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The following authors have contributed to this report.

Central Oregon Agriculture and Research Center

C.K. Campbell, Faculty Research Assistant

Columbia Basin Agricultural Research Center

D.A. Ball, Professor, Weed Science
L.H. Bennett, Faculty Research Assistant
S.M. Frost, Faculty Research Assistant

Cooperative Extension Service – OSU

S. Aldrich-Markham, Extension Agent, Yamhill County
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 Botany and Plant Pathology

L.B. Coop, Assistant Professor/Senior Research
C.M. Ocamb, Associate Professor and Extension Plant Pathologist

Department of Crop and Soil Science – OSU

R.P. Affeldt, Faculty Research Assistant
B.D. Brewster, Former Senior Instructor, Weed Science
T.G. Chastain, Associate Professor, Seed Crop Physiology
N.W. Christensen, Professor, Soil Fertility
C.M. Cole, Faculty Research Assistant
J.B. Colquhoun, Assistant Professor and Extension Weed Control Specialist
G.C. Fisher, Professor, Field Crop Entomology
C.J. Garbacik, Senior Faculty Research Assistant
J.M. Hart, Professor and Extension Soil Scientist
C.M. King, Graduate Research Assistant
C.A. Mallory-Smith, Professor of Weed Science
K.D. Orthel, Graduate Research Assistant
S. Rao, Assistant Professor, Entomology
D.D. Schumacher, Graduate Research Assistant
T.B. Silberstein, Senior Faculty Research Assistant
W.C. Young III, Professor and Extension Agronomist
M.L. Zapiola, Graduate Research Assistant

Department of Horticulture

R.E. Peachey, Senior Faculty Research Assistant

Eastern Oregon University

G.L. Kiemnec, Soil Scientist, EOU-OSU Agriculture Program, LaGrande

National Forage Seed Production Research Center - USDA-ARS

S.C. Alderman, Professor and Research Plant Pathologist
J.C. Baldwin, Plant Molecular Biologist
G.M. Banowetz, Research Microbiologist and Research Leader
R.E. Barker, Professor and Research Geneticist
R.N. Brown, Research Associate
J.E. Dombrowski, Assistant Professor and Research Plant Molecular Geneticist
L.F. Elliott, Former Research Microbiologist
H.M. El-Nashaar, Research Associate
S.M. Griffith, Assistant Professor and Research Plant Pathologist
G.W. Mueller-Warrant, Associate Professor and Research Agronomist
W.F. Pfender, Professor and Research Plant Pathologist
J.J. Steiner, Professor and Research Agronomist
G.W. Whittaker, Research Hydrologist

Other

A. Boateng, Research Chemical Engineer, USDA-ARS Eastern Regional Research Center, Wyndmoor, PA
J.L. Carroll, Agronomy Field Representative, CHS, Madras, OR
R.P. Crockett, Technical Development Manager, Monsanto Co., Vancouver, WA
C.R. McNeal, Field Representative, Blue Mt. Seeds, Inc., Imbler, OR
B.M. Quebbeman, Crop Consultant, Quebbeman's Crop Monitoring, LaGrande, OR
S. Sedegui, Plant Pathologist, Oregon Dept. of Agriculture, Salem, OR
S.E. Warnke, Research Plant Geneticist/Physiologist, USDA-ARS National Arboretum, Washington, DC
L.L. Welch, Research Specialist, Valent USA Corp., Hood River, OR

SPRING IRRIGATION MANAGEMENT OF PERENNIAL RYEGRASS SEED PRODUCTION IN THE WILLAMETTE VALLEY

C.M. King, T.G. Chastain, C.J. Garbacik and W.C. Young III

Introduction
Until recently, the majority of perennial ryegrass grown in the Willamette Valley was produced under dry land conditions. This is in part due to a lack of irrigation availability, but more prominently due to the fact that older varieties of perennial ryegrass matured in advance of drought stress. Increasing numbers of later maturing varieties, and increasing availability of irrigation, has prompted research of spring irrigation management of perennial ryegrass in the Willamette Valley.

Drought stress during certain periods of reproductive development has a negative impact on the yield of grass seed. In Oregon, sudden onset of warm dry weather can occur during the spring, and is more likely to coincide with reproduction in later maturing varieties. Irrigation to alleviate plant stress during reproductive development in the spring may substantially increase yields in perennial ryegrass. This study was designed to evaluate perennial ryegrass yield response to spring irrigation treatments.

Our objectives include: (i) determine crop water use and water use efficiency of both irrigated and non-irrigated perennial ryegrass varieties; (ii) observe water use differences as a result of cultivar differences in perennial ryegrass; (iii) compare seed yield and seed yield components of different varieties within irrigated and non-irrigated treatments; (iv) determine appropriate timing and amount of irrigation to apply if it is revealed that irrigation enhances yield.

Procedure
Field Studies
Six cultivars of perennial ryegrass were selected for this experiment ('Caddieshack,' 'Cutter,' 'Derby Supreme,' 'CIS-PR85,' 'Pirouette,' and 'SR4500'). All cultivars were planted May 2002 at Hyslop Research Farm, Corvallis, Oregon.

An Acre Master® linear irrigation system provided by Pierce corporation was used to apply irrigation in three treatments: no irrigation, a series of irrigation treatments to fill the soil profile once, and scheduled irrigation treatments to maintain a soil water content above 50 mm deficit from field capacity. Soil volumetric water content was measured weekly and sometimes biweekly to schedule irrigation and monitor plant water use. Horizontally installed time domain reflectometry (TDR) probes were utilized for these purposes.

Spring tiller and spike samples were taken to observe differences in fertile tiller and seed yield components between varieties and treatments. Grass was swathed at 35% moisture content, and combined at 12%. Seed was cleaned prior to dry weight yield analysis, and sub-samples were hand cleaned to analyze 1000 seed weight.

Progress
In 2003, four inches of combined irrigation was applied to fill the profile once, and five inches to maintain minimal soil water deficit, respectively. Preliminary results provide substantial evidence that irrigation increased seed yield (Table 1). Yield response to applied water was different among cultivars and irrigation treatments. Filling the profile once resulted in yield increases ranging from 231-373 lb/a. Whereas maintaining a minimal deficit caused seed yield increases ranging between 294-475 lb/a respectively. Despite observed differences in yield between varieties, no irrigation cultivar interaction was observed. Therefore, differences in yield increase between cultivars can be attributed to innate genetic differences.

Table 1. Effect of spring irrigation and cultivar on seed yield, seed weight, and seed number of perennial ryegrass in 2003.

Treatment	Cultivar	Seed yield	1000 seed wt.	Seed number
		(lb/a)	(g/1000)	(no./sq ft)
Control	Cutter	1523	1.85	8545
	Pirouette	1803	1.52	12290
	Derby Supreme	1260	1.81	7219
	SR 4500	1493	1.63	9496
	Caddieshack	1618	1.68	9987
	CIS PR-85	1396	1.47	9877
Profile filled	Cutter	1895	1.94	10149
	Pirouette	2035	1.62	13039
	Derby Supreme	1526	1.90	8364
	SR 4500	1867	1.80	10777
	Caddieshack	1956	1.75	11609
	CIS PR-85	1655	1.51	11340
Maintained	Cutter	1965	2.00	10179
	Pirouette	2208	1.64	13966
	Derby Supreme	1554	1.93	8340
	SR 4500	1921	1.75	11426
	Caddieshack	2093	1.81	12009
	CIS PR-85	1832	1.61	11843

From 2003 results, spring irrigation significantly increased seed yield in perennial ryegrass. Increased seed weight and number were the seed yield components responsible for the observed increases in seed yield. The relative contribution of these two components to yield increases for the six cultivars are expressed as a percentage of the non-irrigated control (Table 2).

Table 2. Difference in seed yield, seed weight, and seed number expressed as a percentage of non-irrigated and moisture maintained treatments in perennial ryegrass.

Cultivar	Seed yield	1000 seed wt.	Seed number
	------------------(%)------------------		
Cutter	29.0	8.5	19.1
Pirouette	22.4	7.6	13.6
Derby Supreme	23.3	6.6	15.5
SR 4500	28.6	6.9	20.3
Caddieshack	29.3	7.6	20.2
CIS PR-85	31.2	9.7	19.9

In 2004, approximately four inches of combined irrigation was applied to the profile filled treatment, and nine inches to maintain soil moisture, respectively. Water deficit had reached 50 mm below field capacity on 8 April 2004. In 2003, the same deficit did not occur until 29 May. With respect to 1000 seed weight, seed number, and yield, all cultivars responded differently to irrigation providing a significant cultivar by irrigation interaction. All cultivars in 2004 responded positively to irrigation with respect to seed yield and 1000 seed weight. Seed number was increased in all but one cultivar under irrigation. Yield increase in irrigated vs. non-irrigated treatments ranged between 65 to 342 lb/a (Table 3). As with 2003, yield increase associated with irrigation was a result of differences in seed number and seed weight. The relative contribution of these two components is summarized in Table 4.

Summary

Irrigation improved perennial ryegrass seed yield in both years of the study. In 2003 no cultivar by irrigation interaction was observed while an interaction was observed in 2004. Environmental conditions could be responsible partially responsible for the observed interaction. Regardless, spring irrigation of perennial ryegrass seed production is beneficial. Timing of irrigation should focus on alleviation of water deficit from the onset of anthesis to the end of seed fill. A series of irrigation to fill the soil profile once at Hyslop farm (approximately 3.75 inches) was sufficient to achieve these results and increase seed yield. A sandy soil with lower water holding capacity may need to receive more frequent irrigation, but at reduced rates.

Table 3. Effect of spring irrigation and cultivar on seed yield, seed weight, and seed number of perennial ryegrass in 2004.

Treatment	Cultivar	Seed yield	1000 seed wt.	Seed number
		(lb/a)	(g/1000)	(no./sq ft)
No irrigation	Cutter	1392	1.69	8592
	Pirouette	1376	1.49	9593
	Derby Supreme	1641	1.76	9687
	SR 4500	1263	1.59	8289
	Caddieshack	1407	1.57	9358
	CIS PR-85	1378	1.44	9954
Irrigation	Cutter	1568	1.87	8745
	Pirouette	1706	1.62	10958
	Derby Supreme	1706	1.87	9500
	SR 4500	1498	1.71	9107
	Caddieshack	1749	1.75	10425
	CIS PR-85	1632	1.54	11023

Table 4. Difference in seed yield, seed weight, and seed number expressed as a percentage of no irrigation and irrigation in six cultivars of perennial ryegrass in 2004.

Cultivar	Seed yield	1000 seed wt.	Seed number
	------------------(%)-------------------		
Cutter	12.6	10.6	1.8
Pirouette	24.0	8.4	14.2
Derby Supreme	4.0	6.1	-1.9
SR 4500	18.6	7.9	9.9
Caddieshack	24.4	11.6	11.4
CIS PR-85	18.4	7.2	10.7

Acknowledgments:
The authors wish to thank Pierce Corporation (Eugene, Oregon) and Nelson Corporation (Walla Walla, Washington) for their donation of the irrigation system.

SPRING IRRIGATION MANAGEMENT OF TALL FESCUE SEED CROPS IN THE WILLAMETTE VALLEY

K.D. Orthel, T.G. Chastain, C.J. Garbacik and W.C. Young III

Introduction
In recent years, Willamette Valley tall fescue seed production has shifted to areas that have the capability to apply irrigation to the traditionally dryland crop. This has occurred in parallel with a shift by breeders toward later maturing cultivars. Yields of irrigated crops have been reported by growers to increase by up to three hundred pounds per acre when compared to non-irrigated production. Growers, prompted by these circumstances, have inquired about water needs for tall fescue seed crops.

Research indicates that the plant component in most active development at the point of stress will be most adversely affected. In the Willamette Valley, winter and spring rains provide ample moisture for early grass growth and development. However, cultivars are exposed to drought during critical periods of the grasses' reproductive life cycle, specifically from anthesis through seed fill. Therefore, it would be plausible to assume a reduction in seed number and potentially seed weight as a result of the stress.

The objectives of this study were to: (i) measure the impact spring irrigation has on seed yield components of tall fescue seed crops; (ii) develop spring irrigation management practices for Willamette Valley seed producers; and (iii) determine if response to irrigation treatments is cultivar dependant.

Procedure
A field study was established in 2002 at Hyslop Research Farm, Corvallis, Oregon to elucidate the effects of spring irrigation on tall fescue seed crops. The trial was arranged in a strip plot design with four replications of plots that measured 10 by 50 feet.

Three irrigation regimes were applied to six cultivars of tall fescue ('Arid 3', 'Barrington', 'Bingo', 'Fawn', 'Velocity', and 'SR8600'). A control treatment which received no irrigation was compared to a single application to fill the soil profile to field capacity just prior to peak anthesis and a series of applications which maintained the soil at or above a deficit of 50 mm until peak anthesis. Soil moisture was measured with time domain reflectrometry (TDR) probes in all treatments in three of the replicates and two of the varieties ('Velocity' and 'Arid 3'). TDR wave guides were placed at 6-, 12-, 18- and 24- inch depths in the root zone.

Irrigation was supplied through a custom-designed Pierce Corporation AcreMaster Linear (Eugene, Oregon) equipped with minimal drift Nelson Corporation (Walla Walla, Washington) sprinklers.

Seed yield components, including floret, spikelet and fertile tiller number, panicle length, total biomass and reproductive biomass were determined on tiller samples collected prior to anthesis.

Plots were harvested with a small plot swather and combine. Representative yield samples were conditioned and percent clean out was used to report marketable yield. Thousand seed weights were measured on clean seed.

Climatic Conditions and Irrigation
The 2003 and 2004 growing seasons contrasted sharply in weather conditions leading up to harvest. In 2003, the growing season was wet during the first half (April rainfall was 216% of normal) and dry during the second half (54 and 21% of normal for May and June, respectively). This corresponded with reduced soil water beginning near the onset of anthesis. The 2004 season was characterized by alternating periods of wet and dry (45, 94, 68 and 122% of normal for March, April, May and June, respectively). Soil water declined earlier in 2004 and was being drawn down during culm elongation through seed fill in non-irrigated plots.

Both irrigated treatments received 78 mm of water between June 4 and June 8 in 2003. In 2004, the single treatment received 112 mm of water between May 24 and May 31. The maintained treatment received 172 mm of water between April 28 and May 31.

Results
Panicle number and characteristics were not affected by the increase in available water. Panicle length, panicle biomass and spikelets per panicles were cultivar dependent in both years (data not shown).

For seed yield, a cultivar by irrigation interaction existed in both years. In 2003, cultivars had varying but positive responses to irrigation (Table 1). Irrigation increased yield by 28% across all cultivars. The range of yield increase was from 13% ('Velocity') to 39% ('Bingo'). Across cultivars, seed yields averaged 1695 lb/acre under irrigation while non-irrigated yields averaged 1325 lb/acre.

In 2004, 'Velocity' was unresponsive to irrigation while the remaining cultivars had increased yield with irrigation. Yields were increased by 11% each for the single irrigation treatment and maintained treatment, respectively. Across cultivars, seed yields averaged 1804 lb/acre without irrigation while the single treatment yielded 1999 lb/acre and the maintained treatment yielded 2006 lb/acre.

Seed weight was dependant on cultivar and irrigation treatment in both years. In the first year, seed number was dependant on cultivar and irrigation, but was not influenced by irrigation in 2004 (Table 1). Increases in seed weight were most likely due to a slight extension of the seed fill period in irrigated plants. Increases in seed number could be due to a reduction in seed abortion, a shift towards higher seed weight or an increase in assimilates available for seed fill. In both years, the relative contribution of seed weight or seed number to the yield increase depended on cultivar.

The difference in seed yield between irrigated and non-irrigated tall fescue cultivars was greatest in 2003 when less precipitation was received during anthesis and seed fill. In 2004, the lack of yield increase in the maintained treatment over the single treatment indicates that the single treatment provided water at a critical point of tall fescues' reproductive development. Precipitation coincided with anthesis and the single irrigation treatment (Figure 1) minimizing the yield response to irrigation.

Conclusions:
Variability exists among tall fescue cultivars for response to spring irrigation. Increases of seed number are critical to improving yields of tall fescue as greater yield responses were observed when irrigation increased seed number. Findings indicate water availability is critical in tall fescue during seed fill. Maintaining soil moisture at a level that prevents stress did not provide any additional benefits to a well-planned irrigation just prior to seed fill. Therefore, irrigation should be timed to provide water at the beginning of seed fill in tall fescue seed crops.

Acknowledgments:
The authors wish to thank Pierce Corporation (Eugene, Oregon) and Nelson Corporation (Walla Walla, Washington) for their donation of the irrigation system.

Table 1. Influence of irrigation treatment, cultivar and year on seed yield, weight and seed number. Percent increase over non-irrigated plots is reported for each irrigation treatment and cultivar.

