess internal field variability.
2. Identify timing of wildlife use of selected perennial ryegrass fields.
3. Compare two statistical tests for measuring yield differences caused by wildlife grazing.

Materials and Methods

During 1999 through 2001 we conducted a study on perennial ryegrass (*Lolium perenne* L.) to measure the impact of wildlife grazing on crop yields. In order to accomplish this goal a combination of methods for documenting wildlife grazing activity and measuring the impacts of grazing on perennial ryegrass yields were adopted (Louhaichi, 2002). Our methods included:

1. Creation of base maps for each field. They consist of themes or layers of geographic data including such features as soil type, topographic contours, and ponded areas.
2. Construction of exclosures with poultry wire and fiberglass fence posts to keep grazing wildlife from entering small areas scattered throughout the test fields. These areas served as controls that provided the basis for knowing perennial ryegrass seed yield without grazing impacts. The exclosures were large enough for a commercial-size combine to harvest through them.
3. Monitoring and mapping of wildlife activity throughout their stay in the area using ground level photos and GPS. This served as ground-truth verification of presence of wildlife.
4. Combines equipped with yield monitors to map yields. The yield monitoring system simultaneously records yield, grain moisture, and position of the combine. All these data are necessary to produce yield maps. The Grain Flow Sensor measures the weight of grain as it passes from the clean grain elevator to the loading auger in the clean grain tank. Most yield-monitoring systems include a "flagging" function in the operator interface, which allows the operator to geo-reference (pinpoint) and tag any number of variables that are observed during harvest. These factors include the presence of weeds, ponded areas, spray misses, etc. Properly flagged variables can result in significant time saving when analyzing the data.

Statistical Tools

One sample t-test

A one-sample *t*-test is used to compare a sample mean to a given value, μ. The t-test calculates the probability that the sample mean is different than the population mean. The t-score is made a relative score by dividing the difference between the sample average and μ by the standard error of the mean.

$$t_{n-1} = \frac{\bar{x} - \mu}{S/\sqrt{n}}$$

where $\bar{x}$: sample average
μ: population mean
S: Sample standard deviation
n: number of observations in the sample
The test statistic, t, has n-1 degrees of freedom

Paired Sample t-test

A paired t-test is a statistical test, which is performed to determine if there is a (statistically) significant difference between two means. It compares two paired groups. It calculates the difference, d, between each set of pairs, and analyzes that list of differences based on the assumption that the differences in the entire population follow a normal distribution. A test statistic called "t" is then calculated. This t score is a measure of how far apart the average difference score is from zero in standard units. The *t* ratio for a paired *t*-test is the mean of these differences divided by the standard error of the differences. The larger the t value the more likely it is that the difference score is not zero and that the means really are different.

$$t_d = \frac{\bar{d} - \mu_d}{s_d / \sqrt{n}} \qquad \mu_{d=0}$$

where $\bar{d}$: average of sample differences
μ_d: hypothesized difference
s_d: standard deviation of sample difference
n: number of pairs

Yield Monitoring Tools

The study site is located in the Willamette Valley of western Oregon. Yield-mapping-system equipped combines, incorporating global positioning system (GPS) technology, were used to measure and map yields. We also established paired plots, involving exclosures and associated plots available for grazing. Spatially located yield data, soils information, exclosure locations, and grazing patterns were integrated via geographical information system (GIS) technology.

Grazing Patterns and Intensity

Wildlife grazing pattern and intensity in this study were not controlled by the researchers. Wildlife grazed where and when they wanted except when farmers hazed them off their fields. Farmers believed that wildlife grazing caused substantial economic damage, therefore hazing was often intense. In general, less intensively hazed fields tended to have more grazing. Thus, in this study, we were attempting to quantify grazing impacts under normal farming practices, which included hazing.

Plants grazed were often left with 4 inches or less of remaining leaf/stem. As the season progressed, we observed that areas that had been grazed previously were more likely to be grazed again. In ungrazed and previously lightly grazed areas, the taller grass could be perceived as cover for predators causing a shift to more open areas (Belling, 1985). In areas previously grazed, regrowth of grass plants could have been preferred because digestibility and protein were likely higher as was found in a study by Bédard *et al.* (1986).

Results and Discussion

Two analyses were performed for assessing goose grazing. One compared all exclosures to their respective paired plot. The second stratified exclosures based upon soil type. In both cases, we separated observations based on the timing of grazing. When observations on all soil types were considered together we had a greater number of pairs (n) per grazing class. Separating observations by soil type decreased the number of possible paired plots available for statistical analysis.

Statistical analysis without taking into account soil differences

One field (Npr-00) was newly seeded perennial ryegrass with approximately 100,000 estimates of yield. This field was grazed across its entire surface in January of 2000, thus there were no ungrazed areas of the field except within exclosures. The area grazed by geese became progressively smaller as the season advanced, from January to April. The same field was monitored during the following year (Epr-01).

During the first year of the study, wildlife grazing into March did not result in a statistically significant yield reduction when exclosures were compared to paired plots. However, grazing through mid-April resulted in a 231 lb/acre and 286 lb/acre reduction respectively for one sample t-test and paired t-test (Table 1).

During the second year of growth, either January or March grazing resulted in approximately 120 lb/acre yield reduction but statistically was insignificant (p-value = 0.1674 and 0.193 respectively). However, the reduction in yield was greater (174 lb/acre) for areas grazed continuously through March (p-value = 0.0026 and 0.0027) (Table 1).

For the one sample t-test, in almost all cases yield in exclosures was higher than the yield in the area open to grazing surrounding the exclosure. The exception was March light grazing where the yield was similar (p-value 0.33). In general, both the one sample t-test and the paired t-test showed similar results for various grazing intensity and for both years.

Table 1. Statistical-temporal analysis of wildlife grazing without taking into account soil differences (yield in pounds per acre)

Season of Grazing	Npr-00* March Light Grazing	Npr-00 January through March	Npr-00 January through April	Epr-01 only January Grazing	Epr-01 only March Grazing	Epr-01 January through March
		Comparison of ungrazed (exclosures) to area grazed				
n	3	7	5	3	3	8
$\bar{x}$ (exclosure)	1855	1794	1712	1532	1545	1574
μ	1948	1753	1481	1405	1441	1400
S_d	329	212	117	175	163	123
One sample t-test	-0.487	0.512	4.426	1.256	1.101	4.003
p-value (one tail)	0.3363	0.314	0.0057	0.1674	0.193	0.0026
		Comparison of ungrazed (exclosures) to grazed paired plots				
Grazed plot	1183	1766	1427	1408	1419	1387
$\bar{d}$	672	28	286	124	126	186
S_d	402	315	215	83	63	73
Paired t-test p-value (one tail)	0.0969	0.3210	0.0115	0.0776	0.1143	0.0027

*Npr: Newly seeded perennial ryegrass field
Epr: Established perennial ryegrass field
00: Yield estimate during summer 2000
01: Yield estimate during summer 2001

Statistical analysis accounting for soil differences

First, an analysis of variance of data within soil types indicated that there were seed yield differences between soil types. Exclosures on the Woodburn soil produced 2086 lb/acre, Amity soil produced 1692 lb/acre and, Dayton soil produced 1695 lb/acre. Yield differences between soil types were significant at $P < 0.05$. Thus, grazing impacts are reported by soil type for this field. This additional classification decreased the number of possible paired plots available for statistical analysis. With fewer pairs, differences have to be larger to be statistically significant.

Areas of the Dayton soil that were ungrazed (exclosures) produced higher seed yields compared to areas on this soil that were grazed from January through March and or through April. Both the one sample t-test and the paired t-test produced significant p-values (Table 2).

Light March grazing on the Amity soil resulted in a greater seed yield of about 70 lb/acre (p-value = 0.2). The same trend was found for the effect of grazing through March, but it was more pronounced when using the one sample t-test (112 lb/acre reduction in yield with a p-value = 0.05) (Table 2).

Summary and conclusions

The yield-mapping system developed for commercial combines proved to be an effective method for determining the pattern of yield throughout the field. The flagging option allowed us to document yields in specific areas that could be compared to yields in other areas. For example, we were able to compare yields from within exclosures to paired plots outside the exclosures by turning on the exclosure "flag" when entering and turning it off when exiting an exclosure. Exclosures provided nongrazed controls. During the second year of the study all combines used were equipped with yield monitors so we could census the entire field. Thus differences were actual differences not subject to sampling error and statistical analysis was not necessary to determine whether or not differences were real as long as combines were calibrated correctly.

Nevertheless, we performed two statistical tests: a one sample t and a paired t. The decision about what comparison test to use for a particular analysis is of vital importance to making unbiased and correct decisions about any research results. The benefits of performing a t-test is that it is easy to understand and generally easy to perform. In general, results from both tests were comparable. This was true for analysis performed with or without accounting for soil differences. Later and more intensive grazing tended to decrease yield more. Both paired-plot comparisons (paired sample t-test) and comparisons of larger areas of homogeneous soils and grazing patterns (one-sample t-test), to exclosures were effective in documenting wildlife grazing impacts.

Table 2. Statistical-temporal analysis of wildlife grazing (yield in pounds per acre).

Season of Grazing	Npr-00 March Light Grazing Amity	Npr-00 January through March Amity	Npr-00 January through March Dayton	Npr-00 January through April Dayton	Epr-01 only January Grazing Amity	Epr-01 January through March Dayton
		Comparison of ungrazed (exclosures) to area grazed				
N	2	3	3	4	2	6
$\bar{x}$ (exclosure)	1668	1690	1752	1665	1431	1522
μ	1739	1803	1530	1465	1415	1370
S_d	83	70	127	60	24	90
One sample t-test	-1.22	-2.76	3.04	6.71	0.96	4.14
p-value (one tail)	0.2189	0.0549	0.0467	0.0033	0.2565	0.0045
		Comparison of ungrazed (exclosures) to grazed paired plots				
Grazed plot	1740	1696	1612	1357	1362	1368
$\bar{d}$	-72	-6	140	309	154	69
S_d	17	77	155	171	37	64
P paired t-test (one tail)	0.2471	0.4750	0.0226	0.0259	0.0425	0.0188

*Npr: Newly seeded perennial ryegrass field
Epr: Established perennial ryegrass field
00: Yield estimate during summer 2000
01: Yield estimate during summer 2001

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AN EXAMINATION OF YIELD DATA PATTERNS GENERATED BY YIELD MONITORS

D.E. Johnson and M. Louhaichi

Introduction

Yield monitors are the first step for many grass seed growers into the world of precision agriculture. A yield monitor, combined with Global Positioning System (GPS) technology, is basically an electronic tool that collects data on crop performance for a given year at a given location. The monitor measures and records such information as grain flow, grain moisture, area covered, and geographic location. Most yield monitors installed on combines use an impact plate and mass flow sensor located atop the clean grain elevator of the combine to estimate grain flow. As grain leaves the clean grain elevator, it strikes the impact plate. A mass flow sensor at the sensor plate develops an electronic signal that is proportional to the mass of grain hitting the plate. This signal, adjusted via a calibration equation and moisture content as determined by a moisture sensor, is used to estimate instantaneous grain flow mass. Mass of the grain thrown at the sensor by the grain elevator paddles is measured per unit of time (Lotz, 1997).

A yield monitor must be calibrated to provide accurate yield data. Calibration must be performed for each type of grain harvested at the beginning of the harvest season. Accuracy usually improves when several loads are used to perform the calibration. Re-calibration should be performed as necessary, especially later in the season as average moisture content drops or when there is a significant change in crop conditions. Calibration is usually as simple as weighing and recording the moisture of the first several loads collected under a variety of conditions, such as various operating speeds or grain flow rates (Casady *et al.*, 1998).

Study objectives

The main focus of this study was to examine individual estimates of yield and the pattern of the data in what we judged by visual inspection as a relatively uniform portion of a field. In addition we wanted to identify variation within a line of data (sequential observations) and across lines. We also tested another area, to see how a very localized disturbance caused by a narrow flooded channel, perpendicular to the combine track, affected yield estimates. Once the internal variability was determined we could also calculate the sample size necessary to estimate the mean within a given confidence interval.

Methods

The study site is located in the Willamette Valley of western Oregon. We selected a perennial ryegrass (*Lolium perenne* L.) field, which appeared to us as relatively uniform and homogenous. This field covered 188 acres. To reduce any internal variability still further, a small portion of the field was extracted for analysis. This area had the same soil type (Woodburn silt loam), flat topography, and was free from weeds and wildlife grazing. Four adjacent parallel lines of yield monitor data with 27 observations each were extracted from the data set and imported into MS Excel® for statistical analysis. This data included the longitude, latitude, grain flow (lbs/sec), time, cycles (seconds covered by the data), distance traveled by the combine, swath width, and percent moisture of the seed. In the MS Excel® spreadsheet we calculated the yield in lbs/acre by dividing the flow in a second by the land area harvested (distance traveled x swath width) in that second. We also looked at the entire field for areas in which there was a rapid change in yield.

Results

Internal Variability in Yield Estimates

First we plotted raw data on yield with each of the combine passes labeled as a line (Figure 1). As Figure 1 illustrates, yield estimates for line A (on the west side of the harvested block) demonstrated a downward trend ($P = 0.00002$) and an increasing yield for line D ($P = 0.0059$). Lines B and C did not show a significant trend in the data across the test block ($P = 0.6936$ and $P = 0.1878$ respectively). Each line had considerable internal variability with the following standard deviations: line A = 221 lbs/acre, B = 211 lbs/acre, C = 185 lbs/acre, and D = 197 lbs/acre. We interpolated from point data by means of a distance-weighted averaging algorithm to provide a continuous surface of yield. Weights were equal to the reciprocal of the distance squared using a 6-point search radius about each interpolated point. Figure 2 shows the spatial characteristics of interpolated yield within the test block. Normal variation in estimates exists over the map in Figure 2; however, the lower left corner has decreasing yields that are probably the result of environmental factors.

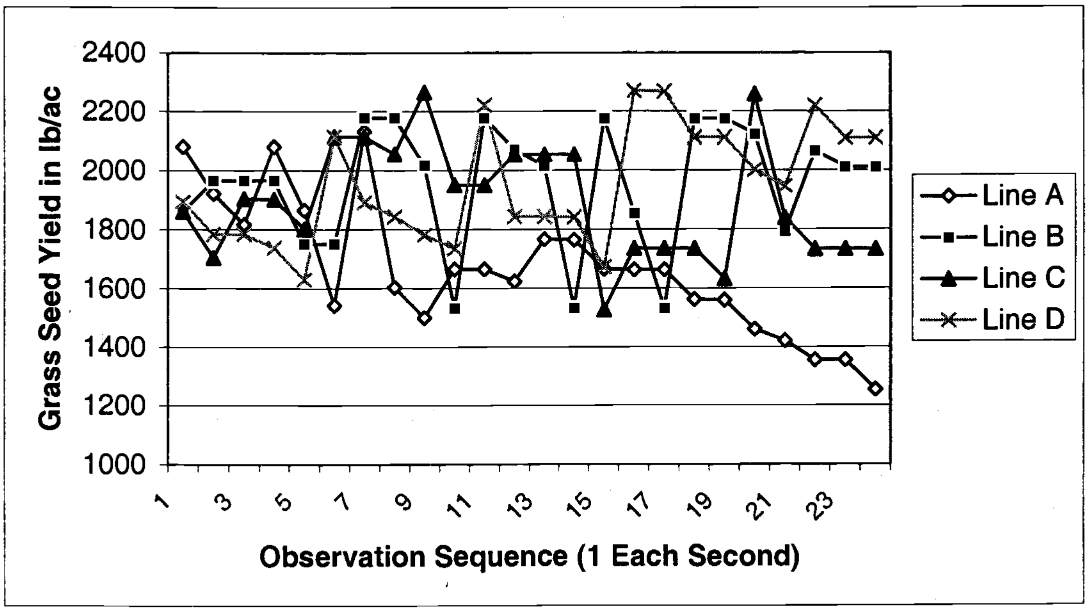

Figure 1. Comparison of four adjacent lines of yield monitor data from a uniform portion of a perennial ryegrass field in the southern Willamette Valley. Line A had a significant downward trend in the yield over the sequential observations ($P = 0.00002$). Line D, on the opposite side of the test block, had a slight increase in yield over this area ($P = 0.0059$). Both lines B and C showed no trend in the data.

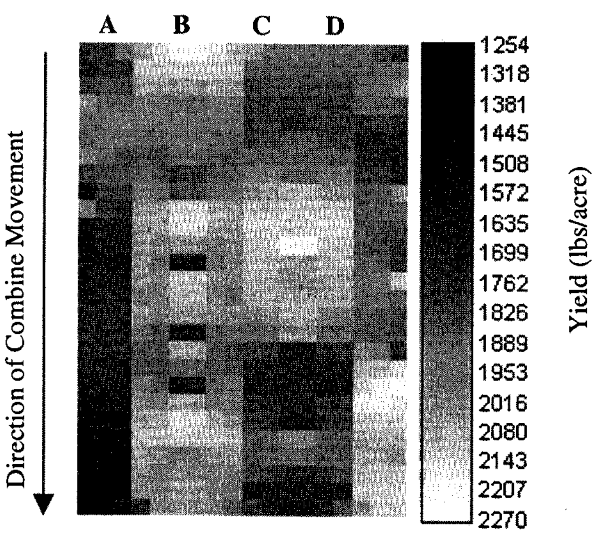

Figure 2. This map was generated by interpolating estimates of yield (lbs/ac) from four lines of combine data. Line A decreased in the lower left portion of the test block.

Examination of data patterns

In order to examine the data patterns as generated by the yield monitor (raw data), we used a running mean of 5, 10, and 20 observations to plot the yield estimate. Figure 3 shows how individual estimate bounces up and down. As we try to average over larger areas (10 or 20 meters), this variability tends to smooth the line that may obscure small areas of substantially different yield (Figure 3). We further examined the sensitivity of the yield monitor as it travels through ponded areas or other factors influencing the yield. Figure 3 illustrates the reflection of two adjacent small areas impacted by water. We can see how the yield dropped from 1700 lbs/ac to zero and rebounded back in just a few meters.

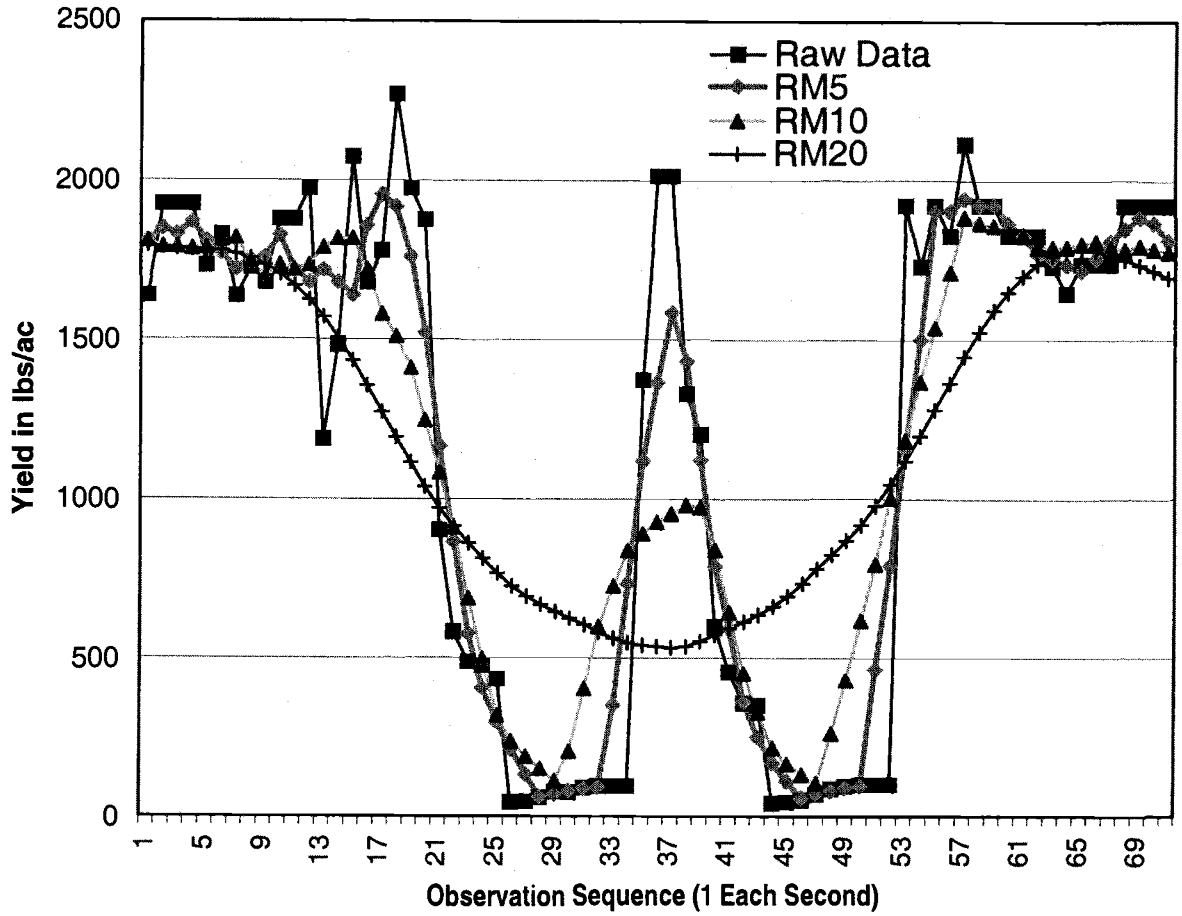

Figure 3. This is a plot of data from a portion of a field with two water damaged (ponded) areas separated by a narrow strip of perennial ryegrass. The combine was moving at slightly more than 1 meter per second. The sequence of raw data points is plotted with a heavy black line while running means calculated on the basis of 5, 10, and 20 observations are also graphed.