	Seed yield					1000 seed weight					Seed number per m^2				
Cultivar	None	Single		Moisture maintained		None	Single		Moisture maintained		None	Single		Moisture maintained	
	(lb/a)	(lb/a)	(%)	(lb/a)	(%)	(g)	(g)	(%)	(g)	(%)	(no. x 10^4)	(no. x 10^4)	(%)	(no. x 10^4)	(%)
2003															
Arid 3	1318	1679	27	1622	23	2.456	2.566	5	2.582	5	6.02	7.33	22	7.05	17
Barrington	1325	1718	30	1893	43	2.355	2.492	6	2.492	6	6.31	7.73	23	8.53	35
Bingo	1527	2132	40	2094	37	2.323	2.379	2	2.446	5	7.37	10.09	37	9.61	30
Fawn	775	1138	47	866	12	3.115	3.264	5	3.306	6	2.79	3.91	40	2.71	-3
Velocity	1394	1606	15	1547	11	2.520	2.586	3	2.565	2	6.20	6.96	12	6.76	9
SR8600	1613	2047	27	1990	23	2.368	2.458	4	2.439	3	7.64	9.34	22	9.16	20
Mean	**1325**	**1720**	**30**	**1669**	**26**	**2.523**	**2.624**	**4**	**2.638**	**5**	**6.05**	**7.56**	**25**	**7.30**	**21**
2004															
Arid 3	1612	1741	8	1774	10	2.352	2.451	4	2.414	3	7.70	7.96	3	8.40	9
Barrington	1234	1491	21	1650	34	2.243	2.296	2	2.323	4	6.17	7.28	18	7.99	29
Bingo	2033	2301	13	2279	12	2.262	2.311	2	2.334	3	10.06	11.19	11	10.96	9
Fawn	1847	2104	14	2054	11	3.228	3.247	1	3.162	- 2	6.42	7.27	13	6.95	8
Velocity	1907	1849	- 3	1728	-8	2.344	2.449	4	2.405	3	9.12	8.45	- 7	8.05	- 12
SR8600	2184	2510	15	2548	17	2.237	2.290	2	2.262	1	10.95	12.27	12	12.62	15
Mean	**1804**	**1999**	**11**	**2006**	**11**	**2.444**	**2.507**	**3**	**2.483**	**2**	**8.40**	**9.07**	**8**	**9.16**	**9**

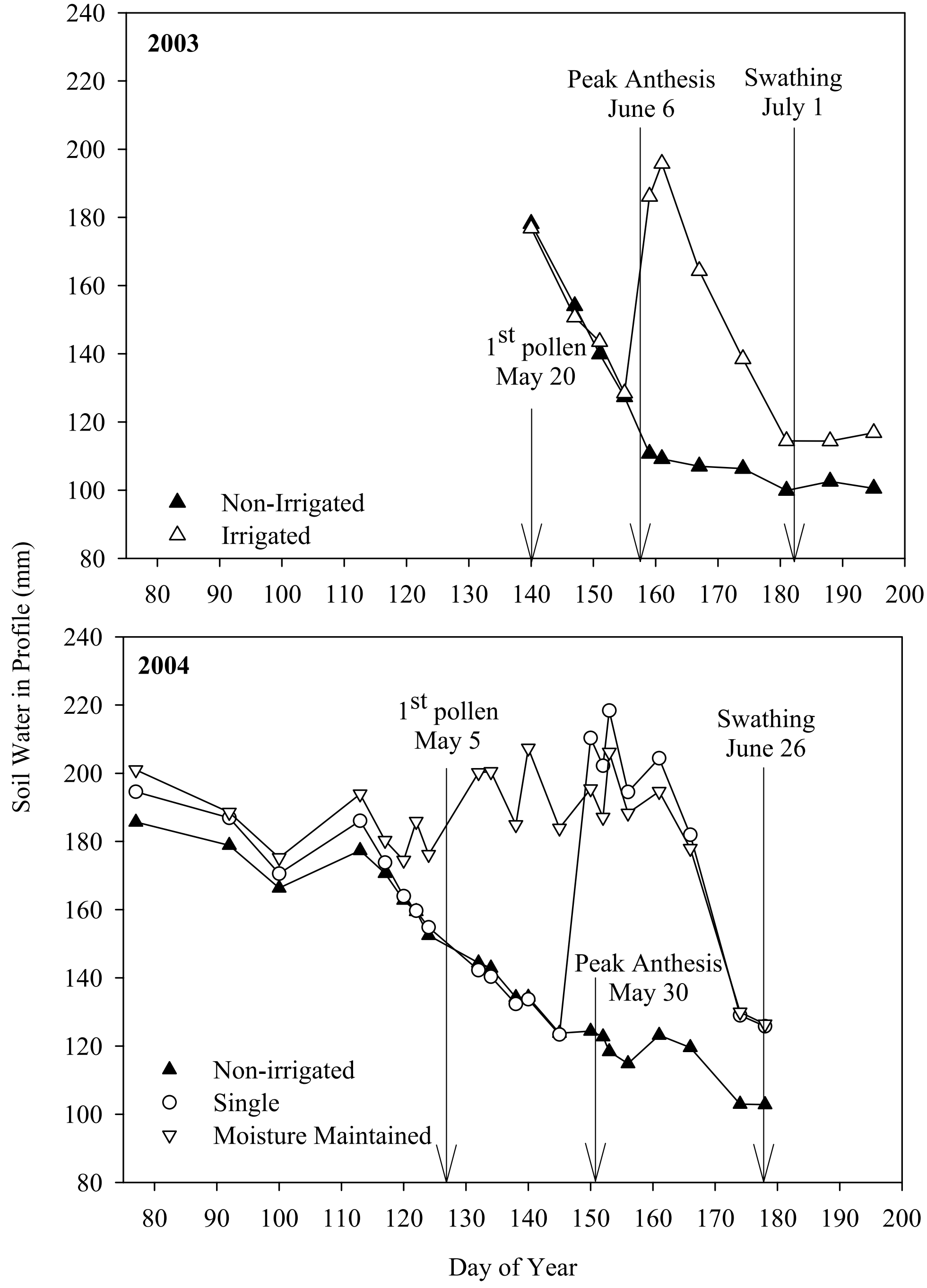

Figure 1. Soil water in profile (mm) for 2003 and 2004. Values are averaged across cultivars 'Velocity' and 'Arid 3'. In 2003, irrigated treatments were pooled for presentation.

THE EFFECT OF FUNGICIDES ON SEED YIELD AND ECONOMIC RETURNS IN PERENNIAL RYEGRASS

G.A. Gingrich and M.E. Mellbye

Introduction

Stem rust can be a serious disease in many grass seed fields in the Willamette Valley. Severity and subsequent impact on seed yields depend on weather patterns, the variety being grown and the age of the stand. In addition to reducing seed yields and potential income control measures cost millions of dollars annually. The two species most impacted are perennial ryegrass and tall fescue. It is estimated that approximately $13 million was spent in 2004 on rust control in these two species alone. The following list shows the criteria used to estimate costs during the 2004 crop year.

Perennial ryegrass
- 177,600 acres
- 2.25 average applications/yr (1 to 4/yr)
- $22.50/a - estimated cost per application
- $8,991,000 - approximate total annual cost

Tall fescue
- 142,000 acres
- 1.2 average applications/yr (0 to 2/yr)
- $23.00/a - estimated cost per application
- $3,919,000 - approximate total annual cost

This study was conducted to determine the effect various fungicide applications had on seed yields of perennial ryegrass (Table 2). In addition, an economic analysis of the costs and returns associated with each treatment was conducted (Tables 1 & 3). The level of rust in most fields with susceptible varieties in 2004 was considered to be a fairly heavy rust pressure year.

Methods

The data for this report was obtained from two large scale, on-farm yield trials conducted on first year turf type perennial ryegrass fields. One site was located in the Gervais area (var. Paragon) and the other one in the Talbot area (var. Extreme). Fungicides used were:

Propiconazole (Tilt 428 GS)
Chlorothalonil (Echo)
Azoxystrobin (Abound)
Pyraclostrobin (Headline)
Azoxystrobin + Propiconazole premix (Quilt)
Trifloxystrobin + Propiconazole premix (Stratego)*
*at printing Stratego had not yet received a label for use on grass seed crops

Fungicide applications were made using an ATV mounted sprayer with a 20 ft boom equipped with TeeJet 11002 VS nozzles at 30 psi calibrated to apply 15 gpa. Crop oil concentrate (COC) at 0.5% vv was added to each fungicide treatment. Plots were arranged in a randomized complete block design with three replications. Individual plot size was 24 feet wide x 300 to 400 feet long to allow harvest using grower equipment. A weigh wagon was used to measure seed yields from each plot. Sub-samples of the harvested seed from each plot were collected to determine 1000 seed weight, percent cleanout and calculate total clean seed yields.

Results

Weather conditions in 2004 led to early rust development in many fields and high rust pressure by harvest time. At both locations three fungicide applications were made to provide effective rust control. All treatments provided acceptable rust control when compared to the untreated check. The treatment that did not include a strobilurin product gave the lowest seed yield increase compared to treatments that included a strobilurin fungicide.

Table 2 provides details on the rust infection levels, seed yield data and seed quality data for each treatment. At both locations fungicide applications gave significantly higher seed yields than did the untreated checks. A visual evaluation of rust infestation just prior to swathing also shows high levels of rust in the check plots and excellent rust control in all fungicide treated plots. All treatments provided a significant seed yield increase over the untreated check.

The percent cleanout was considerably greater in the seed harvested from the untreated plots at both locations and significantly higher at the south valley site. Seed quality appears to be improved by controlling rust in that the 1000 seed weight from the untreated plots at each location was significantly lower than seed in the treated plots.

Fungicide applications increased seed yields 440 to nearly 700 lb/a depending on the location and treatment. At both locations the highest seed yield was obtained from the treatment program that started with Headline. However, at neither location did this early Headline treatment increase seed yields significantly higher than the best of the other treatments in the trials. More studies should be conducted to further evaluate the benefit of the early strobilurin treatments on plant health and seed yield response.

All fungicide products provided acceptable rust control at the application rates used in this trial. This study demonstrates that the dollars spent for rust control will be recovered several times over. The use of lower rates may not provide the control desired or may require additional applications to obtain effective control for the entire season.

An economic analysis of costs and benefits to controlling rust in these trials was also conducted. In every case there was a significant positive economic benefit to the rust control treatments made at each location. The return to each dollar spent for rust control ranged from $3.02/a to a high of $5.41/a at the two field locations used in 2004.

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Appreciation is extended to BASF, Bayer CropProtection and Syngenta for their support of these OSU Extension Service fungicide trials. We also express our appreciation to the growers who allowed us to use their fields for the trials and assisted with seed harvest.

Table 1. Treatment table: fungicide application rates, timings, and costs, 2004

	Application dates and rates (product/acre)			
Treatments	First application (5/21/04) Boot stage to early heading	Second application (6/11/04) Full heading to early anthesis	Third application (6/23/04) Late anthesis to early seed fill	Total Cost ($/a)
Tilt sequence	Tilt 6 oz. + Echo 1 pt	Tilt 6 oz.	Tilt 6 oz.	$64.23
Abound sequence	Tilt 6 oz. + Echo 1 pt	Abound 9 oz.	Abound 9 oz.	$69.85
Headline sequence	Tilt 6 oz. + Echo 1 pt	Headline 9 oz.	Headline 9 oz.	$69.85
Quilt sequence	Tilt 6 oz. + Echo 1 pt	Quilt 17.50 oz.	Quilt 17.50 oz.	$68.95
Stratego sequence	Tilt 6 oz. + Echo 1 pt	Stratego 12 oz.	Stratego 12 oz.	$66.57
Headline early sequence	Headline 9 oz.	Headline 9 oz.	Tilt 6 oz.	$64.45

Note: Applications with 1/2% COC, 30 psi, 15 gpa.
Varieties: Extreme, first seed crop (Linn Co.) and Paragon, first seed crop (Marion Co.)
Cost includes products and application @ $5.50/acre.

Tilt	$285/gal	$13.36/a @ 6 oz/a
Abound	$230/gal	$16.17/a @ 9 oz/a
Headline	$230/gal	$16.17/a @ 9 oz/a
Quilt	$115/gal	$15.72/a @ 17.5 oz/a
Stratego	$155/gal	$14.53/a @ 12 oz/a
Echo	$43/gal	$5.40/a @ 1 pt/a
COC @ 1/2%	$10.00/gal	$2.25/a for 3 applications

Table 2. The effect of fungicides on stem rust severity and seed yield of turf type perennial ryegrass on two Willamette Valley fields, in a year of severe late season rust pressure, 2004.

Treatments	North Valley – Gervais area (var. Paragon) Rust (7/1/04)	Seed yield	Clean-out	1000 seed wt.	South Valley – Talbot area (var. Extreme) Rust (7/5/04)	Seed yield	Clean-out	1000 seed wt.	Two-site average seed yield
	(%)	(lb/a)	(%)	(g)	(%)	(lb/a)	(%)	(g)	(lb/a)
Untreated Check[1]	85	963	6.1	1.42	60	1279	25.0	1.65	1121
Fungicide treatments									
Tilt sequence	10	1537	3.9	1.56	5	1718	20.9	1.79	1628
Abound sequence	6	1566	3.4	1.70	0.2	1754	19.4	1.81	1660
Headline sequence	5	1578	3.8	1.62	2	1808	20.3	1.79	1693
Quilt sequence	6	1620	3.9	1.63	1	1801	19.9	1.88	1711
Stratego sequence[2]	6	1609	4.0	1.62	1	1725	20.2	1.87	1667
Headline early sequence	6	1652	3.5	1.67	5	1873	19.5	1.82	1763
LSD (0.05)	5	85	NS	0.11	6	187	1.5	0.07	-

[1] The check was harvested as one strip and not included in statistical analysis for seed yield.
[2] Stratego did not have a label for use in grass seed crops when this report went to press.

Table 3. An economic comparison of the net return above product and application costs from fungicide treatments on two perennial ryegrass seed fields, Willamette Valley, 2004.

Treatments Fungicide	North Valley Cost	Seed yield	Added seed	Net return	Return per $ invested	South Valley Seed yield	Added seed	Net return	Return per $ invested	Two-site average net return
	($/a)	(lb/a)	(lb/a)	($/a)	($)	(lb/a)	(lb/a)	($/a)	($)	($/a)
Untreated Check	0	963	0	$0.00	$0.00	1279	0	$0.00	$0.00	$0.00
Tilt seq.	$64.23	1537	574	$280.17	$4.36	1718	439	$199.17	$3.10	$239.67
Abound seq.	$69.85	1566	603	$291.95	$4.18	1754	475	$215.15	$3.08	$253.55
Headline seq.	$69.85	1578	615	$299.15	$4.28	1808	529	$247.55	$3.54	$273.35
Quilt seq.	$68.95	1620	657	$325.25	$4.72	1801	522	$244.25	$3.54	$284.75
Stratego seq.	$66.57	1609	646	$321.03	$4.82	1725	446	$201.03	$3.02	$261.03
Headline early seq.	$64.45	1652	689	$348.95	$5.41	1873	594	$291.95	$4.53	$320.45

PRELIMINARY EVALUATION OF THE EFFECTIVENESS OF THE USDA RUST MODEL ON PERENNIAL RYEGRASS IN 2004

G.A. Gingrich, M.E. Mellbye, W.F. Pfender and L.B. Coop

Introduction

Stem rust can be a serious disease in many grass seed fields in the Willamette Valley. The two species most impacted are perennial ryegrass and tall fescue. Uncontrolled rust infections can cause significant seed yield losses in fields of both species. Each year millions of dollars are spent to control rust. In 2004 it is estimated that approximately $13 million was spent on rust control programs in these two species alone. Timely applications of fungicides are critical in obtaining effective control and keeping application costs to a minimum.

One objective of this study was to determine the effectiveness of fungicide applications applied according to information provided by the USDA Rust Model in comparison to traditional application sequences. In addition an economic analysis of the costs and returns associated with fungicide applications was conducted.

Methods

The data for this report were obtained from two large scale, on-farm yield trials conducted on first year turf type perennial ryegrass fields. One site was located in the Gervais area (var. Paragon) and the other one in the Talbot area (var. Extreme). A weather station was installed prior to the rust season either in the field or near by the field where the two trials were located. Data from the weather station were used to determine potential rust infection initiation and severity, and fungicide timing for the "rust model treatment" was determined using the USDA Rust Model.

Fungicides used were:

Propiconazole (Tilt 428 GS)
Chlorothalonil (Echo)
Azoxystrobin (Abound)
Pyraclostrobin (Headline)
Azoxystrobin/Propiconazole (Quilt)
Trifloxystrobin/Propiconazole (Stratego)*

*at printing Stratego had not yet received a label for use on grass seed crops

Fungicide applications (Table 1) were made using an ATV mounted sprayer with a 20 ft boom equipped with TeeJet 11002 VS nozzles at 30 psi calibrated to apply 15 gpa. Crop oil concentrate (COC) at 0.5% vv was added to each fungicide treatment. Plots were arranged in a randomized complete block design with three replications. Individual plot size was 24 feet wide x 300 to 400 feet long to allow harvest using grower equipment. A weigh wagon was used to measure seed yields from each plot. Sub-samples of the harvested seed from each plot were collected to determine 1000 seed weight, percent cleanout and calculate total clean seed yields.

Results

The level of rust in most fields of susceptible varieties was considered to be fairly heavy in 2004. All treatments resulted in significant seed yield increases over the untreated check.

Seed yield from the rust model treatment, in which fungicide application timing was based on the USDA Rust Model, was similar to seed yields from most of the other fungicide treatments in the experiment (Table 2). Although yield from the model-assisted treatment was significantly less than the highest-yielding treatment in the North Valley experiment, it was not significantly different from the average of all non-model fungicide treatments at either location. When averaged across both locations, yield from the model treatment was not significantly different from the non-model mean or the highest-yield treatment. Final rust severity (scored in early July) was significantly higher in the rust model treatment than in any other fungicide treatments. In previous experiments we have determined that rust can be detrimental to 1000-seed weight as well as total yield. The 1000-seed weights were not significantly different between model and non-model treatments, suggesting that the rust severity in the model treatment was not great enough to reduce seed weights.