Estimating the required sample size using Stein's two-stage sampling

Stein's two-stage procedure (Steele and Torrie, 1960) is considered to be the most interesting and practical sequential procedure for hypotheses testing and estimation. This procedure estimates the required sample size, using a preliminary set of observations usually of small size. Wilson (2002) reported that Steps in Stein's two-stage sampling approach for determining required sample size include:

1. Define the width of the confidence interval (*2d*) and the confidence level required to meet the objectives of the study.

2. Collect sample data in a pilot study and calculate the sample variance.

3. Look up *t*, using the degrees of freedom of the pilot study and the set confidence level.

4. Calculate *n* using the following formula:

$$n = \frac{t_1^2 s^2}{d^2}$$

The value *n* is the estimate of the sample size needed to meet the study objectives, given the variability of the data. A smaller sample size would be inadequate; a larger sample size would increase cost and effort.

Lines B and C, which showed no increase or decrease across the test block, required 19 and 16 observations to estimate the mean within 5 % with a 95 % confidence. To be within 10 % of the mean with a 95 % confidence, we only needed 5 and 4 yield estimates on lines B and C, respectively (Table 1).

Table 1. Statistical inferences and sample size

	Line A	Line B	Line C	Line D
Number of Observation / Line	27	27	27	27
Mean	1674	1977	1896	1943
Standard Deviation	221	211	185	197
Regression Standard Error	156	214	182	172
Stein's Two Stage Estimates				
n required for 95% confidence within 5% of the mean.	29	19	16	17
n required for 95% confidence within 10% of the mean.	7	5	4	4
n required for 95% confidence within 5% of the mean (using Standard Error from regression analysis)	14	20	15	13

Summary and Conclusions

Yield mapping involves the measurement of the harvested portion of a crop over space and time and the summarization of those measurements in numeric, graphical, or map form. As grain flows from the top of the clean-grain elevator, it hits the sensor's curved impact plate. The movement of the combine as well as impact of seed influences the sensor and its estimate of yield. This measurement, along with the clean-grain elevator speed, is used to calculate harvested mass per unit area.

In our test block we had 108 estimates of yield with a mean of 1873 lbs/acre and standard deviation of 233 lbs/acre. Individual yield estimates may vary substantially from the previous or subsequent observations. Trends in the data were apparent even in this small uniform area of the field. Application of Stein's Two Stage Procedure for estimation of sample size indicated that averaging the data over 15 to 20 points provided an estimate within 5% of the mean with 95% confidence. Data averaging did, however, mask large differences that occur over short distances, such as narrow strips of water damage. This implies short-distance, high-impact effects are best seen in data that has not been averaged but comparisons of areas with 5% to 10% differences in yield will require data averaging over portions of the field. We encourage continued evaluation of yield monitor data collected under field conditions and hope that the university will conduct a well designed and executed experiment that contrasts yield monitors and weight wagons.

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RESPONSE OF OVERWINTERING CEREAL LEAF BEETLE ADULTS TO AGGREGATION PHEROMONE IN THE FIELD

S. Rao, B.M. Quebbeman and D.L. Walenta

Introduction

The cereal leaf beetle (CLB), *Oulema melanopus* (L.) (Coleoptera: Chrysomelidae), is a new pest in cereals in the Pacific Northwest. Although the pest has been in the Eastern and Midwestern regions of the United States since 1962, the first detection of CLB in Oregon occurred in 1999. By 2002, CLB was detected in 17 out of 36 counties in OR and 14 out of 39 counties in Washington. Rapid dispersal of CLB adults contributes to increased spread of the pest into previously uninfested areas of Oregon.

Cereal leaf beetle adults and larvae cause extensive damage to the foliage of oats, wheat and barley. In addition to cereal grains, perennial grass species grown for seed, and warm season grass crops, can also be damaged by the CLB, and act as potential hosts. In 2002, a new stand of tall fescue in Northwest OR was damaged by CLB adults in late summer. This pest has added to production costs due to increased use of insecticides for its control. In Oregon, acreage treated with insecticides for CLB control has increased dramatically from 0 acres in 1999 to over 26,600 acres in 2002. In addition to crop damage, quarantine restrictions on the movement of hay, straw, and forage from infested counties in Oregon and Washington into neighboring California and Canada pose additional economic concerns. Labor intensive annual surveys, which involve sweep-net sampling and plant examination, are now required in all counties of Oregon and Washington. An effective attractant for CLB would facilitate the early detection of the pest in new areas during survey efforts.

The CLB has one generation per year and over-winters in the adult stage. In spring, adults migrate from over-wintering sites into crops with succulent new foliage, especially irrigated spring cereals. The adults feed, mate, and lay eggs for a period of 6 weeks. Extensive damage is caused by larvae feeding on the foliage in spring and summer. Mature larvae drop to the ground, pupate, and emerge as adults 2-3 weeks later. These newly emerging adults, also known as summer adults, are present in the field during late summer and feed for about 3 weeks prior to migration to over-wintering sites.

Monitoring of adults as they migrate from over-wintering sites to crops of economic value will facilitate early detection and development of management plans in spring. The development of a monitoring program that utilizes pheromone/attractant baited traps would likely improve early detection efforts and reduce labor requirements.

In 2001, a preliminary trapping study was conducted in Eastern OR to evaluate the response of CLB adults to an aggregation pheromone which was isolated from CLB adults by Allard Cossé, Robert Bartelt and Bruce Zilkowski at the USDA-ARS laboratory in Peoria, IL. The pheromone baited traps attracted late summer CLB adults but there were no significant differences in numbers of captured adults when comparing pheromone to non-pheromone control treatments. In this preliminary study, the captured beetles were newly emerged, non-reproductive summer adults that were feeding prior to entering the over-wintering diapause stage. We speculate that adult CLB that have gone through diapause and are migrating from over-wintering sites to newly planted cereal fields may exhibit a different response to the pheromone. The present study was conducted to evaluate the response of post-diapause / over-wintering adults to the CLB aggregation pheromone.

Procedures:

The study was conducted at the Oregon State University Eastern Oregon Agricultural Experiment Station located in Union in a newly-seeded 2.4 hectare field of spring planted oats (var. 'Jerry') in 2002. Normal crop production practices were followed but insecticides were not applied at any time. Yellow sticky traps were attached to bamboo stakes for trapping CLB adults. Trap height was initially 60 cm and later raised to 90 cm above ground level. Traps were baited ten days prior to emergence of oat plants. Six treatments were evaluated and the experiment was set up as a randomized block design with ten replicates. In each block, traps were set up in a line, 15 m apart.

The pheromone was tested at 3 dose levels to determine if there was a dose response. In addition, we tested a volatile compound produced by oats in high quantities in response to feeding injury, (Z)-3-hexenyl acetate (HA), to determine if there was a synergistic effect to the pheromone attractant. Treatments included: 50 μg P + HA; 150 μg P + HA; 500 μg P + HA; HA alone; 500 μg P alone; unbaited control. Freshly formulated P was added to rubber septa and stored in a freezer prior to use in the field. HA (4 mg) was added to rubber septa that were placed in capped polypropylene vials to which a single pin-hole opening was made for slow release of the material. P and HA lures were attached with clips on the downward side of the yellow sticky traps. A week later, captured CLB adults were counted, removed from the sticky trap, and preserved in 70 % alcohol. Lures and sticky traps were replaced every week. The experiment was set up on May 9th and continued for 5 weeks.

Results:

The data on numbers of captured adults was transformed using *log* (*X*+1) and analyzed using ANOVA. The analysis indicated that differences in the number of captured adults across treatments were highly significant (Figure 1). While all three pheromone doses tested captured more adults than the control, the highest pheromone dose attracted the greatest numbers of adults. These results suggest that response to pheromone is dose-related. The trap baited with only the plant volatile compound, HA, attracted the same number of beetles as the control. In addition, there were no differences in numbers of captured adults when comparing the highest pheromone dose with and without HA. This suggests that HA does not have a synergistic effect on the pheromone. The number of captured adults across all treatments increased from an average of 12.5 beetles per trap in the first week to 27.5 per trap in the third week (Figure 2). Subsequently there was a decline and the weekly average dropped to 1.08 per trap in the fifth week. In the first three weeks, a comparison of the treatments with the highest (500 μg P) and lowest (control) mean captures indicated that there were more than thrice as many adults on traps with 500 μg P compared to the control in each week.

The results of the present experiment differ from those of the preliminary study conducted in late summer 2001. During the earlier study, there were slightly higher numbers of beetles captured on traps baited with CLB aggregation pheromone, compared with control traps, but the differences were not significant. In the earlier study, the beetles were newly emerged adults that were engaged primarily in feeding behaviors prior to entering overwintering diapause. In the present experiment, the captured adult CLB had already overwintered and were moving into the oat field to begin reproduction. It is likely that the effect of the pheromone on CLB behavior depends on their physiological state (reproductive or diapause). The overall numbers of CLB captured in the 2001 study were lower than in the present study (3.3 versus 27.8 CLB per trap per week, respectively). It is unknown whether the differences between the two studies are related to responsiveness to the pheromone, propensity for flight, or the overall population levels. Additional research is needed on behavioral responses of CLB in different physiological states.

Many studies have documented that host volatiles enhance responses of insects to aggregation pheromones. However, in the present study, no behavioral response to the plant volatile, HA, could be demonstrated in the field, either as an attractant or as a pheromone synergist. Pheromone synergism by host volatiles may still occur in the CLB, but experimental changes might be required to demonstrate this, such as the use of blends of compounds or adjustments to the emission rate.

The CLB aggregation pheromone has potential to become an important monitoring and management tool, especially in the spring, as new fields become infested by beetles emerging from diapause. One particular benefit with the CLB pheromone is that, unlike many pheromone-based tools, the egg-laying sex can be attracted. In this study, numbers of captured CLB adults increased for the first three weeks and then declined again. This pattern likely reflects, first, the immigration of beetles into the field, and, eventually, the cessation of reproductive activity. CLB monitoring data is likely to be rich in biological information, but more research will be required to learn how to interpret and use this information. Other future research needs include: 1) determination of the optimum pheromone release rate, 2) evaluations on seasonal and ecological parameters that affect pheromone activity, 3) estimation of synergism by addition of key (individual or a blend) host volatiles, and 4) development of a more efficient trap design.

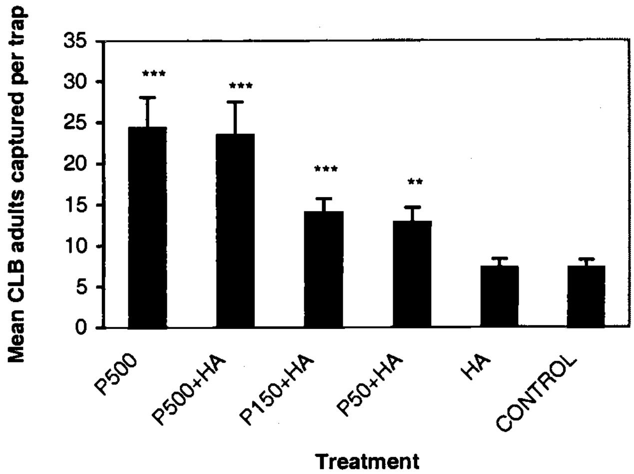


Figure. 1. Mean number (+ SE) of overwintering CLB adults captured in 5 weeks on yellow sticky traps, baited with synthetic CLB aggregation pheromone (P) and plant-related compound (Z)-3-hexenyl acetate (HA), placed in an oat field in Oregon. Means significantly different from the control at the α = 0.001 and 0.01 levels denoted by *** and **, respectively

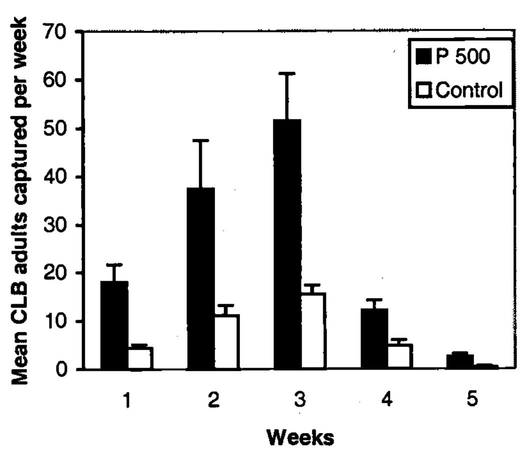


Figure 2. Comparison of mean numbers (+ SE) of overwintering CLB adults captured each week on yellow sticky traps baited with 500 μg synthetic CLB aggregation pheromone (P 500) and unbaited control traps placed in an oat field in Oregon.

INTRODUCTION, DISPERSAL, AND MANAGEMENT OF SMALL BROOMRAPE IN RED CLOVER SEED PRODUCTION: A GROWER SURVEY

K.C. Ross, J.B. Colquhoun and C.A. Mallory-Smith

Introduction

Small broomrape is a relatively new introduction in the Pacific Northwest and has contaminated limited acreage of the primary red clover (*Trifolium pratense* L.) seed production area of the world. In 1999, there were 21,500 acres of red clover seed production in Oregon, with $6.8 million in annual crop value. In 1998, small broomrape was detected in a certified red clover seed field in Clackamas County, Oregon. Although, small broomrape was first documented in Oregon in 1923, the 1998 observation was the first in Oregon commercial agriculture (Oregon State University Herbarium 1923). Small broomrape is a federally listed noxious weed that is prohibited in interstate commerce. In 2000, Oregon Department of Agriculture (ODA) received funds from the Interstate Pest Control Compact (IPCC) and United States Department of Agriculture (USDA) to complete a comprehensive survey of the North Willamette Valley clover fields to determine the extent of the small broomrape problem.

Red clover is grown in a production system utilizing either fall or spring planting. In the fall planting system, red clover is planted in monoculture in late August to early October, and harvested in late May to early June for forage. In late August to early September, the red clover is then harvested for seed and grown for an additional year, contributing another forage and seed harvest. In the spring planting system, red clover is broadcast over an established grain crop in late winter or early spring, or red clover may be sown with spring grain. In the spring planting system, the grain is harvested at maturity and the red clover is grown for two forage and seed harvests over two years, similar to the fall planting system. Beginning in 1999, all red clover seed lots were required to be tested for small broomrape seed prior to sale and shipment out of Oregon.

The objective of this study was to evaluate mechanisms of introduction and dispersal and current management practices by surveying Oregon red clover seed growers who have had recent experience with small broomrape.

Procedure

Survey recipients were red clover seed growers who had one or more red clover seed fields contaminated with small broomrape in 1999, 2000, or 2001. Growers were asked 19 questions about their farming operation in order to determine characteristics of their farms, assess the accuracy of small broomrape identification, history and culture of the contaminated site, and potential introduction and dispersal mechanisms (Table 1). Names of individuals, farms, custom operators, agronomy companies, seed companies, and seed cleaning facilities were kept confidential.

A cover letter describing the purpose of the survey, a small broomrape information sheet with small broomrape biology, ecology, and description, and the survey questions were mailed to each grower. Growers were given opportunity to add comments outside of the written questions.

The survey covered Clackamas, Columbia, Linn, Marion, Multnomah, Washington, and Yamhill counties, and thus included the primary red clover production area in Oregon. This section of Oregon is in the Northern Willamette Valley and is characterized by a variety of soils that are typically deep, well drained, fertile, and surrounded by suburban development. Crop rotation varies among farms and among fields within an individual farm. Cropping systems are both dryland and irrigated.

Results

Survey feedbacks were excellent. Twenty (80%) complete surveys were received, one (5%) survey was undeliverable, and the remaining four (15%) surveys were not returned. All questions in returned surveys were complete and provided insight to the biology and mechanisms of introduction and dispersal of small broomrape (Table 1).

When respondents were allowed to provide additional information on the survey, a few respondents described their management tactics for their small broomrape infestation, which included rouging, application of glyphosate, and mowing, followed by harvest or destruction of seed. A second focus of respondents' additional comments was the role of wildlife, deer and geese, as mechanisms of small broomrape seed introduction and dispersal.

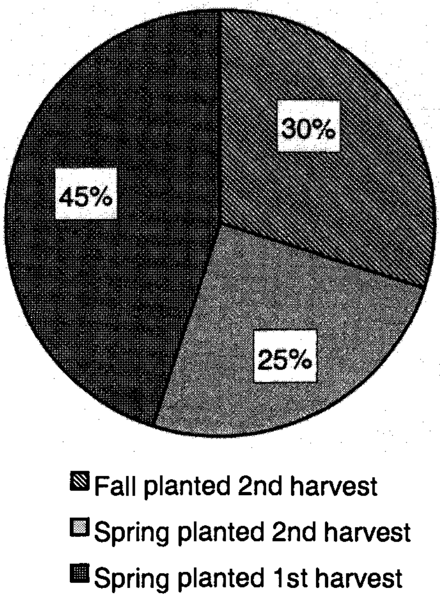
Red clover was grown on limited land area on most farms as a rotation crop for control of weeds and volunteer crops, and fertility enhancement between monocotyledons crops. All survey responses validated that growers were familiar with identification of small broomrape. Growers were more aware of other small broomrape infestations after viewing infestations in their own fields. One (5%) respondent claimed to have seen small broomrape parasitizing strawberries (*Fragaria* spp.); however, strawberries have not been previously reported as a small broomrape host.

No respondents had small broomrape parasitize fall planted red clover prior to or during the harvest of the first crop (Figure 1).

In the fall of the year, red clover planted in the spring with no harvest removed, is similar in size and phenology to red clover that been harvested one or more times. In the fall of the year, red clover planted in the fall with no harvest removed, is not similar in size and phenology to red clover that been harvested one or more times or spring planted red clover that has not been harvested. Red clover planted in the fall at the beginning of the cold rainy season is not be developed enough to promote parasitism by small broomrape. It is hypothesized that small broomrape begins germination during wet winter and early spring months when soil moisture is high. The late fall, winter, and early spring months are the only months that soil moisture is great enough in the dryland production systems of the Oregon's North Willamette Valley to allow small broomrape to parasitize a host. The inability of small broomrape to parasitize seedling red clover may be due to a relationship between either germination or haustoria initiation stimulants with soil temperature and soil moisture levels. Production of germination and haustoria initiation stimulants by seedling red clover may be inadequate for small broomrape to respond due to the small size of the red clover seedling, low soil temperature, and high soil water content. Germination and haustoria initiation stimulants are diluted and quickly leached away from small broomrape seeds that are in adequate proximity to successfully attach to a red clover seedling. A red clover plant with a larger root system may produce more stimulants to overcome the effect of lower stimulant production due to low temperature and dilution and leaching effects from water.

Cropping history and crop rotations varied among respondents, but generally consisted of a monocotyledonous crop followed by a dicotyledonous crop (Table 2). This crop rotation allows growers to rotate mechanical and chemical weed control mechanisms and meet seed certification requirements. The clover grown by all respondents were an assortment of clover species and red clover cultivars (Figure 2). Forage harvest occurs prior to small broomrape emergence; therefore, small broomrape contamination can only occur with transfer of soil with forage harvest. Custom field operations do not appear to be a major dispersal mechanism for small broomrape.

Figure 1. Planting and harvest regime of red clover (*Trifolium pratense*) grown for seed in small broomrape (*Orobanche minor*) contaminated fields.



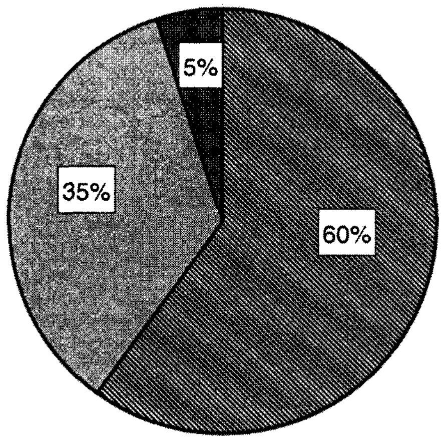
[a] Survey responses that included each planting and harvest regime / number of survey responses x 100.

Table 2. Crops included in rotation with red clover in fields contaminated with small broomrape (*Orobanche minor*).

Crop	Latin name	Grower response
		(%)[a]
Alfalfa	*Medicago sativa* L.	5
Arrowleaf clover	*Trifolium vesciculosum* Savi.	5
Barley	*Hordeum vulgare* L.	5
Common vetch	*Vicia sativa* L.	5
Crimson clover	*Trifolium incarnatum* L.	35
Field corn	*Zea mays* L.	5
Oat	*Avena sativa* L.	45
Perennial ryegrass	*Lolium perenne* L.	25
Radish	*Raphanus sativus* L.	10
Red clover	*Trifolium pratense* L.	100
Snap bean	*Phaseolus vulgaris* L.	5
Strawberry	*Fragaria* spp.	5
Sugar pea	*Pisium sativa* L.	10
Sugarbeet	*Beta vulgaris* L.	5
Sweet corn	*Zea mays* L.	10
Tall fescue	*Festuca arundinaceae* Schreb.	25
Wheat	*Triticum aestivum* L.	95

[a]survey responses that included each crop in rotation/number of survey responses x 100.

Figure 2. Clover seed species grown by respondents of small broomrape (*Orobanche minor*) survey.



[a] Survey responses that included each combination of crop species / number of survey responses x 100.

No respondents could recollect the seed lot number of the red clover seed stock used for planting the small broomrape contaminated fields. Companies that sold or cleaned red clover seed are referred to as "Company A through I" (Table 3). Company "A" cleaned 6 seed lots and provided seed stock for 6 small broomrape contaminated fields. Company "A" may have unintentionally assisted in dispersal of small broomrape to new sites and seed lots; however, all seed lots were tested by the OSU Seed Laboratory and certified free of small broomrape seed. Other companies had a lower potential for dispersing small broomrape seed because they cleaned fewer small broomrape contaminated red clover seed lots and sold fewer red clover seed stocks that eventually were grown in a small broomrape contaminated field (Table 2).