The economic comparison of fungicide treatments at these two sites (Table 3) shows that the model fungicide treatments produced returns that were similar to, or better than, most non-model fungicide treatments. At the North Valley site 3 fungicide applications were made in the model and non-model treatments. Since yields were similar among treatments, economic returns from the three applications were similar among the treatments. Economic return from the model-assisted treatment was less than that from the highest-yielding treatment, but similar to the overall average. At the South Valley site, however, the rust model suggested that the third fungicide treatment was not needed. In this case the model-assisted treatment produced seed yield similar or slightly higher to the other treatments, but with only two applications instead of three. Therefore the economic return was more favorable for the model-assisted treatment at this site.

The USDA Rust Model for perennial ryegrass is under active development, and 2004 was the first year to test the model in large yield trials. With improvements that are currently in progress for the model, we expect that final disease severities in model-assisted fungicide scheduling will be less than the 15-16% final severities seen in these experiments. The 2004 results do illustrate, however, the type of performance that can be expected from using a disease estimation model for management decisions. In some cases, depending on winter and spring weather conditions and/or planting date and cultivar, decisions made with reference to the model will not produce fewer applications than without the model. In other cases, however, we can expect model-assisted management to reduce the number of sprays without sacrificing yield. In any case the model is intended to provide the maximum efficacy for fungicide applications, through optimum timing of sprays. This goal was not realized completely in these experiments, but we are optimistic that it will be reached with newer versions of the model.

The current version of the stem rust model is available on the Internet (http://pnwpest.org/cgi-bin/stemrust_gw.pl). The website, hosted by OSU's Integrated Plant Protection Center (IPPC), allows users to select a weather station for conditions representative of their region. Scouting information (number of rust pustules seen per foot of row, and date of the observation) and fungicide applications are also entered. Then the model computes the estimates for rust development and displays them. There is a "help" box on the web page, where explanatory text appears when the cursor is moved over the question marks ("?") placed near the main input or output displays.

Acknowledgements:

Appreciation is extended to BASF, Bayer CropProtection and Syngenta for their support of these OSU Extension Service and USDA-ARS fungicide trials. We also express our appreciation to the cooperation of the growers who allowed us to use their fields and assist with the seed harvest.

Table 1. Treatment table: fungicide application rates and timings on two perennial perennial ryegrass seed fields in the north and south Willamette Valley, 2004.

Treatments	Application dates and rates (product/acre)			
	First application (5/21/04) Boot stage to early heading	Second application (6/11/04) Full heading to early anthesis	Third application (6/23/04) Late anthesis to early seed fill	Cost ($/a)
Untreated Check	None	None	None	$0.00
Non-rust model treatments				
Tilt sequence	Tilt 6 oz. + Echo 1 pt	Tilt 6 oz.	Tilt 6 oz.	$64.23
Abound sequence	Tilt 6 oz. + Echo 1 pt	Abound 9 oz.	Abound 9 oz.	$69.85
Headline sequence	Tilt 6 oz. + Echo 1 pt	Headline 9 oz.	Headline 9 oz.	$69.85
Quilt sequence	Tilt 6 oz. + Echo 1 pt	Quilt 17.50 oz.	Quilt 17.50 oz.	$68.95
Stratego sequence	Tilt 6 oz. + Echo 1 pt	Stratego 12 oz.	Stratego 12 oz.	$66.57
Headline early sequence	Headline 9 oz.	Headline 9 oz.	Tilt 6 oz.	$64.45
Rust model treatments				
South Valley	Abound 9 oz. (6/4/04)	Abound 9 oz. (6/11/04)	None	$44.84
North Valley	Abound 9 oz. (6/4/04)	Abound 9 oz. (6/11/04)	Tilt 6 oz	$64.45

Note: Applications with 1/2% COC, 30 psi, 15 gpa.
Varieties: Extreme, first seed crop (South Valley) and Paragon, first seed crop (North Valley)
Cost includes products and application @ $5.50/acre.

Costs used in economic analysis in Table 3 and 4:

Tilt	$285/gal	$13.36/a @ 6 oz/a
Abound	$230/gal	$16.17/a @ 9 oz/a
Headline	$230/gal	$16.17/a @ 9 oz/a
Quilt	$115/gal	$15.72/a @ 17.5 oz/a
Stratego	$155/gal	$14.53/a @ 12 oz/a
Echo	$43/gal	$5.40/a @ 1 pt/a
COC @ 1/2%	$10.00/gal	$2.25/a for 3 applications
Perennial ryegrass seed	$0.60/lb	

Table 2. Results summary: the effect of fungicides on stem rust severity and seed yield of turf type perennial ryegrass in the north and south Willamette Valley, 2004.

	Results								
	North Valley (var. Paragon)				South Valley (var. Extreme)				Two-site
Treatments	Rust (7/1/04)	Seed yield	Cleanout	1000 seed wt.	Rust (7/5/04)	Seed yield	Cleanout	1000 seed wt.	average seed yield
	(%)	(lb/a)	(%)	(g)	(%)	(lb/a)	(%)	(g)	(lb/acre)
Untreated Check[1]	85	963	6.1	1.42	60	1279	25.0	1.65	1121
Non-rust model treatments									
Six treatment mean[2]	7	1594	3.8	1.63	2	1780	20.0	1.83	1687
Highest yield treatment	6	1652	3.5	1.67	5	1873	19.5	1.82	1763
Rust model treatment	16	1552	4.1	1.57	15	1952	18.2	1.81	1752
LSD (0.05)	5	85	NS	0.11	6	187	1.5	0.07	-

[1] The check was harvested as one strip and not included in statistical analysis for seed yield.
[2]Average of six fungicide treatments reported in "The Effect of Fungicides on Seed Yield and Economic Returns in Perennial Ryegrass."

Table 3. An economic comparision of the net return above product and application costs from fungicide treatments on two perennial ryegrass seed fields, Willamette Valley, 2004.

		Results								
		North Valley				South Valley				
Treatments Fungicide	Cost	Seed yield	Added seed	Net return	Return per $ invested	Seed yield	Added seed	Net return	Return per $ invested	Two-site average net return
	($/a)	(lb/a)	(lb/a)	($/ac)	($)	(lb/a)	(lb/a)	($/a)	($)	($/a)
Untreated Check	0	963	0	$0.00	$0.00	1,279	0	$0.00	$0.00	$0.00
Non-rust model										
Six treatment mean[2]	$67.32	1,594	631	$311.08	$4.63	1,780	501	$233.18	$3.47	$272.13
Highest yield	$64.45	1,652	689	$348.95	$5.41	1,873	594	$291.95	$4.53	$320.45
Rust model										
South Valley (2 apps)	$44.84					1,952	673	$358.96	$8.01	$323.96
North Valley (3 apps)	$64.45	1,552	589	$288.95	$4.48					

[2]Average of six fungicide treatments reported in "The Effect of Fungicides on Seed Yield and Economic Returns in Perennial Ryegrass."

PERSISTENCE, KICK-BACK ACTIVITY AND TIMING EFFECTS OF FUNGICIDES FOR STEM RUST

W.F. Pfender

Introduction

Optimum number and timing of fungicide sprays for controlling stem rust in grasses depends on several aspects of fungicide activity. Duration of protective activity (fungicide applied prior to infection) and curative or "kick-back" activity (fungicide applied after infection) are important, as are the subsequent effects on spore production. In grass stem rust, there is also a very important phase of the disease in which rust spreads quickly from an infected sheath to the flower head and stem (see pages 44-45 of "2003 Seed Production Research"). Understanding the effects of fungicides on this process is critical to adequate disease management.

The systemic fungicides commonly used in our region are triazoles (principally propiconazole and tebuconazole) and strobilurins (principally azoxystrobin). Experiments were conducted to provide quantitative information about activity of these fungicides.

Materials and Methods

*Protective and curative activity of fungicides***.** A field experiment was conducted twice in 2001 and once in 2003 to determine protective and curative properties of propiconazole and azoxystrobin when applied at various durations before and after an infection event. The experiment was done with perennial ryegrass cultivar Morningstar, planted on October 10, 2000 (for the 2001 trials) and October 6, 2002 (for the 2003 trial). For each trial, there were 4 replicates per treatment, with a treatment being one fungicide treatment at one application date. There were two check treatments in which no fungicide was used; one was inoculated with the pathogen and the other was left non-inoculated as a check on background levels of disease. In the three trials of this experiment fungicide application dates ranged from 15 days before infection to 14 days after infection. Fungicide was applied with a flat-fan Tee-Jet nozzle attached to a CO_2-powered sprayer operating at 20 psi pressure. Fungicides were applied at standard, labelled rates (6 oz/acre of Tilt per, and 9 oz/acre of Quadris, in 20gal/acre of water). A non-ionic surfactant was added to the Quadris.

All replicates (except for a non-inoculated treatment) within a trial were inoculated on the same date with urediniospores of the stem rust fungus (*P. graminis* subsp. *graminicola*). Approximately 16 days after inoculation, plants were scored (number of pustules per tiller) for disease severity.

Production and viability of spores from fungicide-treated plants. Field-grown perennial ryegrass plants were transplanted to pots, then brought into a greenhouse and inoculated with urediniospores of *P. graminis* subsp. *graminicola.* Pots were divided randomly into three groups for treatment with fungicides: propiconazole, azoxystrobin, or non-treated. Plants were sprayed with water or with fungicide solution at labeled rates as described previously. Two days after fungicide treatment, accumulated urediniospores were removed and discarded from randomly-selected pustules by gently vacuuming. This was done to remove spores that may have been produced before fungicide treatment, as well as fungicide that may have been deposited on the pustules. Two days later (4 days after fungicide treatment) newly-produced urediniospores were collected for analysis of spores produced on fungicide-treated plants.

Effect of fungicides on within-plant disease spread. Perennial ryegrass plants undergoing reproductive growth were obtained by transplanting vernalized plants from the field into pots in a greenhouse. When tillers reached the stage of flag-leaf sheath exposure, they were inoculated to produce a single lesion on the flag leaf sheath. Tillers were individually tagged for future identification.

Previous research had shown that urediniospores are released from the inner face of the infected sheath at the pustule site when the pustule erupts, one latent period after the primary infection occurs on the sheath surface. These spores then cause multiple secondary infections on the stem as it extends from within the enclosing sheath. In the experiment reported here the fungicides were applied after the secondary infections had begun, in order to determine fungicide effects on the secondary stem infections. The experiment was conducted twice. In the first trial fungicide was applied to some plants at 10 days after sheath inoculation (1 day after sheath pustules opened), and to others at 14 days post-inoculation. In the second trial fungicide application was done and 11 and 16 days post-inoculation.

After inflorescence extension was complete (approximately 21 days after inoculation), 1 additional latent period was allowed to pass so that all latent secondary infections on the inflorescence had time to erupt. Then, 30 days after inoculation of the sheath, the length and location of secondary infections on the inflorescence were measured.

Results

Protective and curative activity of fungicides. Most fungicide treatments had significantly less disease than the respective inoculated non-treated check, except for propiconazole treatments 15 days prior to infection or $\geq$ 9 days after infection. That is, both fungicides displayed protective and curative activity against stem rust on perennial ryegrass. When applied near the time of infection both fungicides had equivalent effects, reducing disease nearly to zero (Figure 1). As the time between pre-infection (protective) fungicide application and infection increased, the degree of fungicide activity decreased, and the decrease was sharper for propiconazole- than for azoxystrobin-treated plants. In post-infection treatment, azoxystrobin showed more prolonged curative effects than propiconazole did: azoxystrobin provided 90% control, and propiconazole provided 30% control, when applied 14 days after infection.

*Production and viability of spores from fungicide-treated plants***.** Rust spores, produced between 2 and 4 days after pustules were sprayed with propiconazole at labeled rates, were just as viable (about 95%) as the spores from non-sprayed plants. Azoxystrobin, in contrast, reduced viability of spores to 82%.

Between 2 and 4 days after plants were sprayed with propiconazole, the number of urediniospores produced per pustule was only 27% of the number produced by pustules on non-treated plants. Pustules on azoxystrobin-treated plants produced only 5% as many spores as pustules on the non-treated plants.

Effect of fungicides on within-plant disease spread. When plants were inoculated at a single site on the flag leaf sheath, the severity of secondary disease from within-plant spread was greatly affected by the type and application time of fungicide (Figure 2). If propiconazole was applied early in the secondary-infection process (11 days after primary infection, which is about 1 day after presumed start of secondary infections), there was only about 40% disease control. If the time of propiconazole treatment was delayed until most of the flower extension had occurred, final levels of control rose to approximately 90%. In contrast, azoxystrobin treatment during secondary, within-plant disease spread gave approximately 90% control, whether treatment occurred early or late in the stem extension process. This difference between the fungicides is due to their difference in inhibiting the secondary stem infections that occur by the fungus sporulating on the inner face of an infected sheath. An examination of the inner sheath surfaces directly under the initial inoculation sites at the end of the experiment showed that only 7% of the azoxystrobin-treated plants had spores at these sites, significantly less than the 72% of the propiconazole-treated plants or the 90% of the non-treated check plants that had abundant spores there.

Summary

Both fungicides we tested have good protective and curative (“kick-back”) activity. Propiconazole has shorter effective durations in both directions than the strobilurin, but both fungicides can give provide good control when applications are timed to consider the persistence of one application and the kick-back of the next application. Azosystrobin has better activity than propiconazole at reducing spore production and viability on infected plants treated with fungicides.
Azoxystrobin also has markedly better activity than propiconazole in reducing the spread of the pathogen from the inner face of a sheath to the enclosed stem or inflorescence as it elongates. Since this within-plant spread can account for more than half of the final disease in a rusted field, strobilurin-type fungicide is the material of choice when inflorescences are extending. The stem rust model, currently available on the internet in a provisional form, incorporates these timing issues into the calculation for estimated efficacy of the different fungicides during rust development.

It is very important to use both of these valuable fungicides in a way that preserves their utility into the future. That is, it is important to avoid practices that favor the development of fungicide-resistant strains of the rust fungus. Fungicides should be alternated during the season or tank-mixed, using levels that approach or equal the concentrations (active ingredient per acre) when used singly. If exclusive use is made of azoxystrobin compounds, we may well lose these excellent fungicides due to insensitivity that could develop in the rust population.

Acknowledgment:
I thank Sheila Seguin for excellent technical assistance in the experiments.

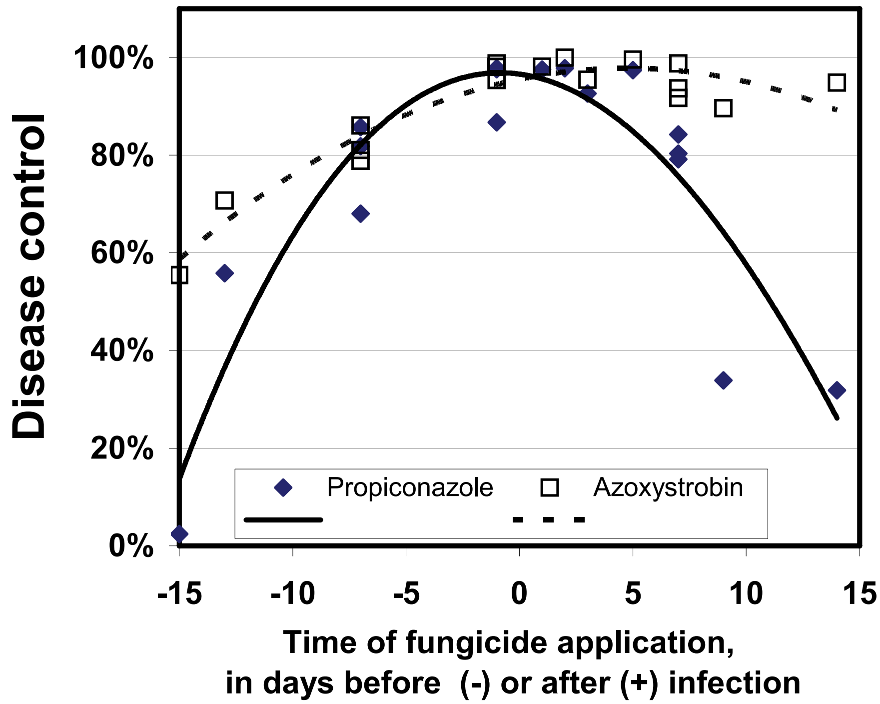


Figure 1. Protective and curative activity of two fungicides on grass stem rust.

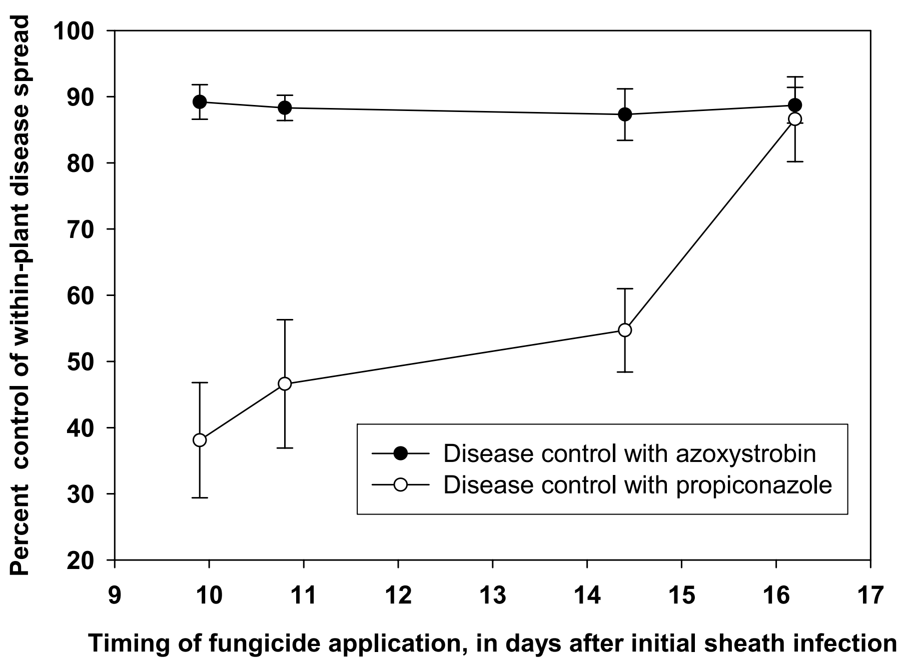


Figure 2. Effect of fungicide timing on spread of rust disease to the inflorescence from a single infection on the flag sheath.