Seeds are frequently dispersed from one location to another by floating on the surface of water (Radosevich et al., 1997). Streams and water-holding facilities that are open to the environment typically contain weed seed floated in by water, blown in by wind, or brought in by birds and wildlife (Radosevich et al., 1997). Geese have the ability to move small broomrape seeds on their feet or after ingestion from contaminated fields or water. Fourteen (70 %) respondent's small broomrape contaminated field have surface water run across the field, irrigated the field from a water source other then a well, or have seen geese inhabit the field. These three mechanisms are likely to have assisted in dispersal of small broomrape seed.

Table 3. Seed company that supplied red clover (*Trifolium pratense*) seed for planting or cleaned the red clover seed from a small broomrape (*Orobanche minor*) infested field.

Seed company[a]	Seed lots purchased	Seed lots cleaned
	(Number)	
A	6	6
B	2	0
C	1	0
D	1	1
E	1	3
F	2	1
G	0	2
H	0	1
I	0	1
Unknown	7	0
Destroyed seed	0	1

[a]Seed company referred to as "A" through "I", "Unknown" if the seed company is unknown, or "Destroyed seed" if the seed lot was destroyed.

Implications

The specific mechanism behind dispersal of small broomrape is difficult to determine because the parasite is only visible in the presence of a host after emergence. Small broomrape is likely to have been dispersed by a combination of contaminated machinery, seed lots, water, and wildlife.

While respondents were able to accurately identify small broomrape, the subsequent management practices and management of seed varied. This suggests that further education is appropriate, particularly in the areas of small broomrape prevention and control. Furthermore, the process of seed cleaning and identifying contamination of certified red clover seed lots should be examined. A majority of red clover seed growers in Oregon have either quit growing red clover seed, or drastically reduced the land area committed to red clover seed production, because they have not been educated on control measures for small broomrape in red clover.

Acknowledgements

The authors gratefully appreciate Oregon red clover seed growers for contributing their time and experiences.

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Table 1. Respondents' answers to survey questions

Question	Answer	Quantity (%)[a]
Yearly average red clover seed acreage	Less than 50 acres	90
	Greater than 50 acres	10
Total farm acreage	Less than 250 acres	55
	Between 250 and 1000 acres	40
	Greater than 1000 acres	5
Observed small broomrape prior to the year their field was found contaminated	Yes	10
	No	90
Observed small broomrape in neighboring red clover fields	Yes	25
	No	75
Observed small broomrape parasitizing plants other than red clover	Strawberries	5
	None	95
Small broomrape parasitized red clover planted in the spring, with parasitism occurring before the first seed harvest	Yes	45
Small broomrape parasitized red clover planted in the spring, with parasitism occurring before the second seed harvest	Yes	25
Small broomrape parasitized red clover planted in the fall, with parasitism occurring before the first seed harvest	Yes	0
Small broomrape parasitized red clover planted in the fall, with parasitism occurring before the second seed harvest	Yes	30
Crop rotation of the small broomrape-contaminated site	See Table 2	
Clover species grown by the farm	Only red clover	60
	Red clover and crimson clover	35
	Red clover and arrowleaf clover	5
Variety of red clover grown in the small broomrape-contaminated site	Kenland	40
	Hedges	5
	Not stated	55
Custom operations conducted on the small broomrape-contaminated site	Spraying and fertilizing	10
	Leased to a third party	5
	Forage harvest	10
	Seed harvest	10
	None	65
Seed lot number of red clover seed stock planted in the small broomrape-contaminated site	Not stated	100
Seed company that red clover seed stock was purchased from	See Table 3	
Seed company that cleaned the red clover seed from small broomrape-contaminated site	See Table 3	
Surface water runs across the small broomrape-contaminated site	Yes	30
	No	70
The small broomrape-contaminated site has been irrigated from a water source other than a well	Yes	35
	No	65
Geese inhabit the small broomrape-contaminated site	Yes	55
	No	45

[a]survey responses that included each answer / number of survey responses x 100

EVALUATION AND COST ANALYSIS OF ALTERNATIVE RESIDUE MANAGEMENT METHODS FOR KENTUCKY BLUEGRASS SEED PRODUCTION IN THE GRANDE RONDE VALLEY

D.L. Walenta, P.L. Diebel, L.R. Gow and G.L. Kiemnec

Introduction

The production of high quality grass seed is important to the agricultural economy of the Grande Ronde Valley (GRV) of eastern Oregon. The predominate grass seed crops grown in the area are Kentucky bluegrass and fine fescues. Historically, open-field burning has been an effective, economical means by which to remove residue and maintain seed yield and quality. The continued concern for air quality and public health have led to the adoption of alternative residue management methods that place less reliance on open-field burning of full straw residue loads.

Past research conducted in Oregon identified potential alternative residue management strategies that maintain seed yield and quality in the absence of open field burning (Chastain et al. 1997, Chastain et al. 2000). Although not included in previous research efforts in the GRV, mechanical removal of residue followed by propane-flaming of stubble has been widely adopted in the GRV as one alternative to open-field burning. In 2001, residue management efforts in the GRV utilized propane-flaming on 46% of the total harvested grass seed acreage.

Recently, a need was identified to conduct further research on alternative residue management methods currently used for Kentucky bluegrass seed production in the GRV. A large, on-farm study was established in 2001 to address the following objectives: 1) determine the effect of alternative residue management methods on seed yield and quality of Kentucky bluegrass; 2) conduct a cost-analysis of non-thermal and propane-flaming residue management methods over a period of three seed crop years; and 3) develop educational programs for dissemination of information obtained from this study to producers and the agricultural industry.

Materials and Methods

The study was established in the summer of 2001 in a commercial Kentucky bluegrass (var. 'Kelly') seed production field in the GRV. The experimental design of the study consisted of 4 residue management treatments arranged in a randomized complete block with 3 replications. Residue management treatments consisted of: 1) bale only; 2) bale + flail; 3) bale + propane early; and 4) bale + propane late. Individual plots are 25 ft by 400 ft. Production practices (e.g., fertilizer and chemical application) for the study site were managed by the cooperating producer according to common commercial production practices utilized in the GRV.

Commercial production-sized equipment were used to make ag-chemical applications and to harvest the seed crop. Data collection consists of clean seed yield, purity, and germination. A weigh wagon was used to measure bulk seed harvested from each plot. Sub-samples were collected during harvest to determine clean seed yield and quality.

Residue management treatments were initiated in the summer of 2001 following the first commercial seed harvest. Bale only, bale + flail, and bale + propane early treatments were applied on August 8-9, 2001. The bale + propane late treatment was applied on September 12, 2001 to Kentucky bluegrass with approximately 2-3 inches of vegetative re-growth. Individual plots were swathed with a commercial-size swather on July 10, 2002 and were harvested with a commercial-size combine on July 26, 2002. Sub-samples collected during the 2002 seed crop harvest were processed during the fall of 2002 by cleaning one time with a Clipper M2-B Cleaner with three screens. Clean seed samples were subjected to germination and purity analysis at the OSU Seed Laboratory. Post-harvest residue management treatments including bale only and bale + flail were applied on August 5, 2002. The bale + propane early treatment was applied on August 7, 2002 and the propane late treatment was applied on September 3, 2002.

Results and Discussion

Results from the first seed harvest following application of residue management treatments are shown in Table 1. Seed yields were significantly reduced when residue was baled off and stubble was left intact (bale only) when compared to baling followed by late thermal treatment. A slight increase in seed yield was observed when baling was followed by flailing or early thermal treatment of the remaining stubble, however, these yields were not significantly different. Early and late thermal reduction of stubble resulted in equivalent seed yields. Although the results indicate that mechanical residue removal followed by late thermal treatment produced greater seed yields than any other treatment, it is unclear at this time if the yield increase is a varietal response due to late thermal treatment. Seed purity and germination levels were not influenced by mechanical or thermal residue management methods.

Results from the first year of this study indicate that the amount of residue and stubble remaining in the field after harvest affect seed yield and are similar to previously reported results. The study will continue for two additional seed crop harvests to determine if locally adopted residue management methods will maintain seed yield and quality. An economic analysis will be conducted at the completion of the study to determine economic return from each of the residue management methods.

Acknowledgements: This research is supported by funds from the Agriculture Research Foundation. Appreciation is also expressed to Pete Nilsson for providing land, equipment, and labor necessary for conducting this study, to Bryon Quebbeman for technical assistance, and the CBARC-OSU for use of seed processing equipment..

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Table 1. Residue management influence on seed yield and quality in Kelly Kentucky bluegrass, 2002.

Treatment	Seed yield	Purity: Pure Seed	Purity: Inert	Germination
	(lb/acre)	(%)	(%)	(%)
Bale only	1087 b[1]	96.1	3.9	91.0
Bale + Flail	1236 ab	97.0	3.0	94.3
Bale + Propane Early	1256 ab	96.8	3.2	93.0
Bale + Propane Late	1416 a	98.1	1.9	93.3
LSD 0.05	257	NS[2]	NS	NS

[1] Means in columns followed by the same letter are not significantly different by Tukey's mean pairwise comparison test.
[2] N.S. = not significant.

EVALUATION OF PALISADE ON KENTUCKY AND ROUGH BLUEGRASS, 2002

M.D. Butler and C.K. Campbell

Research to evaluate Palisade plant growth regulator on Kentucky bluegrass has been conducted annually since 1999. Seed yields have been increased by 32 to 36 percent in two of the three years compared to untreated plots when Palisade was applied at 22 oz/a from detection of the first and second node (Feekes 7) to when the head just becomes visible (Feekes 10.1). Late application when the heads extended just above the flag leaf (Feekes 10.4) produced the greatest reduction in plant size, while plants tended to out grow the effect of earlier Palisade applications. There have been no differences between treatments in weight per 1000 seed. Percent germination for Palisade treated plots was equal to or better than the untreated plots.

During 2002, plots 10 ft x 25 ft were replicated four times in a randomized complete block design in commercial fields of 'Geronimo' Kentucky bluegrass and 'Laser' rough bluegrass near Madras, Oregon. Palisade was applied at 1.4 pint/acre, 2.1 pints/acre, and 2.9 pint/acre on the first application date and at 2.1 pint/acre on the second application date. Treatments were applied to Kentucky bluegrass on April 30 (2nd node detectable) and May 10 (very few heads visible) and to rough bluegrass on May 7 (2nd node detectable) and May 21 (very few heads visible).

Treatments were applied with a CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal/a water using TeeJet 8002 nozzles. Prior to harvest, a Jari mower was used to cut three-foot alleyways across the front and back of each row of plots. A research-sized swather was used to harvest a 40-inch by 22-foot portion of each Kentucky bluegrass plots July 5. Rough bluegrass plots were harvest July 8. 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 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.