PREVALENCE OF ORCHARDGRASS CHOKE DISEASE, 1998-2003, AND ESTIMATED REGIONAL SEED YIELD LOSS

W.F. Pfender and S.C. Alderman

Background

The pathogenic fungus *Epichloë typhina*, which causes orchardgrass choke disease, was introduced into the Willamette Valley orchardgrass seed production area in the mid 1990s, and spread throughout the region by 1998. Choke prevents seed production in an infected tiller by preventing emergence of the inflorescence. Once a plant becomes infected it remains so for its entire life, so the disease typically increases from year to year within a field. This increase affects not only the levels of seed yield loss in sequential years of production, but also limits the number of years a stand is profitable for production. For these reasons, it is important to assess rates of yearly disease increase in commercial production and understand the relationship between disease levels and yield loss. Choke in orchardgrass is apparently not seed-borne, although this has not been conclusively established.

Methods

Survey of choke disease severity in commercial orchardgrass seed fields. A current list of orchardgrass seed production fields registered with the Oregon Seed Certification Service was obtained each year. Fields were selected arbitrarily from this list to represent the geographic range of orchardgrass seed production in the Willamette Valley of Oregon. Fifty-two fields were surveyed in the 1998 harvest year. Fewer fields were surveyed in 1999 and 2000 (14 and 17 fields, respectively). In 2001, 2002 and 2003 we surveyed 42, 51 and 65 fields, respectively. In each survey year we included as many previously-surveyed fields as possible, although some fields were taken out of production. Sampling was done from late May until harvest in late June.

The method for sampling fields was to examine 10 quadrats (about 3 ft^2 each) along each of 4 transects, oriented diagonally to the field borders, in each field. The number of tillers with "chokes" was counted in each quadrat to give 40 values for diseased tillers/3 ft^2 for each field. In 4 to 6 quadrats in each field, the total number of potentially-fertile tillers was determined by counting the number of seed-producing heads and adding this number to the number of choked tillers in the quadrat. Disease severity (% choked tillers) in the field was calculated by dividing the average of the 40 observations for choked tillers/ 3 ft^2 by the average of the counts of total tillers per 3 ft^2. Change in the amount of choke disease over time within a field was analyzed by comparing the 40 estimates of choked tillers per 3 ft^2 among the different years.

Yield loss relationship. Data for the relationship of seed yield to choke disease severity was obtained from a 1997 planting of orchardgrass (cultivar Takena) at the Hyslop Research Farm. On 26 June 2001 and 30 June 2002, randomly-selected samples of the planting were harvested. Each sample consisted of a 3-ft wide swath cut perpendicular to the rows across a 7-row strip. In each sample, the total number of potentially-fertile tillers was determined by counting choked tillers and healthy seed heads. The percent choke in each sample was calculated as the number of choked tillers divided by the sum of the choked tillers and healthy seed-producing heads. The healthy seed heads then were allowed to dry for 1 wk in burlap bags hanging from a drying line outdoors. The seed weights were determined after threshing and cleaning each sample individually and drying the seed to constant weight.

Results

Occurrence and increase of choke disease in commercial fields. Of 99 fields included in the survey, 57 were visited in more than one year. In 41 (72%) of the revisited fields, there was a significant increase in disease for at least one of the yearly intervals. Considering all 125 annual visits, there was a significant ($P < 0.05$) disease increase in 40% of the cases, a significant decrease in 3%, and no statistically significant change in 57% of the revisits. Disease severity increased rapidly over some yearly increments in some fields, e.g., 1-yr increases of more than 15% choked tillers were observed in some fields. In other fields, yearly changes were more moderate.

On average, orchardgrass fields planted in 1998 or 1999 reached approximately 10% severity in their third year of production, but the average disease severity in fields planted in 2001 reached this level in their second year (Figure 1). By 2003, the average percent choke severity was approximately 10% in stands of any age older than one year. The highest disease severities observed over the 6 years of the study were 35 to 45%. Fields reaching this level of severity were commonly taken out of production. In 1998, 60% of the fields surveyed were affected to some degree by choke. This proportion increased to approximately 90% by 2000, and remained at that level through the end of the study in 2003. In 1998, 32% of fields older than 1 yr were free of choke, whereas only 1-2% of the fields in this category were free of choke in 2002 and 2003. Average disease severity in first-year fields was 0 to 0.25% from 1998 to 2001, but was 1.4 and 0.8% in 2002 and 2003.

In the survey data, we found that disease severity (% tillers diseased) was correlated with prevalence (% quadrats containing choked tillers) among the 217 observations. A prevalence of 75% (30 of 40 quadrats having at least one choked head) corresponded to an overall severity in the field of approximately 9.4%.

Yield loss due to choke disease. Regression analysis of the combined data for the two years shows that, for disease severities between 8 and 65%, each 1% increase in choke is correlated with a 1% reduction in seed yield (Figure 2). There was no evidence for seed yield compensation by the healthy seed heads in diseased plots. Likewise there was no significant effect of disease severity on total number of tillers per plot, indicating that diseased plants do not produce a greater number of tillers than healthy plants.

Loss of orchardgrass seed yield due to choke disease in the Willamette Valley region was estimated from the yield loss relationship described in the previous paragraph, combined with an analysis of disease severity in the production fields. Since choke severity depends on stand age, regional disease severity estimates require information about the percentage of orchardgrass acreage for each stand age. We obtained summary statistics for acreage of certified orchardgrass seed fields from the Oregon State University Seed Certification Service. For the 2004 harvest year, 15.5% of the certified orchardgrass acreage was in its first year of production. From our measurements of disease severity as a function of stand age we estimate that this acreage had an average disease severity of 0.8%, and that the remaining 84.5% of the certified acreage had an average disease severity of 10.5%. These calculations produce an overall estimate of 9.0% disease severity in the certified crop, and therefore a 9.0% seed yield loss.

Summary

The survey data reported here show that orchardgrass choke disease, caused by *E. typhina*, is now endemic and ubiquitous in the Willamette Valley seed-production region of Oregon. Since 2000, approximately 90% of the fields are affected each year. The unaffected 10% corresponds approximately to the proportion of acreage that is in the first year of production, when choke is relatively uncommon. Fields older than one year, however, are now almost all affected to some degree. Even several first-year fields were affected in 2002 and 2003, and one of the first-year fields surveyed in 2003 had a severity of 6.3% choked tillers. The fact that the average severities are similar among all stand ages above 1 yr may reflect the removal of stands from production when the severity reaches some threshold level that prompts grower action.

Yearly rates of increase of choke disease within individual fields are currently 5 to 8% additional diseased tillers per year, with some instances of a yearly increase as high as 20% and other cases of insignificant increase. We noted rare instances of a significant decline in choke disease from one year to the next; the apparent decrease in average percent choke for 1998-planted fields between 2002 and 2003 (Figure 1) is due to a steep decline in percent severity for two fields. We do not have an explanation for the differing rates of increase in different fields, despite attempts through interviews with growers to determine the differences in production practices that might be correlated with different rates of choke increase. We did note that several of the fields with a significant decline in disease also showed general signs of plant stress expressed as a thin stand. Volunteer seedlings in an infected stand could reduce the number or proportion of choked tillers if the new (and typically non-infected) plants replace older, less vigorous, infected plants.

In equating loss with severity, we assume that the same relationship we observed for disease severities of 8% to 65% holds also for severities below 8% disease. We consider this assumption to be justified, as we found no evidence for significant yield compensation, either in number of tillers produced or in seed yield per healthy head, in the presence of the disease. Regional loss estimates can be computed by multiplying the average severity for given stand age by the proportion of the planted area that is of that age. We used data on the distribution of stand ages in the certified-seed production acreage in Oregon to compute a 9.0% loss in the 2004 crop. The certified acreage represented 56% of the total area of orchardgrass seed production in Oregon in 2004 (Oregon State University Extension Service estimates). Non-certified fields are likely to stay in production longer than certified fields, so the non-certified crop area is likely to have a higher proportion of older ($\geq$ 2 y) fields than is present in the certified area. Therefore applying the yield loss estimate of certified production area to the non-certified area would be a conservative estimate of loss. Farm gate value (certified plus non-certified) of Oregon orchardgrass seed in 2004 was $9.11 million, so a yield loss of 9.0% represents $820,000 of loss due to orchardgrass choke disease in 2004.

Prevalence of choke disease is now very high in Oregon, so the wind-borne inoculum of the pathogen will undoubtedly be abundant over the growing region each year. Our confirmation of the equivalence between severity and yield loss will enable individual growers to make appropriate decisions about the economic consequences of maintaining or removing a stand infested with choke. Precise estimates of percent disease severity are quite time-consuming, but severity can be estimated from prevalence within a field; if you find choke in 75% of the places you check in a field, the disease severity (and yield loss) is generally about 10%.

Acknowledgment:

We thank Barbara Matson for technical assistance.

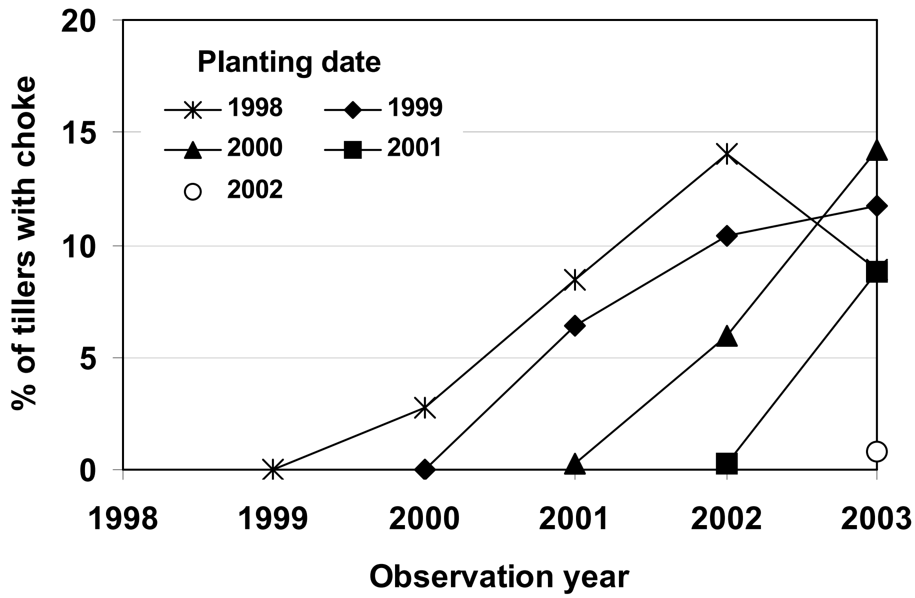


Figure 1. Yearly levels of severity of choke disease (% of tillers diseased) in commercial orchardgrass seed-production fields in Oregon. Each data point is the average for several fields of the indicated planting year in each observation year. The graphed data, a subset of the complete data set, include only fields that were sampled every year from the first year of seed production.

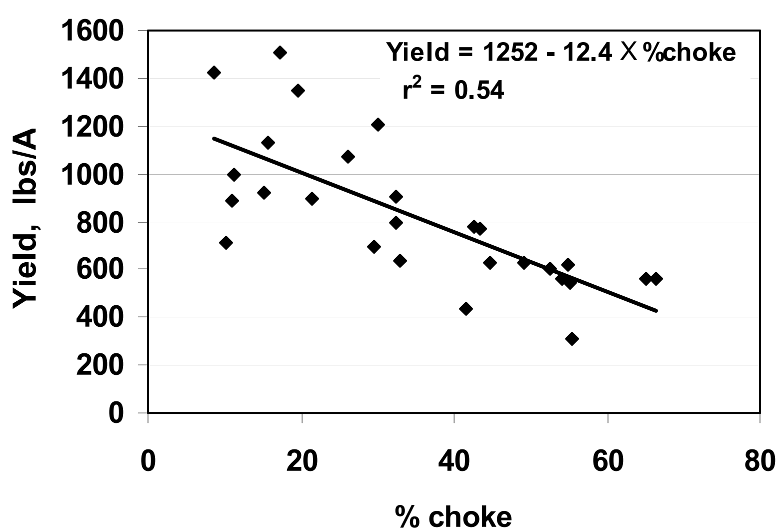


Figure 2. Relationship between % choked tillers and seed yield.

A DNA ASSAY FOR THE DETECTION OF CHOKE IN ORCHARDGRASS

J.C. Baldwin, J.E. Dombrowski and S.C. Alderman

Introduction

Choke, caused by the endophytic fungus *Epichloë typhina*, is an important disease of orchardgrass (*Dactylis glomerata L.*) grown for seed. The recent introduction and rapid spread of choke has been problematic for orchardgrass seed producers. Infected plants remain asymptomatic during most of the year. As reproductive tillers elongate, and just prior to seed head emergence, a rapid and dense growth of the fungus within and among leaf sheaths effectively blocks the emergence of seed heads. A whitish, felt-like stroma bearing conidia develops on the surface of infected tillers, and the tillers resemble small cattails. Perithecia develop as the stroma matures. In infested fields, up to a third of reproductive tillers can be infected resulting in little to no seed production from the infected tillers. The pathogen has not been shown to be transmitted through the seed in orchardgrass, but can be in other grasses.

Little is known about the timing of infection of orchardgrass by *E. typhina.* Attempts to infect orchardgrass foliage or flowers with conidia or ascospores have not been successful. Invasion of *E. typhina* through cut ends of seed stalks was reported, although it was not established whether plants ultimately become infected through the stalks. Detection of *E. typhina* early in the disease cycle can be difficult due to the often sparse distribution of hyphae in the plant. Even during flowering, not all infected plants express symptoms, and on infected plants, some tillers can escape the otherwise systemic infection. Symptoms are manifested only near the time of emergence of seed heads and detection of infection at other times of the year is difficult.

There are several methods available for detection of *Epichloë* species in plants, including differential staining of the fungus in leaf tissue and microscopic examination; serological methods, including ELISA or immunoblot tests, and DNA based assays such as, polymerase chain reaction (PCR). Staining methods work well in seed and reproductive tillers, although the fungus may be difficult to detect in plants with sparse hyphae. Serological methods may not be entirely reliable due to cross-reaction with plant proteins, and may include false positives from closely related fungi. PCR methods provide a reliable and rapid approach for fungal detection in plant tissues. However, a PCR assay is currently not available for detection of *E. typhina* in orchardgrass. The objective of this study was to develop a DNA test (specifically a PCR based method) for detection of *Epichloë typhina* in orchardgrass.

Materials and Methods

Plant materials:

Field samples of locally grown (Willamette Valley, Oregon) orchardgrass, cultivars Ambassador, Alpine and Early Arctic were collected based on the presence or lack of choke symptoms in and around the time of flowering. The samples were harvested from 2 fields heavily infected with choke (25-30%), 2 fields with minimal choke (less than 2%), and 2 young fields not known to contain choke. Samples were randomly collected in fields along four transects at roughly 2-3 meters intervals in a diamond shaped pattern.

PCR Protocol:

Polymerase chain reaction (PCR) is molecular technique that can be used to specifically amplify a minute amount of DNA into large quantities. The amplified DNA fragments can then be separated on agarose gels based on their size/length, defined as base pairs, or "bp". The DNA is then visualized as discrete bands using ultraviolet light. Specific bands can be used to identify the presence of a particular organism or pathogen. A PCR method was developed to amplify a specific region of the *actin1* gene that would readily discriminate *E. typhina* from other common species of fungi in orchardgrass plants.

Results and Discussion

The objective of this study was to develop and evaluate a DNA method for detection of *Epichloë typhina* in orchardgrass. A PCR method was developed to amplify a specific gene that could readily discriminate *E. typhina* in infected plants. We found that our PCR method was sensitive enough to be able to detect *E. typhina* in low level infections (sparse hyphae) that may be found in vegetative tillers. In addition this PCR method was able to detect *E. typhina* in all tissues tested except in a rare panicle that emerged from below a stroma on an infected reproductive tiller. In such cases, the panicle emerged before fungal proliferation and likely escaped infection. We found no evidence of flower or seed infection by *E. typhina*, supporting results of others. However additional studies using the PCR approach need to be conducted to establish whether or not seed infection is possible.

Due to the similarity between *E. typhina* and several other fungi such as *Neotyphodium spp.* and related field contaminants such as ergot (*Claviceps purpurea*), we needed to test the method against these potential cross contaminants. Interestingly, we found that choke infected fine fescue, as well as tall fescue and perennial ryegrass infected with *Neotyphodium* spp., produced DNA products between 848-858 base pairs in length, while DNA isolated from choke infected orchardgrass and the *E. typhina* fungus amplified the expected diagnostic 481 base pair product. Confirmatory sequencing of the amplified DNA showed that the diagnostic 481 base pair band was the correct product and matched the expected sequence exactly. While the 848-858 base pair sequences appear to be fungal in origin, they had little sequence similarity to the diagnostic band. However these larger 848-858 base pair bands do appear to correlate strongly with the presence of choke in fine fescue as well as *Neotyphodium spp*. in tall fescue and perennial rye-grass in all samples tested.