At the 90 percent confidence level Palisade at 1.4 pt/acre, 2.1 pt/acre and 2.9 pt/acre applied April 30 (2nd node detectable) significantly increased yields on Kentucky bluegrass by 35, 24 and 31 percent, respectively (Table 1). There does not appear to be a cost effective reason to apply more than 1.4 pt/a of Palisade. Seed yields resulting from Palisade applied May 10 (very few heads visible) and Apogee applied April 30 were similar to untreated plots.

At the 90 percent confidence level Palisade at 2.9 pt/a significantly increased seed yield on rough bluegrass by 21 percent compared to untreated plots (Table 2). Though not significant, Palisade at 1.4 pt/a increased yield by13 percent and Apogee at 14.5 oz/a increased yield by 12 percent.

Table 1. Effect of Palisade growth regulator on yield of Kentucky bluegrass, Madras, Oregon,2002.

Treatment	Application timing April 30	Application timing May 10	Seed yield (lb/a)	Seed yield (% check)	Biomass (t/acre)	1000 seed weight (g)	Germination (%)
	----------- (product/a)	----------------					
Palisade	1.4 pt	----	2693 a[1]	135	5.8 a	.3003 b	70
Palisade	2.1 pt	----	2483 abc	124	5.9 a	.3204 a	74
Palisade	2.9 pt	----	2613 ab	131	5.8 a	.3124 ab	77
Palisade	----	2.1 pt	2227 bcd	111	5.8 a	.3214 a	84
Apogee	14.5 oz	----	2185 cd	109	4.9 b	.3323 a	76
Untreated	----	----	1999 d	100	5.3 b	.3095 ab	67
							NS

[1]Mean separation with LSD P≤0.1.

Table 2. Effect of Palisade growth regulator on yield of rough bluegrass, Madras, Oregon, 2002.

Treatment	Application timing May 7	Application timing May 21	Seed yield (lb/a)	Seed yield (% check)	Biomass (t/acre)	1000 seed weight (g)	Germination (%)
	----------- (product/a)	----------------					
Palisade	1.4 pt	----	1240 ab[1]	113	3.4	.2114	96 b
Palisade	2.1 pt	----	1119 ab	102	3.3	.2110	97 ab
Palisade	2.9 pt	----	1326 a	121	3.6	.2048	97 ab
Palisade	----	2.1 pt	1131 ab	103	3.4	.2049	98 a
Apogee	14.5 oz	----	1233 ab	112	3.5	.2120	97 ab
Untreated	----	----	1097 b	100	3.3	.2089	95 b
					NS	NS	

[1]Mean separation with LSD P≤0.1.

EVALUATION OF APOGEE ON KENTUCKY AND ROUGH BLUEGRASS, 2002

M.D. Butler and C.K. Campbell

Research to evaluate Apogee plant growth regulator on Kentucky bluegrass was conducted during 1999 and 2001. In 1999 three rates were applied early and late, or as a split application. The greatest reduction in plant height was from split applications at 11 oz/a or 14.5 oz/a. Lodging was best controlled with a late application at 22 oz/a or 29 oz/a. Seed yield showed the greatest increase with an early application at 29 oz/a. The 2001 data provide mixed results due to weather conditions affecting grass seed yields in general.

During 2002, plots 10 ft x 25 ft were replicated four times in a randomized complete block design in commercial fields of 'Geronimo' Kentucky bluegrass and 'Laser' rough bluegrass near Madras, Oregon. Apogee was applied at 14.5 oz/acre, with and without two percent ammonium sulfate (AMS) on the first application date and at 14.5 oz/acre with AMS on the second application date. Treatments were applied to rough bluegrass on May 7 (2nd node detectable) and May 21 (very few heads visible), and to Kentucky bluegrass on April 30 (2nd node detectable) and May 10 (very few heads visible).

Treatments were applied with a CO_2-pressurized, hand-held boom sprayer at 40 psi and 20-gal/a water using TeeJet 8002 nozzles. Prior to harvest, a Jari mower was used to cut 3-foot alleyways across the front and back of each row of plots. A research-sized swather was used to harvest a 40-inch by 22-foot portion of Kentucky bluegrass plots July 5 and of rough bluegrass on July 8. 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 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.

At a 90 percent confidence level there were no significant differences between Apogee and the untreated plots for either Kentucky bluegrass (Table 1) or rough bluegrass (Table 2). However, the trend was for Apogee applied either on May 7 (2nd node detectable) or May 21 (very few heads visible) to increase yields by 10 to 15 percent on rough bluegrass, while Palisade applied April 30 (2nd node detectable) increased yields on Kentucky bluegrass by 24 percent. Apogee treatments on Kentucky bluegrass produced similar yields to untreated plots. There didn't appear to be any advantage from including two percent ammonium sulfate (AMS) with Apogee applications. Palisade increased Kentucky bluegrass yields by 24 percent. Untreated plots produced the lowest yield for rough bluegrass, but not on Kentucky bluegrass.

Table 1. Effect of Apogee growth regulator on Kentucky bluegrass, Madras, Oregon, 2002.

Treatment	Application timing April 30	Application timing May 10	Seed yield		Biomass	1000 seed weight	Germination
	----------- (product/a)	-----------	(lb/a)	(% check)	(t/acre)	(g)	(%)
Apogee	14.5 oz	----	2185 ab[2]	109	4.9 b	.3223 ab	76 ab
Apogee+AMS[1]	14.5 oz	----	1854 b	93	5.3 ab	.3228 ab	69 b
Apogee+AMS	----	14.5 oz	2008 b	101	5.2 ab	.3269 a	82 a
Palisade	2.1 pt	----	2483 a	124	5.9 a	.3204 ab	74 ab
Palisade	----	2.1 pt	2227 ab	111	5.8 a	.3214 ab	84 a
Untreated	----	----	1999 b	100	5.3 ab	.3100 b	67 b

[1]AMS= two percent ammonium sulfate
[2]Mean separation with LSD P≤0.1.

Table 2. Effect of Apogee growth regulator on rough bluegrass, Madras, Oregon, 2002.

Treatment	Application timing May 7	Application timing May 21	Seed yield		Biomass	1000 seed weight	Germination
	----------- (product/a)	-----------	(lb/a)	(% check)	(t/acre)	(g)	(%)
Apogee	14.5 oz	----	1233	112	3.5	.2120	97 a[2]
Apogee+AMS[1]	14.5 oz	----	1209	110	3.5	.2123	92 b
Apogee+AMS	----	14.5 oz	1260	115	3.5	.2105	95 ab
Palisade	2.1 pt	----	1119	102	3.3	.2110	97 a
Palisade		2.1 pt	1131	103	3.4	.2049	98 a
Untreated	----	----	1097	100	3.3	.2090	95 ab
			NS		NS	NS	

[1]AMS= two percent ammonium sulfate
[2]Mean separation with LSD P≤0.1.

EVALUATION OF HERBICIDES FOR CONTROL OF SEEDLINGS IN KENTUCKY BLUEGRASS SEED PRODUCTION, 2001-2002

M.D. Butler, L.G. Gilmore, R.J. Burr and C.K. Campbell

During 2000-2001 herbicides were fall applied in combination over two application dates to Kentucky bluegrass, perennial ryegrass and rough bluegrass to determine efficacy and crop safety. No injury was observed to Kentucky bluegrass or established perennial ryegrass. Treatments that included Axiom provided 90 to 100 percent control of established rough bluegrass and 97 to 98 percent control of volunteer perennial ryegrass. Follow-up treatments of Goal plus Sinbar generally provided greater control than Goal plus Diuron. The objective of this project was to evaluate Axiom combinations and Beacon on Kentucky bluegrass for seedling control, height reduction and seed set reduction.

During 2001-2002, plots were replicated three times in a randomized complete block design in three commercial Kentucky bluegrass seed field (cultivars 'Merit', 'Shamrock', and 'Geronimo') north of Madras. Herbicide treatments were applied October 10 or 11 and November 12, 2001. Treatments applied in October included Axiom alone or in combination with Goal or Beacon, or Sencor plus Goal. November treatments were Goal in combination with Sinbar or Duiron, or Beacon alone.

Treatments were made to 10 ft x 20 ft plots with a CO_2 pressurized, hand-held boom sprayer at 40 psi and 20 gal/acre water. Plots were evaluated March 1, 2002 for seedling control and reduction in crop height, and June 14 for reduction in seed set.

The best seedling control was provided by treatments containing Axiom at 11 or 13 oz/acre alone or in combination with Goal at 8 oz/acre, followed by Goal at 16 oz/acre plus Sinbar at 0.75 lb/acre (Table 1). There were differences in the effect on the various cultivars, with 85 percent seedling control for 'Merit', 52 percent for 'Shamrock', and 52 percent for 'Geronimo'. However, none of the treatments provided adequate seedling control across cultivars.

The treatments that had the greatest effect on reducing crop height (4-22%) contained Axiom (Table 2). Beacon generally had little effect on crop height (0-13%), while Sencor at 4 oz/acre plus Goal at 8 oz/acre followed by Goal at 16 oz/acre plus Diuron at 2 lb/acre had no real effect (1-3%).

Axiom did not significantly effect seed set on 'Merit' or 'Geronimo' (Table 3). However, seed set on 'Shamrock' was reduced by 83 to 88 percent with Axiom at 11 oz/acre and 37 percent at 9 oz/acre. It is unclear whether this is a varietal difference, or the result of differences in the developmental stages between the cultivars when Axiom was applied.

Table 1. Effects of herbicides on seedling control in Kentucky bluegrass, near Madras, OR, 2001-2002.

Treatment		Product/acre		Seedling control		
October 10, 11	November 12	October 10, 11	November 12	Merit	Shamrock	Geronimo
				(%)		
Axiom	Goal + Sinbar	11 oz	16 oz + 0.75 lb	85 a[1]	33 bcd	52 a
Axiom + Goal	Goal + Sinbar	9 oz + 8 oz	16 oz + 0.75 lb	75 ab	35 bcd	35 ab
Axiom + Goal	Goal + Sinbar	11 oz + 8 oz	16 oz + 0.75 lb	78 ab	52 a	40 a
Axiom + Goal	Goal + Diuron	11 oz + 8 oz	16 oz + 2 lb	85 a	45 ab	43 a
Axiom + Goal	----	11 oz + 8 oz	----	62 bc	37 abc	37 ab
Axiom + Goal	Goal + Sinbar	13 oz + 8 oz	16 oz + 0.75 lb	83 a	52 a	33 abc
Beacon	Goal + Sinbar	0.75 oz	16 oz + 0.75 lb	18 ef	20 de	7 d
Beacon	Beacon	0.375 oz	0.375 oz	35 de	23 cde	13 d
Sencor + Goal	Goal + Sinbar	4 oz + 8 oz	16 oz + 0.75 lb	52 cd	10 ef	15 cd
Sencor + Goal	Goal + Diuron	4 oz + 8 oz	16 oz + 2 lb	30 e	0 f	18 bcd
Untreated	----	----	----	0 f	0 f	0 d

[1]Mean separation with LSD at P≤0.05.

Table 2. Effects of herbicides on crop height reduction in Kentucky bluegrass, near Madras, OR, 2001-2002.

Treatment		Product/acre		Height reduction		
October 10, 11	November 12	October 10, 11	November 12	Merit	Shamrock	Geronimo
				(%)		
Axiom	Goal + Sinbar	11 oz	16 oz + 0.75 lb	8 cde[1]	20 a	20 a
Axiom + Goal	Goal + Sinbar	9 oz + 8 oz	16 oz + 0.75 lb	12 abcd	3 de	7 b
Axiom + Goal	Goal + Sinbar	11 oz + 8 oz	16 oz + 0.75 lb	10 bcd	8 cd	15 a
Axiom + Goal	Goal + Diuron	11 oz + 8 oz	16 oz + 2 lb	20 ab	8 c	15 a
Axiom + Goal	----	11 oz + 8 oz	----	22 a	12 bc	6 b
Axiom + Goal	Goal + Sinbar	13 oz + 8 oz	16 oz + 0.75 lb	12 abcd	15 b	18 a
Beacon	Goal + Sinbar	0.75 oz	16 oz + 0.75 lb	2 de	0 e	0 b
Beacon	Beacon	0.375 oz	0.375 oz	13 abc	3 e	2 b
Sencor + Goal	Goal + Sinbar	4 oz + 8 oz	16 oz + 0.75 lb	2 de	2 e	3 b
Sencor + Goal	Goal + Diuron	4 oz + 8 oz	16 oz + 2 lb	5 cde	1 e	3 b
Untreated	----	----	----	0 e	0 e	0 b

[1]Mean separation with LSD at P≤0.05.

Table 3. Effects of herbicides on reduction in seed set in Kentucky bluegrass, near Madras, OR, 2001-2002.

Treatment		Product/acre		Seed set reduction		
October 10, 11	November 12	October 10, 11	November 12	Merit	Shamrock	Geronimo
				----------	(%)	----------
Axiom	Goal + Sinbar	11 oz	16 oz + 0.75 lb	0	85 a[1]	2 bc
Axiom + Goal	Goal + Sinbar	9 oz + 8 oz	16 oz + 0.75 lb	0	37 b	2 bc
Axiom + Goal	Goal + Sinbar	11 oz + 8 oz	16 oz + 0.75 lb	0	88 a	8 a
Axiom + Goal	Goal + Diuron	11 oz + 8 oz	16 oz + 2 lb	7	83 a	2 bc
Axiom + Goal	----	11 oz + 8 oz	----	3	83 a	0 c
Axiom + Goal	Goal + Sinbar	13 oz + 8 oz	16 oz + 0.75 lb	7	88 a	7 ab
Beacon	Goal + Sinbar	0.75 oz	16 oz + 0.75 lb	3	0 c	0 c
Beacon	Beacon	0.375 oz	0.375 oz	0	0 c	0 c
Sencor + Goal	Goal + Sinbar	4 oz + 8 oz	16 oz + 0.75 lb	0	0 c	3 abc
Sencor + Goal	Goal + Diuron	4 oz + 8 oz	16 oz + 2 lb	0	3 c	0 c
Untreated	----	----	----	0	0 c	0 c
				NS		

[1]Mean separation with LSD at $P \leq 0.05$.

EVALUATION OF HERBICIDES ON ROUNDUP READY BENTGRASS AND CONVENTIONAL BENTGRASS IN CENTRAL OREGON, 2000-2002

M.D. Butler, L.G. Gilmore and C.K. Campbell

In response to discussions between The Scotts Company and New Era Seeds to grow Roundup Ready bentgrass in central Oregon, plots were established by the parties involved to determine the effectiveness of seven herbicides on both Roundup Ready bentgrass and conventional bentgrass.

Roundup Ready and conventional bentgrass plugs started in greenhouses were transplanted into an isolated area at the north end of the Agency Plains on October 10, 2000. Roundup Ready plants were placed on 5-foot centers, while the conventional bentgrass was planted on 2.5-foot centers.

Plots were two rows (one row each of Roundup Ready and conventional bentgrass) by 30 feet long. Borders between the plots were one to two rows wide. Plots were replicated three times in a randomized complete block design. Herbicides that were evaluated included Roundup, Fusilade, Envoy, Rely, Vantage, Kerb and Beacon. They were generally applied in combination with crop oil concentrate (COC) at 1% v/v, with and without R11 surfactant at 0.05%. Exceptions were Roundup and Kerb that did not include COC or R11, Beacon that included R11 with and without COC, and one treatment of Rely in combination with AMS. Matt Faletti from The Scotts Company and Ron Crocket with Monsanto applied the herbicide treatments September 28, 2001.

Evaluations were conducted by Marvin Butler and Les Gilmore on April 2 and June 5, 2002. All plots were rated for percent biomass reduction, with the remaining portion of the percentage indicating an estimate of the amount of regrowth present.

With a year of growth following transplanting, plants were quite large when herbicides were applied. Despite the large plants, a variety of herbicides provided significant control of both Roundup Ready and conventional bentgrass (Table 1). The standard of comparison for both evaluations was Roundup at 1.5 lb a.i./acre.

For the April 2 evaluation Roundup at 1.5 lb a.i./acre provided 98 to 99 percent control of conventional bentgrass. Fusilade at 0.375 lb a.i./acre provided an average of 95 percent control of the Roundup Ready bentgrass, while Fusilade at 0.25 lb a.i./acre provided an average of 90 percent control. Envoy at 0.25 lb a.i./acre provided 87 to 88 percent control, Rely at 1.5 lb a.i./acre gave 85 percent control, Vantage at 0.375 lb a.i./acre controlled about 81 percent of the Roundup Ready bentgrass. Kerb and Beacon did not provide adequate control of either the Roundup Ready or conventional bentgrass. Although Rely provided slightly better bentgrass control compared to Vantage, the strength of the regrowth was greater with the Rely.

On the June 5 evaluation efficacy had increased for the top performing herbicides. Fusilade at 0.375 lb a.i./acre and 0.25 lb a.i./acre had only one or two shoots that remained alive per plot, and was rated as reducing biomass by 99 percent. It is possible that given additional time these shoots would have died as well. Envoy at 0.25 lb a.i./acre provided 96 percent control. Inadequate control was provided by Rely at 1.5 lb a.i./acre (56%), Vantage at 0.375 lb a.i./acre (69%), Kerb at 4.0 lb a.i./acre (50%) and Beacon at 0.0356 lb a.i./acre (19%). Percent control increased from the April 2 to the June 5 evaluation for both rates of Fusilade and the single rate of Envoy. Regrowth in the Rely, Vantage, Kerb and Beacon plots is indicated by decreased control for these treatments on the June 5 evaluation. New growth in the Rely plots looked healthy with good recovery, while plants in the Beacon plots remained stunted with no heading taking place.

Although control of bentgrass was 99 percent with Fusilade at 0.375 lb a.i./acre compared to 100 percent with Roundup Pro at 1.5 lb a.i./acre, the control was as near to 100 percent as possible at the June 5 evaluation. The difference being Fusilade activity was slower compared to the quick action of Roundup, and one or two small shoots per plot continued to have some life remaining in the Fusilade treated plots by the June 5 evaluation.

Table 1. Evaluation of herbicides on the percent reduction of biomass on Roundup Ready bentgrass and conventional bentgrass, near Madras, OR, 2002

	Percent Biomass Reduction			
	April 2, 2002		June 5, 2002	
Treatments (lb a.i./acre)	Roundup Ready	Conventional	Roundup Ready	Conventional
Roundup Pro	0.00 f[1]	99.0 a	0.00 f	100 a
Roundup Pro 1.5	0.00 f	98.3 a	0.00 f	100 a
Fusilade .375 + COC 1%	94.0 ab	94.3 ab	98.7 a	94.2 a
Fusilade .375 + COC 1% + R11 .05%	96.0 a	93.3 ab	99.0 a	86.7 ab
Fusilade .250 + COC 1% + R11 .05%	93.3 ab	93.3 ab	99.2 a	93.3 a
Fusilade .250 + COC 1%	86.7 abc	85.0 b	97.7 a	90.0 a
Envoy .250 + COC 1%	86.7 abc	90.0 ab	95.2 ab	89.7 a
Envoy .250 + COC 1% + R11 .05%	88.3 abc	88.3 ab	96.8 a	85.0 ab
Rely 1.5 + AMS 4.5	88.3 abc	88.3 ab	65.8 bcd	58.3 bc
Rely 1.5 + COC 1% + R11 .05%	83.3 bc	83.3 b	46.7 de	46.7 cd
Vantage .375 + COC 1% + R11 .05%	85.0 abc	85.0 b	59.2 cd	41.7 cde
Vantage .375 + COC 1%	76.7 c	70.0 c	78.3 abc	51.2 cd
Kerb 4.0	31.7 d	38.3 d	49.6 de	46.1 cd
Beacon .0356 + COC 1% + R11 .05%	20.0 e	30.0 de	15.0 f	15.0 ef
Beacon .0356 + R11 .05%	23.3 de	26.7 e	23.3 ef	23.3 def
Untreated	0.00 f	0.00 f	0.00 f	0.00 f

[1]Mean separation with LSD at $P \leq 0.05$.

EVALUATION OF FUNGICIDES FOR CONTROL OF POWDERY MILDEW IN KENTUCKY BLUEGRASS SEED PRODUCTION IN CENTRAL OREGON, 2002

M.D. Butler and C.K. Campbell

Fungicides have been evaluated yearly for control of powdery mildew in Kentucky bluegrass seed production fields in central Oregon since 1998. This year fungicides Laredo, Folicur, Tilt, Tilt plus Bravo, Stratego, and the numbered compound BAS500 were evaluated. During 2003 the objective was to compare fungicide performance under high disease pressure where multiple applications may be needed.

During 2002, fungicides were evaluated for control of powdery mildew in a commercial first-year field of 'Merit' Kentucky bluegrass grown for seed near Madras, Oregon. Tilt plus Bravo were applied as the first of multiple treatments, to be followed by various second and third applications. Other fungicides included for comparisons were Bayleton, Laredo, Folicur, Stratego, BAS500, and Tilt applied alone. Treatments were applied to 10-ft x 25-ft plots replicated four times in a randomized complete block design. Plots were treated on April 12, when the disease was well developed. Fungicides were applied with Tee Jet 8002 nozzles on a 9-ft, CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal of water/acre.

Plots were evaluated using a rating scale from 0 to 5, with 0 being no mildew present and 5 indicating total foliar coverage. Pretreatment evaluations were made on all plots on April 10. Post application evaluations were conducted on April 26 (14 days after treatment) and May 3 (22 DAT). As the spring progressed, it became evident that the field was heavily contaminated with an off type grass. At the end of April the grower cooperator and his seed contractor made the decision to take the field out. The field was sprayed with Roundup on May 2. As a result, follow-up applications could not be applied or evaluated.