To further ascertain the effectiveness of our PCR assay we compared it to more traditional detection methods, microscopic examination and immunological detection. We randomly took samples from previously isolated plants collected from high, low and uninfected choke fields, which were asymptomatic for choke as well as several controls, including tall fescue infected with *Neotyphodium spp*. Each tiller was then subjected to three separate tests: microscopic examination, immunoblot assay and PCR detection. Table 1 shows the results of this comparative analysis were tillers 1- 19 were from orchardgrass plants and tillers 20-24 were selected from tall fescue cultivar Kentucky 31plants. All three methods were able to detect the presence of *E. typhina* in the orchardgrass tiller sections. However, the microscopic method failed to detect the presence of the fungal endophyte in one of the 4 endophyte infected samples taken from tall fescue. While all methods were able to detect the presence of fungal endophytes, only the PCR method could readily distinguish the endophyte in tall fescue from choke in orchardgrass, due to the size difference of the amplified product. This is not a surprising result, since staining of fungal material is non-selective process and the antibody used in the immunoblot assay was found to cross react with protein extracts from *E. typhina, C. purpurea* and *Neotyphodium spp.*

To further test our procedure we went to fields with a high incidence of choke, low or uninfected fields and took samples of flowering tillers. PCR analysis of these samples showed we could not only detect *E. typhina* in symptomatic plants, but we did observed latent choke infections in some plants that had flowered in the high choke fields. In contrast we were unable to detect any latent infections from samples taken from the low choke or uninfected fields (data not shown).

In order to track *E. typhina* infection in plants efficiently it is critical to have a simple, fast and reliable method of detection. Of the three methods tested the PCR technique competes favorably with more traditional methods and may offer enhanced specificity in its ability to differentiate between the orchardgrass variant of *E. typhina* and all other related fungi tested here. In addition, this PCR detection method has sufficient sensitivity to detect *E. typhina* in asymptomatic vegetative tillers, which will allow for sampling plants prior to flowering. It is clear that a reliable means of detection for the early stages of choke infection is required to further advance the field of this research and ultimately provide tools to control the spread of the disease.

Acknowledgments:
Special thanks is extended to Barbara Matson USDA-ARS and Vicky Hollenbeck USDA-ARS for their assistance in collecting and generating some of the materials used in this research. To all the orchardgrass growers who allowed us to collect plant tissue from their fields. Experimental methods performed in this research complied with current laws and regulations of the U.S.A. The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the United States Department of Agriculture or the Agricultural Research Service of any product or service to the exclusion of others that may be suitable.

Table 1. Comparison of detection methods for *Epichloë typhina*

Plant	Microscopic	Immunoblot	PCR
Tiller 1	-	-	-
Tiller 2	+	+	+ (481 bp)
Tiller 3	-	-	-
Tiller 4	-	-	-
Tiller 5	+	+	+ (481 bp)
Tiller 6	-	-	-
Tiller 7	-	-	-
Tiller 8	-	-	-
Tiller 9	-	-	-
Tiller 10	-	-	-
Tiller 11	-	-	-
Tiller 12	-	-	-
Tiller 13	+	+	+ (481 bp)
Tiller 14	+	+	+ (481 bp)
Tiller 15	-	-	-
Tiller 16	+	+	+ (481 bp)
Tiller 17	+	+	+ (481 bp)
Tiller 18	-	-	-
Tiller 19	+	+	+ (481 bp)
Tiller 20	+	+	+ (848 bp)
Tiller 21	+	+	+ (848 bp)
Tiller 22	+	+	+ (848 bp)
Tiller 23	-	-	-
Tiller 24	-	+	+ (848 bp)

(+) denotes positive for fungal infection
(-) denotes no fungus detected

OCCURRENCE OF STRIPE SMUT IN GRASS SEED PRODUCTION FIELDS IN THE WILLAMETTE VALLEY DURING 2004

S.C. Alderman, C.M. Ocamb, M.E. Mellbye, G.A. Gingrich and S. Sedegui

During a disease survey in 2003, smut was found in several fields of orchardgrass. Smut was also detected by the Oregon Department of Agriculture during tests for smut on other grasses, including perennial ryegrass, tall fescue, chewings fescue and bentgrass, raising some concern about the occurrence of smut in grass seed production fields.

In 2004, a survey for smut in orchardgrass, perennial ryegrass, tall fescue, fine fescue, and bentgrass was initiated. In each field, 10 1-meter row lengths were examined along each of 4 transects in a diamond pattern. At each site the number of smutted plants were counted. At one site along each transect the total number of plants per meter were counted. Plants suspected to be infected with smut were placed in paper bags and returned to the lab for microscopic examination to verify presence of *Ustilago striiformis* (the causal agent of stripe smut). Smut was detected in 16 of 51 orchardgrass fields examined (Table 1). Among the fields with smut, two fields had 11% to 12% plants with smut, 6 fields had 1% to 8%, and the remaining fields had less than 1% plants with smut. Smut was not detected in tall fescue, perennial ryegrass, chewings fescue or bentgrass. However, a head smut was found on velvetgrass (*Holcus mollis*, and *Holcus lanatas*) in bentgrass fields and this may be a source of smut contamination of grass seed during harvest.

Table 1. Occurrence of *Ustilago striiformis* among grass seed production fields in the Willamette Valley, OR during 2004.

Crop	Fields examined	Fields with smut
Orchardgrass	51	16
Perennial ryegrass	24	0
Tall fescue	24	0
Fine fescue	25	0
Bentgrass	4	0

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

Annual bluegrass (*Poa annua*) has evolved resistance to diuron (Karmex, Direx) in some Willamette Valley perennial ryegrass fields. Preemergence applications of diuron over carbon-seeded perennial ryegrass remain a common management practice. Stand establishment in these fields would benefit from an alternative to diuron.

The objective of this research is to evaluate annual bluegrass control and perennial ryegrass injury resulting from norflurazon (Solicam), pronamide (Kerb), flufenacet (Define), sulfentrazone (Spartan), and mesotrione (Callisto) as preemergence broadcast treatments over activated carbon.

Methods

The experimental design at each of three trial locations was a randomized complete block with four replications. Individual plots were 8 ft by 25 ft. Soil at the OSU Hyslop Research Farm in Corvallis was a Woodburn silt loam with an organic matter content of 2.4% and a pH of 5.4; soil at the Tangent site was a Dayton silt loam with an organic matter content of 2.4% and a pH of 5.7; and soil at the Shedd site was an Amity silt loam with an organic matter content of 3.1% and a pH of 7.0. The Corvallis site was infested with non-resistant annual bluegrass. Both sites in growers' fields were infested with suspected diuron-resistant annual bluegrass.

Perennial ryegrass was seeded October 2, 2003 at the Corvallis site. Seeding took place on October 10 and 14, 2003 at the Tangent and Shedd sites, respectively. 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 treatments were applied on October 7, 2003 at the Corvallis trial, October 10, 2003 at the Tangent site, and October 15, 2003 at the Shedd site. Mesotrione was in the very preliminary stages of testing on perennial ryegrass and crop safety was unknown, so it was only applied at the Hyslop Research Farm. Herbicides were applied in water at 20 gallons per acre at 20 psi. Visual evaluations were conducted to assess annual bluegrass and perennial ryegrass injury.

Perennial ryegrass in each plot was swathed and then machine-threshed. Seed samples were processed with an air/screen cleaner prior to calculating seed yields.

Results

The high rate of diuron applied alone provided good annual bluegrass control at the Corvallis and Shedd sites (Table 1). Annual bluegrass control in Corvallis was excellent through December with all treatments except the low rate of diuron. Annual bluegrass was best controlled at the Tangent location with flufenacet applied alone and diuron applied with either pronamide or norflurazon. The population of annual bluegrass at the Shedd site was uncharacteristically low in 2003-2004. Unseasonably cold weather coincided with annual bluegrass emergence, thus frost-heaving a large percentage of the plants. All herbicide treatments performed well under these conditions.

Crop protection provided by the carbon was adequate in all herbicide treatments and at all locations. The norflurazon and pronamide treatments at both off-station sites caused moderate chlorosis and minor stand-thinning (Table 2), but did not impact grass seed yield (data not shown).

Ryegrass yield was not influenced by any herbicide treatment at any location.

Pronamide is legal for use at in carbon seeding. Flufenacet is one of the active ingredients in Axiom, which is registered for use on established perennial ryegrass. Norflurazon, sulfentrazone, and mesotrione are not currently registered for any application in perennial ryegrass seed production.

Table 1. Annual bluegrass control in carbon-seeded perennial ryegrass at three locations.

		Annual bluegrass control[a]		
Treatment	Rate	Corvallis	Tangent	Shedd
	(lb a.i./a)	----------- (%)	-------------	
Untreated check	0	0	0	0
Diuron	2.4	96	53	94
Diuron	0.8	63	35	96
Flufenacet	0.2	97	95	98
Diuron +	0.8 +			
sulfentrazone	0.5	98	78	97
Diuron +	0.8 +			
pronamide	0.25	95	97	98
Diuron +	0.8 +			
norfluraxon	1.96	98	94	98
Diuron +	0.8 +			
mesotrione	0.24	99	na	na
LSD 0.05		17.5	10.2	3.6

[a]Annual bluegrass control visually rated at Corvallis on December 8, 2003, Tangent on January 16, 2004, and Shedd on January 26, 2004.

Table 2. Perennial ryegrass injury at three locations.

		Perennial ryegrass injury					
		Corvallis		Tangent		Shedd	
Treatment	Rate	10/23/03	12/8/03	10/30/03	1/27/04	10/30/03	1/26/04
	(lb a.i./a)	(%)					
Untreated check	0	0	0	0	0	0	0
Diuron	2.4	0	3	0	0	0	0
Diuron	0.8	0	0	0	0	0	0
Flufenacet	0.2	0	4	0	10	4	5
Diuron + sulfentrazone	0.8 + 0.5	0	3	0	20	3	5
Diuron + pronamide	0.8 + 0.25	0	1	0	16	6	0
Diuron + norfluraxon	0.8 + 1.96	16	19	4	15	11	13
Diuron + mesotrione	0.8 + 0.24	0	0	na	na	na	na
LSD 0.05		9.5	8.8	2.7	5.4	3.5	4.7

MEADOWFOAM SENSITIVITY TO HERBICIDE RESIDUE CARRYOVER

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

Introduction

Meadowfoam could offer growers in the Willamette Valley an excellent rotational crop. Some herbicides used in grass seed or wheat production can have a long soil residual period that could injure the subsequent meadowfoam crop. A study was conducted to determine meadowfoam sensitivity to soil residual herbicides commonly used in grass seed or wheat production.

Methods

The study was established in 2002 and repeated in 2003. In 2002, the study was conducted at the OSU Hyslop Research Farm on a Woodburn silt loam with an organic matter content of 2.4% and a pH of 5.5. 'Mermaid' meadowfoam was seeded on October 2, 2002, and harvested June 25, 2003. In 2003, the study was conducted at the OSU Schmidt Research Farm on a Willamette silt loam with an organic matter content of 2.8% and a pH of 5.3. 'Ross' meadowfoam was seeded on September 29, 2003, and harvested June 30, 2004. In both years, meadowfoam was treated with bifenthrin (Capture) for *Scaptomyza* control and clopyralid (Stinger) for weed control. Pollinator bees were put in the study areas at flowering.

Herbicides were applied to the trial area on bare soil at three timings: late winter, spring, and fall. Treatments consisted of herbicides applied at a low and a high rate. The low rate is a currently labeled use rate. The high rate is either double the use rate or the highest labeled rate, in the case of imazamox (Raptor/Beyond). Pyrithiobac (Staple) was applied in the first year, but was replaced with imazamox in the second year. Meadowfoam was seeded with a no-till drill in the fall, soon after the last herbicide application.

The study was arranged in randomized complete blocks with four replications. Visual evaluations were conducted periodically to assess meadowfoam injury. Seed was harvested at maturity, cleaned, and analyzed for oil content using nuclear magnetic resonance spectroscopy.

Results

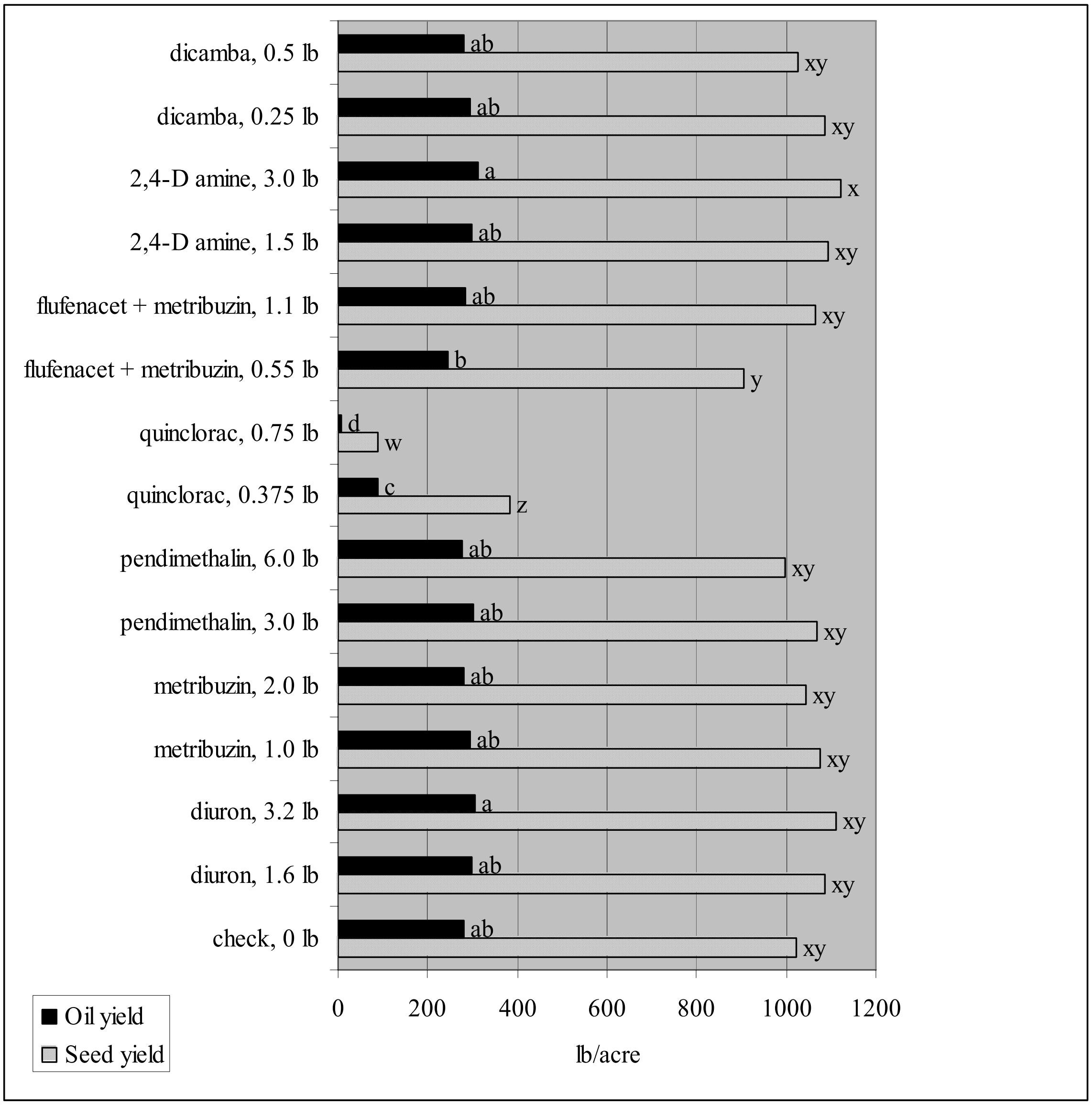
Herbicide carryover could be greater in the study conditions than in an actual crop since the herbicide treatments were applied to bare soil. In a crop situation, some herbicide would be taken up by the crop and be less likely to persist in the soil. Quinclorac (Paramount) and pyrithiobac caused severe injury at the high rates (Table 1). Quinclorac was the only treatment that reduced seed and oil yield compared to the check (Figure 1). The high rate of pendimethalin (Prowl) also caused injury, but seed and oil yield did not differ from the check. Seed and oil yield with flufenacet + metribuzin (Axiom) treatments at both rates did not differ from the check. However, yields were lower with the low rate of flufenacet + metribuzin than the highest yielding treatment, which was the high rate of 2,4-D. At normal use rates, quinclorac was the only herbicide tested that poses a significant carryover risk to meadowfoam.

Table 1. Meadowfoam injury from herbicide carryover in two studies near Corvallis, Oregon.

Treatment	Rate	Planted Oct. 2, 2002		Planted Sept. 29, 2003	
		Nov. 8, 2002	Jan. 27, 2003	Nov. 20, 2003	Mar. 12, 2004
	(lb a.i./acre)	(% injury)			
check	0	0	0	0	0
diuron[1]	1.6	8	0	0	3
diuron[1]	3.2	14	0	0	3
metribuzin[1]	1.0	5	0	0	0
metribuzin[1]	2.0	4	0	0	3
pendimethalin[1]	3.0	5	0	5	33
pendimethalin[1]	6.0	9	35	38	85
quinclorac[1]	0.375	10	3	3	10
quinclorac[1]	0.75	13	60	15	63
flufenacet + metribuzin[1]	0.55	0	0	0	0
flufenacet + metribuzin[1]	1.1	9	3	0	0
pyrithiobac[2]	0.027	13	30	--	--
pyrithiobac[2]	0.054	14	58	--	--
imazamox[3]	0.0313	--	--	0	0
imazamox[3]	0.04	--	--	0	0
2,4-D amine[4]	1.5	5	0	0	0
2,4-D amine[4]	3.0	4	5	0	0
dicamba[4]	0.25	8	0	0	0
dicamba[4]	0.5	6	0	5	13

[1] Applied Jan. 11, 2002 and Feb. 25, 2003
[2] Applied Mar. 29, 2002
[3] Applied Feb. 25, 2003
[4] Applied Sept. 2, 2002 and Sept. 8, 2003

Figure 1. Meadowfoam seed and oil yield combined across two years, following herbicide carryover near Corvallis, OR.



RESPONSE OF SEED YIELD TO SWATHING TIME IN ANNUAL AND PERENNIAL RYEGRASS

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

Seed moisture content is probably the best indicator of the physiological maturity in grass seed crops for determining when swathing (windrowing) is to be done for harvesting seed. Since grass seed crops do not pollinate and mature over a uniform time period, there is a wide range of seed maturity within a crop stand. In order to optimize the time to swath grass seed crops, there is a balance between cutting too early and too late. Cutting too early at a high moisture content shortens the seed fill period and can cause reduced seed size and increase the number of immature seed. Cutting too late at a low moisture content can decrease yield through losses due to seed shattering (Klein and Harmond, 1971; Andersen and Andersen, 1980). Both of these extremes can have an impact on seed quality as well as seed yield. For annual ryegrass, there is very little information for the Willamette Valley on what would be the best cutting time for maximizing seed yield and seed quality. Previous work in the U.K. has identified the range of moisture contents for optimizing harvested seed yield in direct combined annual ryegrass (Hides et al., 1993). Research was also done in the Willamette Valley of Oregon for tall fescue (Andrade et al., 1994) as well as perennial ryegrass, orchardgrass, and fine fescues (Klein and Harmond, 1971). There is also some evidence in research by Andersen and Andersen (1980) on several grass species that the crop is able to continue development as it dries in the windrow. How much this continued development benefits seed yield is not well known.

In addition to using seed moisture content as a factor to determine when to swath, many growers cut their crops under high humidity conditions either at night or early morning to take advantage of dew on the crop as a means to reduce seed shatter. Swathing under high humidity conditions lets the grower delay swathing to allow more time for the later maturing portion of the crop to continue seed fill and hopefully increase harvested seed yield. Though this is a common practice in some areas of seed production in the Willamette Valley, there is little applied research available that quantifies any beneficial effect that high humidity conditions have on seed yield.

In order to address these questions, two experiments were conducted in 2004 (one in perennial ryegrass and one in annual ryegrass) to help determine optimum swathing times. The perennial ryegrass trial was done on-farm in a first-year stand of perennial ryegrass using grower equipment. This trial was designed to compare harvest at three different seed moisture contents and verify recommendations previously available. This also provided an opportunity to compare the efficacy of more modern harvest equipment than was used in previous studies by Klein and Harmond over 30 years ago.

A second trial was conducted at the Hyslop Research Farm in Corvallis, Oregon. This trial was designed to measure two factors: seed moisture content and the impact of dew on the crop at swathing. This information will be used to provide annual ryegrass growers new guidelines to help determine the best times to begin harvest. In addition to the moisture content and dew factors at the annual ryegrass site, a third study was done in the same annual ryegrass plots to determine if there is seed fill (maturation) in the crop following swathing as the crop cures in the field.

Materials and methods

<u>Perennial ryegrass.</u>

On-farm research plots were established in June 2004 at Lindsay Farms near Shedd, Oregon. The field was planted to perennial ryegrass (var. Calypso II) in late May 2003 for a first crop in 2004. The site received 225 lb/a of a fertilizer blend (11-0-30-12) in the fall. Spring 2004 fertility included 250 lb/a of 15-10-10 on March 10 and a single application of 285 lb/a of 40% ureasol (40-0-0) on April 7 for a total spring nitrogen of 150 lb/a. The crop year total (fall + spring) for nitrogen was 175 lb/a. The crop was treated with Palisade® plant growth regulator at a rate of 1 pt/a on April 22. In addition, fungicides were applied to control rust on April 22, May 20, June 1, and June 5. Plots were swathed on July 5, 8, and 12 depending on seed moisture content, then all plots were combined on July 19. Harvested seed yield was determined using a Brent® yield cart to weigh combined plots and sub-samples were also obtained at the same time for cleanout, seed size, and germination tests. Cleanout was determined by using an M2-B clipper cleaner, seed size was measured by taking 1000 seed weights from combine run samples and germination tests were done according to OSTA rules. Seed shattering caused by swathing was estimated following swathing by taking quadrat measurements randomly in several places within the plots in both the open stand and under the windrow. Experimental design was set up as a 3 treatment randomized complete block with four replications. Analysis was done using SAS® statistical software.

<u>Annual ryegrass.</u>

Research plots were established at Hyslop Research Farm in the Winter of 2004 by no-till drilling annual ryegrass into a previous crop of meadowfoam. Following the meadowfoam harvest in 2003, the field was sprayed with 2 qt/a glyphosate on August 8, 2003 to control volunteer sprout and weeds. Additional control of seedling meadowfoam and other seedling sprout weeds was done with an application of 1 qt/a Curtail and 1 qt/a glyphosate on November 3. Pre-plant applications of glyphosate (2 qt/a) and Aim (1 oz/a) were done on February 10, 2004. On February 12, the field was no-till drilled with annual ryegrass at a seeding rate of 25 lb/a using a John Deere power drill. The new planting was fertilized with 300 lb/a of 16-16-16 (50 lb N/a) the following day. Additional fertilizer was applied on March 29 (100 lb N/a as urea) and April 12 (30 lb N/a as urea) for a total N application of 180 lb/a. The field also received an application of 1.5 pt/a Bronate and 0.5 oz/a Aim on April 7. Experimental design was set up as a 5 x 2 factorial with seed moisture content and dew as the two main factors replicated four times. There were five seed moisture contents (50, 45, 40, 35, 30%) at two dew levels (dew present and no dew present) for a total of 10 treatments. Analysis was done using SAS® statistical software. Plots were swathed using a modified JD 2280 swather and combined July 13 with a Hege 180 plot combine.

Samples for the seed maturation part of this study were taken concurrently with the five swathing times. Experimental design was set up as a split-plot factorial with seed moisture content (five seed moisture levels) as the main plot and field cure times (5 cure times) as sub-plots. Treatments were replicated four times. Each plot had 5 sub-samples (sub-plots) taken that were bagged into cloth sacks and left in the field to allow air drying as would occur in the windrows. The cure treatments were hand harvested by using a 12 inch quadrat across two rows and cutting at ground level then carefully inserting the heads into the sack to protect from losses due to shattering. The five cure dates in each plot were left in the field for a prescribed period of time, then removed and oven dried (approx 110° F) for 24 hours to dry the samples for threshing. The first cure date in each plot was oven dried immediately the day of swathing, three more samples were allowed to field dry (cure) for two, three, and five days respectively prior to oven drying, and the fifth cure sample was allowed to field dry until the large plots were combined. The cure date samples were hand threshed to remove the seed and conditioned using a table top clipper cleaner.

Results

Perennial ryegrass

Plots at Lindsay Farms were swathed at three different maturities that were determined by the grower. The first date was estimated to be 3-4 days prior to when the grower would normally swath, the second date was the normal grower swathing time, and the third date was about 3-4 days later than the normal swathing date. The seed moisture content in the plots for the three dates - July 5, 8, and 12 were 45, 36, and 29% respectively. Plots were swathed at approximately 10:00 AM each day. Seed yield (Table 1) was highest on the normal swath date (July 8) and was statistically lower on the later swath date (July 12). Yield on the first harvest date (July 5) was intermediate between the two other dates and not statistically different than either. Seed size as measured by 1000 seed weight was not affected by the different swathing dates, nor was cleanout. Germination tests resulted in no differences and ranged from 95.8 to 97 percent, a range of only 1.2 percent.

In addition to seed yield, shattered seed populations (Table 2) were estimated in the plots by counting actual seed on the ground (blank seeds were ignored). As seed moisture levels decreased, the shattered seed populations increased under the swaths indicating a rapid increase in shattered seed. The seed densities between the swaths did not change any as seed moisture decreased. These plots were harvested using a draper type deck on the swather. Because of the draper deck, there were few seed shattered between the windrows and it can be concluded that the losses in the windrow were primarily caused by the swathing process and not pre-swathing shatter. This may have been a contributing factor in the decrease in seed yield for the last swath date though it does not account for the all the difference.

Table 1. Harvest components in perennial ryegrass swathed at different seed moisture contents, Lindsay Farms, 2004.

Seed moisture at swathing	Seed yield		Clean-out	1000 seed wt.	Seed germ.
(swath date)	(lb/a)		(%)	(g)	(%)
45 (7/5)	1695	ab[1]	14.5	1.84	95.9
36 (7/8)*	1727	a	15.1	1.82	97.0
29 (7/12)	1662	b	14.5	1.87	95.8
LSD 0.05	48		NS	NS	NS

[1] Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values.
* Field swathing moisture content (grower norm).

Table 2. Seed shatter at swathing time in perennial ryegrass swathed at different seed moisture contents, Lindsay Farms, 2004.

	Estimated shattered seed density		
Seed moisture at swathing	Between swaths	Under swaths	Weighted average
(%)	---------------- (no. sq ft)	----------------	
45	2	17 a[1]	7 a
36	3	78 ab	28 ab
29	4	131 b	46 b
LSD 0.05	NS	82	28

[1] Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values.

Annual ryegrass

Seed Moisture and Dew. Annual ryegrass plots were swathed at the five different moisture contents listed in Table 3. Seed yield was highest at the 45 percent seed moisture. Harvesting below 40 percent seed moisture caused a rapid decline in seed yield. In addition, there was a significant seed moisture x dew interaction. The interaction, presented in Table 4, shows the benefit of swathing when humidity in the crop is high at times when seed moisture is below optimum levels. At 50 and 45 percent moisture, there was no difference in yield due to the presence or absence of dew on the crop. However, once the seed moisture dropped to 40 percent, yield was reduced by an average of 430 lb/a, equal to an average loss of 18% at the three lower seed moistures (40, 33, and 28 percent seed moisture, respectively). Shattering was visually evident when the plots were swathed under the drier conditions. Seed size (1000 seed weight) increased significantly as the crop was harvested at lower seed moistures. This is probably due to more than one factor, a couple of which may be the loss of the smaller seed at the distal end of the spikelets as they tend to shatter first, and the continued fill of seeds that did not shatter. The largest seed are at the base (proximal) of the spikelet and do not shatter as readily, thus increasing the portion of seed that is larger and hence increasing 1000 seed weights. There was no difference in germination of the seed harvested at these different seed moistures. Germination averaged from 97.7 to 98.3 percent.

Table 3. Seed yield, 1000 seed weight, and germination in annual ryegrass swathed at different seed moisture contents and dew levels, Hyslop Research Farm, 2004.

Treatment	Seed Yield	1000 seed wt.		Seed germination
	(lb/a)	(g)		(%)
Seed moisture % (swath date)				
50 (6/22)	2575	2.511	d[3]	98.0
45 (6/26)	2790	2.756	c	97.9
40 (6/28)	2594	2.870	b	97.9
33 (6/30)	2386	2.930	b	98.3
28 (7/2)	1906	3.047	a	97.7
LSD 0.05	*[1]	0.068		NS
Time of day				
Dew present [2]	2567	2.820		---
No dew present	2333	2.825		---
LSD 0.05	*[1]	NS		

[1] Significant interaction at $P<0.05$.
[2] Early morning for dew present, Early afternoon for no dew present.
[3] Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values.

Table 4. Seed yield interaction in annual ryegrass swathed at different seed moisture contents and time of day at Hyslop Research Farm, 2004.

Seed moisture at swathing	Dew present[1]		No dew		Difference (dew – no dew)
(%)	------------------	(lb/a)	--------------------		
50	2562	a[2]	2589	ab	(27)
45	2732	a	2848	a	(116)
40	2807	a	2382	bc	426
33	2607	a	2165	c	442
28	2129	b	1684	d	445
LSD 0.05	-------- 261 --------				

[1] Early morning, - with dew present; early afternoon - no dew present.
[2] Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values.

Maturation study. At the same time the seed moisture plots were swathed, hand harvested samples were taken in the un-cut portions of the large plots. The bagged samples were allowed to dry in-situ in the plots to mimic field drying conditions. Data for the maturation study are presented in Tables 5 and 6. The data under the Seed moisture section of Table 5 are the means of all five cure times at each seed moisture, and the data under the Cure duration section are the means of all five seed moistures at each cure time. Seed yield increased as seed moisture decreased from 50 percent down to 45 percent seed moisture, then yield peaked at 45 percent followed by a steady decrease in harvested seed yield down to the lowest seed moisture with the yield at 2016 lb/a. This represents a 33 percent decline in harvested seed in only six days. There was no seed yield response to cure time in the field. Seed yield responded similarly to what the large plots did but were somewhat higher in overall yield. This is probably due to less shatter that occurred during the sampling operations.

There was also a significant interaction of seed moisture content with field cure duration in the germination tests. The data from these germination tests are presented in Table 6. Seed germination was significantly less when the samples were taken at 50% seed moisture content and not allowed to cure in the field (first column in Table 6). Once the seed moisture content dropped to 45% the was very little effect in germination on how long the samples cured in the field. These data indicates that the seeds were probably not as fully mature when harvested at 50% than at lower moisture contents. Seed weight was also less in plots when harvested at the higher seed moisture contents indicating that there is continued seed fill even past the time of optimum swathing times. The loss of seed during harvest was far greater than any increase due to seed fill if the swathing was delayed.

Table 5. Seed yield, 1000 seed weight, and germination in annual ryegrass sampled at different seed moisture contents and different cure times in the field, 2004

Treatment	Seed yield	1000 seed wt.	Seed germination
	(lb/a)	(g)	(%)
Seed moisture			
50 %	2474 b[1]	2.595 c	96.1
45	3017 a	2.857 b	98.1
40	2798 ab	2.923 ab	97.8
33	2394 bc	2.991 ab	98.2
28	2016 c	3.003 a	98.0
LSD 0.05	419	0.144	*[2]
Cure duration			
No cure	2445	2.851	96.5
1 day	2507	2.829	98.2
2 days	2425	2.857	98.1
4 days	2558	2.833	97.6
Combined	2767	2.950	97.8
LSD 0.05	NS	NS	*[2]

[1] Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values.
[2] Significant interaction at P<0.05.

Table 6. Interaction of seed moisture content and field cure duration on germination of annual ryegrass, 2004

Field cure duration	Seed moisture (%) 50	45	40	33	28
Days	[Total germination (%)]				
0	91.87 c[1]	97.69 b	97.44 b	97.69 b	97.81 a
1	98.38 a	98.44 ab	97.81 ab	98.19 ab	98.25 a
2	97.75 a	98.00 ab	98.38 a	98.75 a	97.75 a
4	96.38 b	97.88 ab	97.50 b	97.94 b	98.06 a
C[2]	96.31 b	98.50 a	97.94 ab	98.19 ab	97.88 a
LSD 0.05	0.71				

[1] Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values.
[2] The day the plots were combined.

Conclusions

Seed moisture content is a useful tool in determining the range of maturity for maximizing yield in grass harvested for seed. In this first year of data the optimum time for swathing in the perennial ryegrass was at 36% seed moisture. These data indicate that cutting a few days early does not impact yield as much as cutting a few days late. The seed loss for cutting early (45% vs 36%) was about 32 lb/a but the yield loss by delaying from 36% down to 29% was twice the early cut amount at 65 lb/a. In the annual ryegrass trial, the optimum seed moisture content was at 45% seed moisture with losses increasing as moisture departed more than five percent from the optimum. However, some flexibility in delaying swathing time in annual ryegrass can be utilized if there is dew present on the crop. The effect of moisture on swathing time was not measured in the perennial ryegrass.

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PALISADE AND FIELD BURNING IN CREEPING RED FESCUE IN THE WILLAMETTE VALLEY

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

Introduction

Open-field burning has been an effective, economical, and widespread management tool to remove post-harvest residue in seed production fields of creeping red fescue, and other cool-season grasses. Field burning has considerable positive impacts on creeping red fescue seed yield. However, public concern over air pollution caused by open-field burning resulted in important, legislatively mandated reductions in the acreage burned per year in the Willamette Valley. Therefore, new practices have to be tested for maintaining high yields as field burning becomes less available.

The height of fall tillers in creeping red fescue was found to be inversely related with seed yield the following spring. The use of Palisade, a plant growth regulator (PGR), in fall applications might enhance seed yield as the stand ages, by reducing plant height during early regrowth. In addition, creeping red fescue grown for seed is prone to lodging, which generally results in lower yields. Spring applications of Palisade might be used to control plant height and therefore reduce lodging problems. Palisade applied in spring, might also increase panicle production contributing to higher yields. The use of Palisade could be an alternative practice to lessen the need for open-field burning in creeping red fescue, and still get high yields and seed quality that characterize Willamette Valley grass seed production.

Procedure

Field trials were conducted to determine the effects of Palisade application and residue management on seed yield and its components. A stand of Shademaster creeping red fescue was established on May 5, 1999 at Hyslop Farm, and six Palisade treatments were investigated and compared in burned vs. flailed stands in a split-plot design. Two rates of Palisade (1.4 pt/acre and 2.9 pt/acre) and two dates of application (early and late) were tested in fall, and one rate (2.9 pt/acre) and two application dates (early and late) in spring. One control with no Palisade application was included for each residue management. Dates of Palisade applications for each year are shown in Table 1.

Table 1. Calendar dates for PGR application.