All fungicide treatments significantly reduced powdery mildew 22 DAT compared to untreated plots (Table 1). There were no differences between the effectiveness of Stratego, Tilt, Laredo, Tilt plus Bravo, Folicur and Bayleton 22 DAT. However, all these materials were more effective than BAS500.

Table 1. Evaluation of fungicides applied May 12 on powdery mildew in Kentucky bluegrass, near Madras, OR, 2002.

Treatment	Rate	Evaluation date		
		April 10	April 26 (14 DAT)	May 3 (22 DAT)
		(Pretreatment)	(Post treatment)	
Untreated	----	3.3[1]	3.0 a[2]	5.0 a
Folicur	6 oz	2.8	2.1 bc	2.1 cd
Bravo + Tilt	16 oz + 4 oz	3.0	2.0 c	1.7 cd
BAS500	9 oz	2.8	2.6 ab	3.6 b
Stratego	10 oz	2.9	1.9 c	1.6 d
Tilt	4 oz	3.1	1.8 c	1.7 d
Laredo	8 oz	2.9	2.0 c	1.7 d
Bayleton	4 oz	2.7	2.1 bc	2.4 c
		NS		

[1]Rating scale was 0 (no mildew) to 5 (total leaf coverage).
[2]Mean separation with LSD at $P \leq 0.05$.

SEED CARROT ABOVE GROUND BIOMASS AND NUTRIENT ACCUMULATION FOR THE 2001/2002 GROWING SEASON

J.M. Hart and M.D. Butler

Abstract

A commercial field of Nantes hybrid carrots grown for seed near Madras, Oregon was sampled for nutrient uptake during the 2001-2002 growing season. Three feet of the outside female row was removed at ground level at four representative locations in the field. Total nitrogen accumulation was approximately 225 lb/a, total K was 175 lb/a and more than 12,000 lb/a of biomass was generated. Biomass accumulated rapidly from early June to late-July, with over three quarters of the total biomass production occurring during this time. Peak N uptake of 2.5 lb/a/day occurred in mid-June, at the beginning of flowering and the peak K uptake rate of 2 lb/a/day occurred a week earlier than peak N uptake.

Introduction

Central Oregon is the major hybrid carrot seed production area supplying the domestic fresh market carrot industry. Understanding nutrient requirements for carrots grown for seed is an important component in maximizing seed production and quality. The 2001-2002 growing season was the second year of the project having the objective to determine nutrient uptake of carrots grown for seed throughout the growing season.

Our hope is to provide growers information that will aid in making decisions about nutrient application and accumulate data that can be used in models that will be developed to predict nutrient need/supply.

Methods and Materials

Samples were collected from a commercial hybrid Nantes seed carrot field near Madras, Oregon by harvesting three feet of the outside female row at ground level from the fall of 2001 through the summer of 2002. Sampling dates were November 9, March 26, April 26, May 3, May 17, June 25, July 12, August 6, and September 20. Flags were place at four representative locations in the field and samples were collected near these flags. Samples were dried, weighed, and analyzed for N, P, K, S, Ca, Mg, S, B, Mn, Cu, and Zn.

A three-parameter sigmoid equation was used to describe biomass accumulation and nutrient uptake (Figure 1). The first derivative of the equation was taken to determine a rate function, dN/dt. An estimate of maximum time of biomass or nutrient accumulation can be estimated by plotting the rate function vs. sampling date (Figure 2).

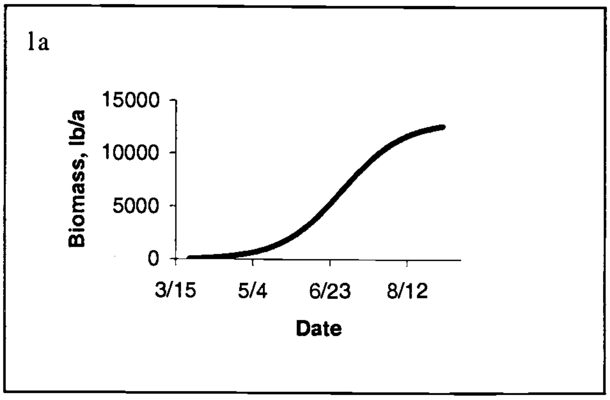
Results and Discussion

Average biomass and nutrient accumulation for each sampling date is presented in Table 1. The end of season biomass amount, 6 t/a is greater than the 4 t/a reported last year (Reference last year's seed report). The carrot variety was not the same each year and the expected primary reason for the difference in biomass accumulation. The peak nitrogen accumulation, approximately 225 lb/a, is consistent with the amount found in many other crops grown in the northwest (PNW 513). The peak or largest amount of nitrogen was measured before harvest and is also consistent with measurements made in other crops grown for seed. Lower leaves are shaded, senesce, and are sloughed by the plant. The cumulative effect is a measured loss of aboveground nitrogen accumulation.

Potassium accumulation, 175 lb/a, is less than the 200 lb/a measured last year. This measurement is curious since the biomass is so much larger this year than last year. The amounts of other nutrients reported in Table 1 are higher for the 2001/2002 growing season than for the 2000/2001 season. This trend is logical and consistent with the biomass production.

Table 1. Average above ground biomass and nutrient accumulation of Nantes hybrid carrots grown for seed in central Oregon. Carrot seed was planted in 2001 and harvested in 2002.

Sampling date	Biomass accumulation	Nutrient accumulation N	P	K	S	Ca	Mg	B	Zn
	(lb/a)								
Nov 19	420	15	1	9	2	6	2	0.02	0.01
Mar 26	574	15	2	7	1	7	2	0.02	0.02
Apr 26	452	16	2	11	2	8	3	0.02	0.03
May 3	1151	45	5	33	6	26	9	0.06	0.07
May 17	958	30	3	21	3	17	6	0.04	0.04
Jun 25	5434	149	17	121	18	88	27	0.23	0.19
Jul 12	7292	158	19	122	21	106	31	0.28	0.21
Aug 6	12096	225	29	175	36	192	52	0.48	0.35
Sep 15	12070	211	28	136	33	209	54	0.54	0.36



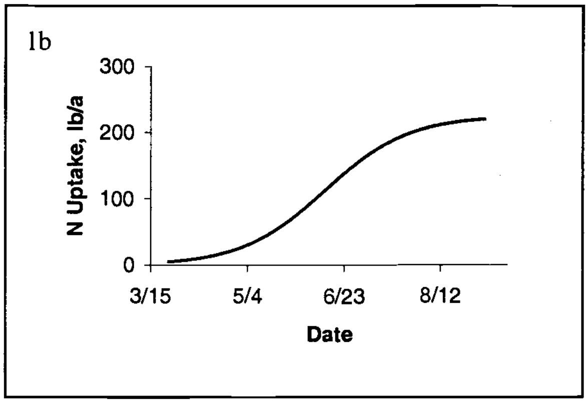


Figure 1. Total biomass and nitrogen accumulation for Nantes hybrid carrots produced for seed in 2001/2002 growing season.

Biomass: Seed carrots grow slowly in the fall and spring, producing only 500 to 1000 lb biomass/a by late April or early May (Figure 1a). From early to mid-June through mid to late-July, the growth is rapid and linear, accounting for two-thirds to three-fourths of the total biomass. Less than 20 percent of the biomass is produced after late-July in 2002. Peak biomass production of 150 to 200 lb/a/day occurs in late June. Growth of carrots for seed slows after seed set. Compared to the previous growing season, seed carrot growth in the 2001/2002 season began earlier, had a lower peak rate, and continued growing later. The peak growth time, mid to late-June was the same in both years. Growth Degree Days (data not shown) were comparable for both seasons. Slight hail damage in occurred in late May of the 2000/2001 season. The hail damage might contribute to the apparent slower early season growth, sharp increase in growth during June, and peak growth rate of more than 200 lb/a/day. Even with consideration of the hail-influenced growth in 2000/2001, the primary reason for the growth dissimilarity measured is expected to have been from varietal difference.

Nutrients: N uptake is rapid during May and June, essentially complete by early August, approximately 5 to 6 weeks before harvest (Figure 1b). The amount of N taken up by carrots grown for seed is variety dependent, primarily a function of biomass production. Total N uptake was approximately 175 lb N/a the 2000/2001 growing season and approximately 225 lb/a in the 2001/2002 growing season.

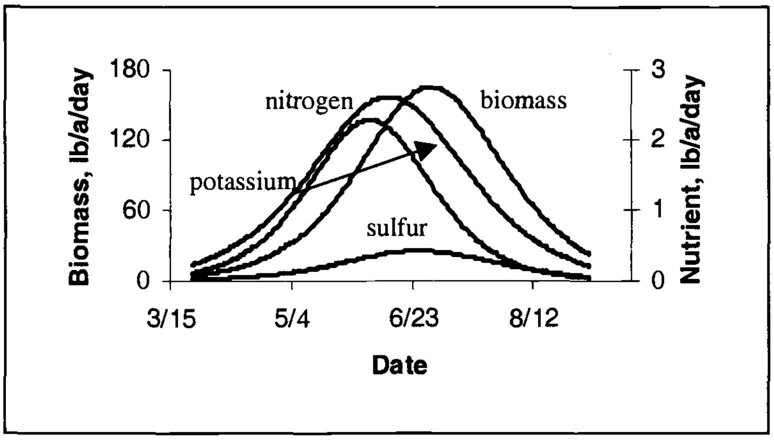


Figure 2. Daily accumulation of biomass, nitrogen, potassium, and sulfur for Nantes hybrid carrots grown for seed 2001/2002 growing season.

Peak N uptake of 2.5 to 3.5 lb/a/day occurred in mid to late-June both years. The peak N uptake rate occurs as bloom is beginning and before bees are placed in the field. The maximum biomass production was estimated to occur one to two weeks after the maximum rate of N accumulation was achieved.

The peak uptake rate of potassium and sulfur preceded the peak production of biomass in the 2001/2002 growing season. During the 2000/2001 growing season, the potassium uptake rate was 2 lb/a/day more than N, but less than N in the 2001/2002 growing season.

Management: After seed set, nutrient uptake decreases rapidly as seed carrots enter Phase III growth, redistribution of nutrients. Nutrients should be supplied well in advance of need, early to mid-May at the latest. If sufficient nutrients are supplied during the early growing season, late season applications are not efficient or effective. Some N should be applied in mid- to late-April to support early growth. The bulk of the N is accumulated during June. A combination of available soil and fertilizer N totaling 150 to 200 lb/a seems a logical rate. Seed carrots grown in central Oregon are often planted in fields where Kentucky bluegrass seed was produced. Decomposition of perennial grass sod in the Willamette Valley provides a substantial amount of N to a warm season crop that follows. Even though 200 lb/a N is used by a carrot seed crop, it may be produced with the application of half or less that amount.

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Business Address

Oregon Seed Council
1193 Royvonne, S., Suite 11
Salem, OR 97302

Tel: (503) 585-1157
FAX: (503) 585-1292
E-mail: dlnassoc@aol.com

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