Timing	2000/2001	2001/2002	2002/2003	2003/2004
Early fall	Oct 11	Oct 9	Oct 14	Oct 20
Late fall	Nov 6	Nov 9	Nov 21	Nov 22
Early spring	Apr 16	Apr 11	Apr 8	Apr 6
Late spring	May 3	Apr 30	Apr 28	Apr 27

Fertile tiller number and height were measured on two 1-ft^2 samples taken prior to peak anthesis from each plot. Total biomass, as well as fertile tiller biomass, was recorded. The seed yield components spikelets per panicle, and florets per spikelet were ascertained from panicles samples taken before peak anthesis. In 2003 and 2004, lodging was assessed prior to swathing by using a numerical scale from one (erect stands) to four (totally lodged stands) considering the general condition of each plot.

The crop was harvested with a small plot swather, and dried in windrows to approximately 12% seed water content. Dried windrows were threshed with a small plot combine and the seed was cleaned with an M-2B Clipper air-screen cleaner to determine clean yield.

Results

Overall, there was a tendency for decreasing seed yield as the stand aged, following the pattern normally seen in seed production fields in the Willamette Valley. Nevertheless, residue management and Palisade treatment effects on seed yield were different across years. Seed yield revealed a clear interaction between residue management and Palisade application in 2001, 2003 and 2004 (Figure 1). In 2002, there was a residue management and a Palisade treatment effect on seed yield, but no interaction was found.

In the first year (2001), relatively small differences in seed yield between burned and flailed plots were found (Figure 1). Only the plots with early fall Palisade application yielded more when burned than when flailed. By the second year (2002), yield from burned plots was 20% greater than that of flailed plots, regardless of Palisade application. Differences in seed yield between burned and non-burned plots were even greater in the third (2003) and fourth (2004) year. The increased magnitude in seed yield differences in burned plots as the stand aged was due, in part, to greater number of spikelets per panicle in 2002, 2003, and 2004, and a greater number of panicles per unit area in 2003 and 2004, for burned plots (Table 2). These differences were evident regardless of Palisade application. The increased number of fertile tillers, when multiplied by the increased number of spikelets per panicle, resulted in a greater number of florets per unit area and therefore, higher yields for burned plots. The increased number of spikelets per panicle in burned plots was paired with an increased length of panicles to accommodate the greater number of spikelets.

In 2001, there were no differences in seed yield between burned and flailed plots with spring application of Palisade. However, in 2002, 2003, and 2004, spring applications on burned plots resulted in greater yields than spring applications on flailed plots. Spring applications increased yield by 40% on both burned and flailed treatments in 2001, and nearly by 50% in 2002. In 2003 and 2004, there was a differential response to spring applications between burned and flailed plots. Palisade applications in spring increased yield on burned plots by 44 and 36% over the untreated check in 2003 and 2004, respectively, and there was nearly no difference between spring treated and the untreated check within flailed plots. Early and late spring applications resulted in similar seed yields in the four years. In 2001, increases in yield in spring-treated plots were attributable to a combination of slightly increased flowering (floret number) and estimated seed set (Table 3). In 2002, spring applications did not improve flowering, but showed a trend toward increased seed set. The estimated seed set was very high for both spring applications in 2002. In 2003 and 2004, there was a trend towards an increased floret number in spring treated plots, and towards a greater seed set in both fall and spring treated plots.

Spring Palisade applications reduced both fertile tiller height and lodging in 2003 and 2004, regardless of residue management. In 2003, spring Palisade applications resulted in 63% reduction in lodging over the untreated check and, in 2004, the reduction in lodging was 58%. This reduction might have resulted in a better environment around anthesis, less shading during seed filling, and made swathing easier.

The rate of fall application had no consistent effect on seed yield. Fall application of Palisade did not increase seed yield during any of the four years, except for a modest increase in seed yield in non-burned plots when applied late in fall of the second year (2002). In general, burned plots out-yielded failed ones with or without fall Palisade application in the four years.

When the cumulative seed yield was analyzed, it was not surprising to find that burned and spring treated plots had greater seed yield at the end of the four years, representing an equivalent of 1.5 additional harvests over the untreated burned check by the end of the stand life. Fall Palisade treatments did not result in a cumulative seed yield increase in any of the residue management treatments.

Harvest index (HI) was not affected by residue management or Palisade treatment in 2001. However, in 2002, spring treated plots had a 48% increase in HI over the untreated check, regardless of residue management. The response of HI to the different treatment combinations in 2003 and 2004 was similar to that found for seed yield in those years. Burned plots with spring Palisade applications showed 88 and 100% greater HI than the untreated burned-check in 2003 and 2004, respectively. There was no difference in HI within flailed plots, and HI tended to be greater in burned plots than in flailed ones, regardless of Palisade application.

Consequently, spring applications of Palisade on unburned plots consistently increased seed yield over the untreated burned control in the first two years. Nevertheless, in the third and fourth year this increase was no longer evident. In addition, burned plots out-yielded flail ones with early fall Palisade application in 2001, and over all treatments the subsequent three years. The use of Palisade in fall applications is not a viable alternative to replace open-field burning in creeping red fescue seed production in the Willamette Valley. Open-field burning plus spring application of Palisade seems to be the best management tool to obtain high seed yields in creeping red fescue seed production fields in the Willamette Valley. Both open-field burning and spring Palisade application resulted in a more efficient crop, reflected in the greater HI, especially as the stand aged.

Table 2. Effect of residue management on yield components in Shademaster creeping red fescue.

Characteristic	Residue	2001	2002	2003	2004
Panicles/ft^2	Burn	365	403	256 a	272 a
	Flail	349	377	117 b	161 b
Spikelets/Panicle	Burn	33	28 a*	34 a	33 a
	Flail	32	23 b	28 b	28 b
Florets/Spikelet	Burn	4.8	4.6	6.9	5.9
	Flail	4.8	4.7	6.4	5.8
Panicle length (cm)	Burn	13.4	11.9 a	13.1 a	12.9 a
	Flail	12.9	10.4 b	11.7 b	11.3 b
Above-ground dry weight (g/ft^2)	Burn	185	165	118 a	105 §
	Flail	143	139	76 b	99

* Means in columns, within each characteristic, followed by a different letter are significantly different by Fisher's protected LSD values (p= 0.05).
§ In 2004, there was an interaction between residue and Palisade treatments for above ground dry weight.

Table 3. Palisade treatment and date of application effects on florets/spikelet and estimated seed set in Shademaster creeping red fescue. Palisade treatment legend: EF= early fall; LF= late fall; ES= early spring; LS= late spring.

Palisade Treatment	Florets/spikelet				Seed set (%)			
	2001	2002	2003	2004	2001	2002	2003	2004
Untreated	4.8 b*	4.4	6.7 abc	5.6 b	16.7	21.7	11.8	17.1
EF 1.4 pt/a	4.7 b	4.5	6.6 bcd	5.8 b	17.5	23.7	12.0	18.6
EF 2.9 pt/a	5.0 ab	4.8	6.5 bcd	5.6 b	18.9	24.1	15.1	18.0
LF 1.4 pt/a	4.4 b	4.4	6.2 d	5.6 b	19.8	24.3	12.5	16.7
LF 2.9 pt/a	4.6 b	4.6	6.4 cd	5.7 b	16.2	25.6	13.8	16.5
ES 2.9 pt/a	5.4 a	4.9	7.0 a	6.4 a	21.0	32.5	12.9	23.8
LS 2.9 pt/a	4.9 ab	4.8	6.9 ab	6.1 ab	22.7	31.5	16.2	19.8

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

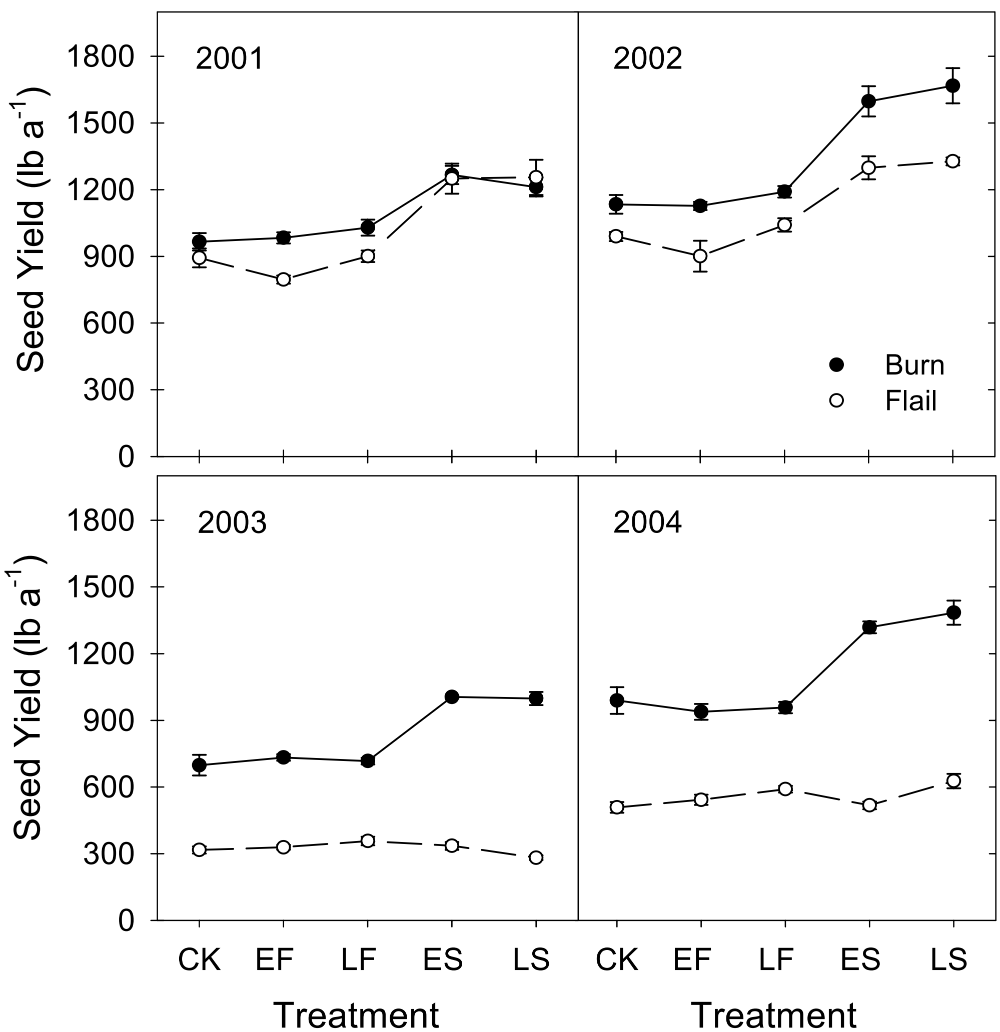

Figure 1. Effect and interaction of residue management and Palisade treatment on seed yield of Shademaster creeping red fescue in first year (2001), second year (2002), third year (2003) and, fourth year (2004). As there were no differences between the two fall rates, an average of the two rates is presented for both fall treatments for graphing purposes. Treatment legend: CK= control; EF= average of two early fall treatments; LF= average of the two late fall treatments; ES= early spring; LS= late spring .Vertical bars represent one standard error of the mean for each treatment combination. Where error bars are not visible, they are obscured by the data symbols.

RESPONSE OF FINE FESCUE SEED CROP CULTIVARS TO RESIDUE MANAGEMENT PRACTICES IN THE WILLAMETTE VALLEY

D.D. Schumacher, T.G. Chastain, C.J. Garbacik and W.C. Young lll

Post-harvest residue management in fine fescue seed production has historically consisted of open-field burning of full straw load. This practice is used to dispose of straw, control disease, recycle nutrients, maintain production costs, control volunteer seedlings, and maintain crown size. Open-field burning has been documented as beneficial to subsequent seed yield in three commercially produced fine fescue subspecies [Chewings fescue (Festuca. *rubra* ssp. *commutata* Gaud.), creeping red fescue (F. *rubra* L. ssp. *rubra*), and slender red fescue (F. *rubra* L. ssp. *littoralis* (Meyer) Auquier)].

Chewings fescue has a bunch growth habit, and some seed yields have been reported to be acceptable under non-thermal residue management practices. However, both creeping red fescue and slender red fescue have a rhizomatous growth habit and previous studies have indicated that seed yields following non-thermal residue management practices are reduced. A growing body of evidence indicates that increased rhizome production occurs under nonthermal methods, and that increased rhizome numbers are directly associated with low seed yields and unacceptable economic returns. A better understanding of the cause for decline in yield in fine fescue seed crops is needed to develop new non-thermal management alternatives.

Results of this research will be utilized to catalog an index of responses to thermal and nonthermal residue management practices to aid producers in establishing economically feasible methods of post-harvest residue management. The objectives of this research include: (i) identify the genetic variability in seed yield responses of fine fescue seed crops and cultivars to thermal and nonthermal post-harvest residue management; (ii) characterize differences in yield components of cultivars among treatments; (iii) ascertain whether response to post-harvest residue treatments is cultivar specific; and (iv) develop potential alternative residue management practices for Willamette Valley fine fescue producers.

Procedure

Field trials were established at Hyslop Research Farm, Corvallis, Oregon in fall 2000. Trials were arranged in a strip-plot design with four replications of plots that measure 10x50 ft. Ten cultivars of fine fescue were selected for this research: four cultivars of Chewings fescue ('SR5100', 'Southport', 'Brittany' and 'Barnica'); four cultivars of creeping red fescue ('Shademaster', 'Cindy', 'Silverlawn' and 'Shademark'); and two cultivars of slender red fescue ('Seabreeze' and 'Marker'). Residue management strategies examined in these trials include: (i) removal of straw by open burning (OB); (ii) removal of straw by baling, then flail chopping low (FL); and (iii) removal of straw by baling, then flail chopping high (FH). Residue management research was conducted in 2002, 2003, and 2004, after the first, second, and third seed harvests in each trial, respectively.

Seed yield components measured include tiller weight, fertile tiller number, spikelets per panicle, florets per spikelet, and panicle length. Plots were harvested with a plot swather and plot combine. Bulk seed sacks were used to determine bulk seed dirt weight. Seed yield and percent cleanout were determined for each cultivar. In 2003 and 2004, subsamples were cleaned to determine 1000 seed weight.

2003 Results

In 2003, open-burning increased seed yield in most subspecies and cultivars (Table 1, Figure 1). However, FL treatment provided acceptable yields in two of the Chewings fescue cultivars and in one cultivar of slender red fescue (Table 1). In contrast, Chewings fescue seed yields did not benefit by the thermal treatment in 'Barnica' and 'Brittany'. However, seed yield of 'Southport' and 'SR 5100' were increased under thermal conditions (Table 1, Figure 1). Strong creeping red fescue had low and economically unacceptable yields across all nonthermal methods. Furthermore, the FH methods produced low seed yields across all cultivars, except one cultivar of slender red fescue, 'Marker'.

Thousand seed weight, panicle length, and florets per spikelet remained relatively constant across all treatments and cultivars. Cultivars displayed differences among treatments in spikelets per panicle and fertile tiller number (data not shown). This provides evidence of different potential seed yield among the cultivars tested.

Seed yield response to residue management in 2003 can be attributed to increased fertile tiller number and spikelets per panicle (Figure 1). Adequate autumn tillering and subsequent spring fertile tiller number are fundamental to high seed yields.

Despite observed differences in yields among subspecies and cultivars within subspecies, differences in yield increase between different cultivars can be attributed to the genetic yield potential of each cultivar, not any specific treatment imposed upon them. This is substantiated by a significant cultivar treatment interaction observed in 2003.

OB and FL treatments had similar seed yield responses in all Chewings fescue cultivars and in one slender red fescue cultivar. Creeping red fescue showed the greatest seed yield reduction in response to nonthermal methods.

Table1. Effect of residue treatment and cultivar on seed yield of Chewings fescue, strong creeping, and slender red fescue in 2003 and 2004.

		2003						2004					
		Flail				Open		Flail				Open	
Species	Cultivar	High		Low		Burn		High		Low		Burn	
		(lb/a)											
Chewings	SR5100	1078	a[1]	1118	b	1165	b	1074	a[1]	1040	b	1672	c
	Southport	770	b	843	ef	850	d	918	b	825	d	1443	d
	Brittany	1087	a	1243	a	1230	ab	1037	b	1036	b	1731	b
	Barnica	788	b	806	ef	776	e	1183	a	1140	b	1223	e
Strong	Shademaster	576	c	666	gh	919	cd	902	c	953	c	1771	b
Creeper	Cindy	579	c	722	fg	832	d	854	c	1024	b	1850	b
	Silverlawn	848	b	888	de	994	c	949	b	882	c	1477	d
	Shademark	866	b	1084	bc	1346	a	1198	a	1401	a	2423	a
Slender	Seabreeze	460	c	550	h	631	f	592	d	674	e	600	g
Creeper	Marker	1069	a	989	cd	821	de	859	c	922	c	745	f
Residue treatment means		816	b[2]	891	a	956	a	957	b[2]	990	b	1494	a

[1]Means in *columns* followed by the same letter are not significant different by Fisher's protected LSD values (P = 0.05).
[2]Means in this *row* followed by the same letter are not significantly different by Fisher's protected LSD value (P = 0.05).

In 2003, OB was beneficial to seed yield in most fine fescue subspecies the following crop year. However, previous studies indicate that FL methods can produce acceptable yields in Chewings fescue by reducing crown biomass and vegetative tiller regrowth. In contrast, the FH treatment did not reduce crown biomass or vegetative tiller production, which resulted in inferior seed yield across most subspecies in this experiment to date.

2004 Results

In 2004, 1000 seed weight and florets per spikelet remained unchanged. However, panicle length was significantly greater for OB plots. This may be a morphological change responsible for supporting an increased number of spikelets as well as heavier seeds within these spikelets.

Flail treatments produced lower seed yields in relation to field burning than in previous years. This confirms some of our earlier findings where field burning treatments best maintained yield over the life of the stand. OB provided greatest yields in all subspecies and cultivars except 'Marker' and 'Seabreeze' slender red fescue cultivars (Table 1, Figure 1).

Examination of 2004 data found that OB was critical in maintaining seed yields in strong creeping red fescue and Chewing's fescue. In contrast, slender red fescue had lower yields under OB, with FH exhibiting the greatest yields (Table 1, Figure 1). Cost analysis may be crucial in determining whether lower yields in slender red fescue under OB offsets the higher yields and increased costs of FH and FL residue management.

Furthermore, in 2004, FH resulted in yields superior to FL. The mechanism of this process may indicate there is a relationship between FH and stand age. The severity of flail height of stubble was dependent on the stand age. Young stands were able to survive FL stubble height in second seed harvest (2003), but not in the third crop year (2004).

Moreover, with respect to fertile tiller number, a significant treatment by cultivar interaction occurred (Figure 1). However, OB resulted in lower cleanout than either FH or FL treatments.

In conclusion, results of this study demonstrate that OB is effective in maintaining or improving seed yields regardless of stand age. A strong emphasis on OB of strong creeping red fescue and Chewings fescue acres needs to be a priority when field burning acreage is being allocated.

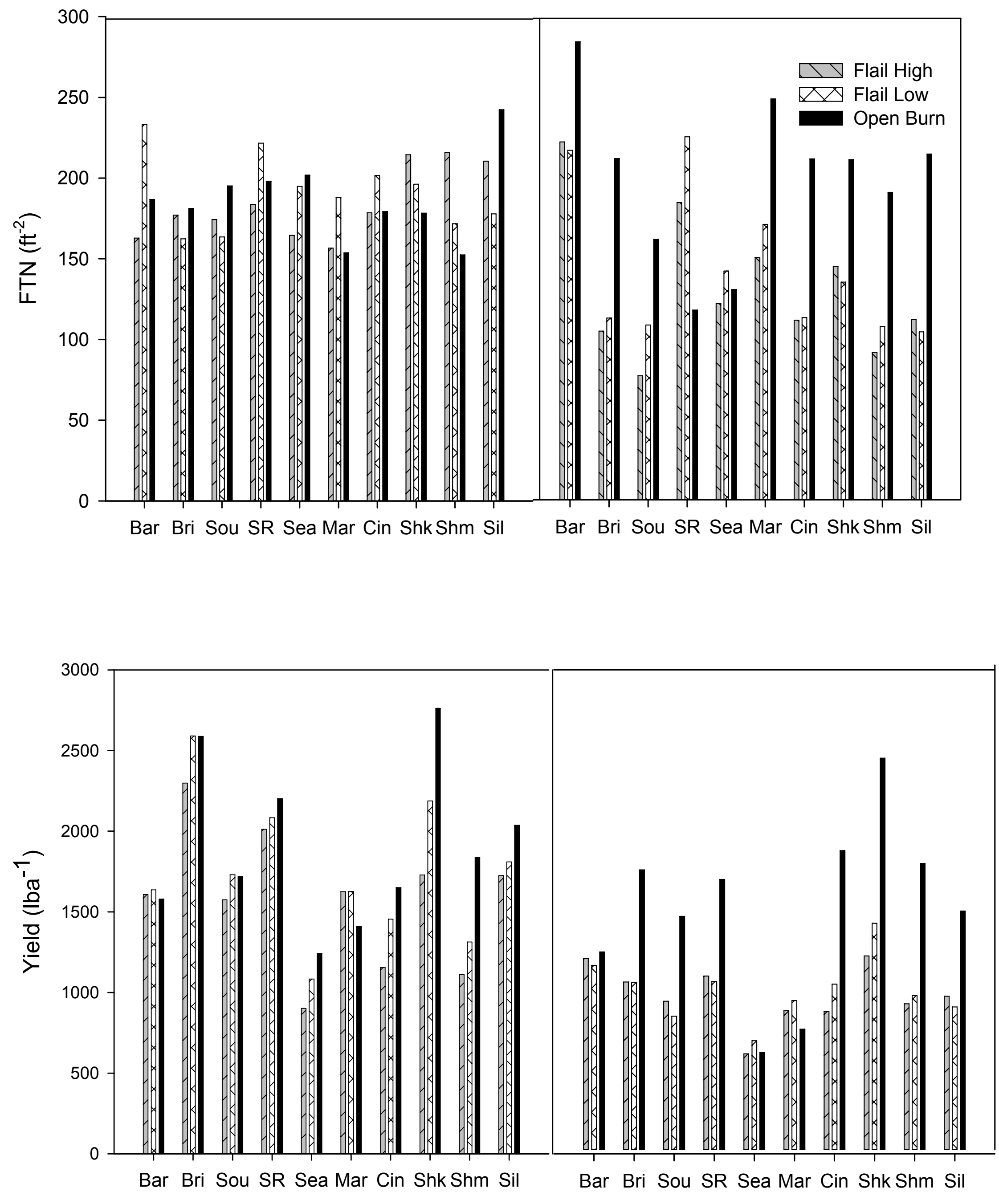

Figure 1. Seed yield and fertile tiller number in ten cultivars of fine fescue (Festuca rubra L.) Bar: Barnica; Bri: Brittany; Sou: Southport; SR: SR5100; Sea: Seabreeze; Mar: Marker; Cin: Cindy; Shk: Shademark: Shm: Shademaster; Sil: Silverlawn, under three methods of residue management in 2003 (left) and 2004 (right).

EFFECTS OF DIRECT SEEDING AND FULL CHOP-BACK RESIDUE MANAGEMENT IN PERENNIAL GRASS SEED PRODUCTION

J.J. Steiner, S.M. Griffith, G.W. Mueller-Warrant, G.W. Whittaker, G.M. Banowetz and L.F. Elliott

At the request of the Oregon Seed Industry and the Oregon Department of Agriculture, we conducted a study from 1992 to 2001 to determine the effects of direct seeding and full chop-back residue management on perennial grass seed production. The purpose for the research at the time was to find alternative ways to produce grass seed without open field burning. Even though the phase-down in field burning was the chief catalyst for this research, economic pressures and legislative actions addressing concerns about natural resource quality have placed further pressure on other grass seed production practices.

Our research was done at three locations that represented a range of seed production conditions in the Willamette Valley. Perennial ryegrass was grown on a poorly drained soil in Linn County, tall fescue grown on a poor-to-moderate drained soil in Benton County, and creeping red fescue on a well-drained soil that easily erodes in the Silverton Hills of Marion County. Even though different combinations of rotation crops were used with the different grass seed crops, common to each site were comparisons of conventional tillage vs. no-tillage establishment and minimal vs. maximal post-harvest straw amounts returned to the field after seed harvest. A total of 73 harvest-year combinations replicated four times were looked at for the three crops over the life of the research experiment. All of the experiments were conducted without burning straw after seed harvest.

Direct Seeding Establishment

Our findings showed perennial ryegrass and tall fescue seed yields were greater when using direct seeding than for conventional tillage (Table 1). Creeping red fescue seed yield was the same when comparing direct seeding with conventional tillage establishment. However, creeping red fescue seed yield in the first seed harvest-year in conventionally tilled stands was greater than that obtained using direct seeding, but declined each of the two following years. Seed yield in the direct-seeded plots did not decrease until the third harvest-year.

A partial budget analysis of establishment costs showed the creeping red fescue system had the greatest establishment cost savings compared to conventional establishment costs ($162 per acre). Lesser but substantial savings were also gained for perennial ryegrass ($46 per acre) and tall fescue ($27 per acre) using direct seeding. The greatest single expense in the no-tillage establishment systems was the cost of the non-selective herbicide needed to kill the established perennial grass stands when changing crops. Greater amounts of herbicide were required for each of the three crops (TF > CRF > PRG), and accounted for the differences in direct-seeding establishment costs.

The reason for the greatest savings for creeping red fescue is the substitution of chemical removal of established stands instead of the use of as many as 15 or more tillage operations applied from after the time of the last seed-year harvest in July until planting a new stand the following spring. Fields prepared for perennial ryegrass and tall fescue seed fields require fewer tillage operations to prepare field for planting because of the relative ease to kill these crops with tillage.

Given that direct seeding either resulted in increased seed yields or no adverse affect on seed yield for the three crops we investigated, the savings in establishment costs when using direct seeding can assure increased net farm income to growers, even if seed yields are not increased. Direct seeding also has the benefit of reducing the amount of soil lost annually to erosion, particularly in creeping red fescue seed production (Table 1).

Full Chop-back Residue Management

Across all production practice combinations, maximal residue management using full straw chop-back did not adversely affect grass seed yield. Even though tall fescue and creeping red fescue seed yields tended to decline with increasing stand age, their seed yield was unaffected by the amount of straw residue remaining after harvest in these non-burned systems. Implementation of maximal residue management did not cause a more rapid decline in seed yield compared to residue removed by raking and baling.

The cost of removing straw after raking and baling followed by a single flail chop is more expensive than the typical maximal residue management practice of twice flail chopping the straw ($27 vs. $5 per acre). However, seed growers who choose low residue management generally do so at no expense because brokers who market the straw accrue all straw removal expenses. The cost savings using a direct-seeded with maximal residue management conservation system were 60, 76, and 84%, respectively, compared to the standard farm practice of using conventional tillage and low residue amount after harvest by either burning the straw or removing it by baling.

What are Farmers Doing

Full straw load chop-back management is more widely used by farmers in large-scale production than direct seeding. However, 80 to 85% of grass seed growers have as much straw as possible removed by baling on the perennial ryegrass and tall fescue fields that are not burned. Those growers using full chop-back residue management perceive a benefit from returning organic matter back to their fields. Once alternative herbicide strategies were identified, emerging weed control problems associated with non-burn culture were greatly reduced where full residue management is used. However, there seems to be general agreement among farmers that more needs to be done to control insect and slug pest problems in fields with full chop-back straw loads.

Large-scale use of direct seeding establishment of perennial ryegrass and tall fescue has just begun to be adopted by some farmers in western Oregon. New-generation direct seed drills, not available in the early 1990s when this research was begun, are now available and being used to plant grass seed and other crops. The primary motivations for adaptation of direct seeding are reduced fuel costs for crop establishment, less time required for field preparation that has increased personal time for family activities, and reduced purchased labor costs. It is anticipated that when new tractors need to be purchased, fewer horsepower units will be acquired.

As with maximal residue management, questions have been raised regarding the impact of direct-seeding establishment on slug populations, particularly in autumn-seeded perennial ryegrass seed fields. Our research showed that we needed to do spring over-seeding as often for conventional tillage as for direct seeded plots. The impact of herbicide carry-over from previous crops in the rotation sequence is another concern. Also, maintaining genetic purity when changing to a different cultivar of the same grass species in a continuous grass crop rotation may be problematic because shattered seeds can germinate and contaminate the newly planted cultivar. Introduction of non-grass crops into rotation sequences could help to ensure genetic standards are met. We found that we could not do continuous creeping red fescue using direct seeding because of crop plant carry-over to the next planted stand.

Our findings are the first to describe the suitability of direct-seeding establishment used in combination with full chop-back residue management in perennial grass seed production systems. This research provides information to assist farmers in making decisions concerning alternative economic options to previous practices that include conventional tillage establishment with post-harvest residue removed from fields by burning or baling.

Table 1. Comparisons of direct seeding with conventional tillage establishment methods on seed yield, establishment costs, and average annual erosion for three perennial grass seed crops grown in western Oregon. Establishment costs are for partial budget expenses. Soil erosion is estimated using the Revised Universal Soil Loss Equation (RUSLE) and full straw chop-back amount with direct seeding and rake-and-bale straw removal for tillage establishment.

	Establishment method					
Crop	Direct	Tillage	Direct	Tillage	Direct	Tillage
	Seed yield (lb/a)		Establishment cost ($/a)		Soil erosion (t/a/yr)	
Perennial ryegrass	1,330 a	1,137 b	17	63	0.1	1.3
Tall fescue	1,276 a	1,056 b	36	63	0.1	1.8
Creeping red fescue	539	546	26	188	0.9	5.9

Seed yield means within a row for each grass species followed by a different letter are significant at $P \leq 0.05$.

A COMPARISON OF NO-TILL DRILLS IN ESTABLISHING PERENNIAL RYEGRASS FOR SEED PRODUCTION

W.C. Young III, G.A. Gingrich and T.B. Silberstein

In order to reduce soil loss on highly erodable soils typical in Oregon's Silverton Hills, agricultural producers have used long rotation perennial crops (3+ years) such as fine fescue and bentgrass to control erosion. However, as economic competition from shorter rotation crops such as perennial ryegrass (2-3 years) encroach on this agricultural land, effective methods for establishing this crop are needed that reduce soil disturbance and keep erosion at a minimum over a wide range of slopes. Though local growers have no-till type drills, stands are often poorly established on steep slopes because of improper seed placement from the drills. Modern direct seeding implements are becoming more adapted to planting small seeded crops into unworked soil. Thus, there is a need to compare the efficiency of these new drills with traditional equipment to determine if they are better suited to provide good stand establishment in Silverton Hills area.

Materials and methods

In this study, four commercial drills were evaluated by comparing stand establishment of the crop and the resulting seed yield. Perennial ryegrass (var. Splendid) plots were established on October 24, 2003 using four different no-till type drills. The previous creeping red fescue crop was open burned following the 2003 seed harvest. The site received 300 lb/a 10-20-20 (Sept. 29), one ton/a dolomite (Oct. 8) and was sprayed with 6 pt/a glyphosate one week before planting (Oct. 17). Seeding rate was targeted to be about 7 lb/a. Plots were planted using four commercially available drills:

1) Tye drill (grower normal)
2) John Deere 1590
3) John Deere 1890 CSS (air assist)
4) Great Plains

A blended fertilizer (15-0-15-18) was applied on January 20 and March 1, 2004 to total 220 lb/a material (33 lb N/a). Additional spring N was split applied in March and April with solution 32 to total 130 lb N/a, resulting in a season total of 163 lb N/a. The site was sprayed for broadleaf weeds on April 10, and treated with Palisade plant growth regulator (3/4 pt/a) on May 12. In addition, fungicide applications to control rust were applied on May 24, June 16, and July 2.

Plots were measured for plant density on February 20 and April 6, 2004 using a five foot diameter measuring wheel. The measuring wheel was equipped with five gap gauges (one inch gaps) mounted on the rim of the wheel at one foot intervals. As the wheel is rolled parallel to the crop row, the gap gauges rotate to a position directly over the row bracketing a one inch interval. Presence of any part of a seedling plant (leaf, tiller, etc.) within the gauge was recorded as a "hit" and bare ground was recorded as a "miss" on a tally counter. Four different rows in each plot were measured along 250 feet of row for a total of 1000 feet per plot. Measuring 1000 feet of row equals 1000 "hits" or "misses" in the plot giving an estimate of the percentage of one inch gaps in the stand. This was done in all 16 plots for a total of 16,000 data points (4 drills x 4 reps x 1000).

It should be noted that this is only a qualitative measurement of the presence or absence of a plant in the row. This does not measure differences in actual plant populations resulting from varied emergence caused by different seeding rates and planting depths. An assumed seeding rate of 7 lb/a should result in an approximate seedling population of 15-20 seedlings per foot of row. If the drill evenly spaced the seeds there should be at least one seedling per inch of row, hence the one inch gap measurements.

Fertile tiller density was determined by in-situ counts using a 12 inch quadrat. Four random observations were taken in each plot to compare stand densities. Seed yield was measured using grower equipment to harvest. Each plot was swathed (July 19) down the center and then combined (July 28). A yield cart was used to measure combined plot 'dirt' seed yields. Sub-samples were taken from each plot to assess seed cleanout for final yield, 1000 seed weights and germination.

Results

Stand establishment

Seedling stand measurements in Winter and Spring were found to differ by drill treatments (Table 1). Plots planted with the JD 1890 CSS drill resulted in a more uniform stand visually and had the highest percent of "hits". Plots established with the Tye and JD 1590 drills appeared less uniform than the JD 1890, and had about the same stand density estimate when compared with each other. Stand density in the plots established with the Great Plains drill was substantially less and had larger areas of no plant emergence in February, but this improved considerably by the April measurement. The direct cause of this is not known, but differences in seeding rate and planting depth may have hindered seedling emergence.

Table 1. Stand density measurements in Winter and Spring, 2004

Drill	Average percent of "hits" February		April	
Great Plains	54	c[1]	85	c
JD 1590	79	b	97	b
JD 1890 CSS	92	a	99	a
Tye	84	b	98	ab
LSD 0.05	5		2	

[1] Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values.

Seed yield and yield components

There were no differences in fertile tiller number between the four no-till drills (Table 2). Tiller densities ranged from 256 to 290 fertile tillers per square foot. Comparing this with the spring stand counts in Table 1, it is apparent that plants were able to compensate for differences in initial plant densities through additional vegetative tillering and subsequent reproductive development – especially the plots seeded with the Great Plains drill.

Final seed yield was statistically the same across all four no-till drill plantings (Table 2). Yield means varied from 1682 to 1731 lb/a, a range of only 49 lb/a. In addition, 1000 seed weight was unaffected by establishment method.

Table 2. Seed yield, seed size and fertile tiller density measurements comparing four No-till drills

Drill	Seed yield	1000 seed weight	Fertile tiller density
	(lb/a)	(g)	(no./sq ft)
Great Plains	1682	1.99	258
JD 1590	1685	1.89	256
JD 1890 CSS	1731	1.97	290
Tye	1715	1.95	265
LSD 0.05	NS	NS	NS

Summary

These data indicate that the drills compared in this trial were capable of effectively planting into an untilled stand and, providing the conditions for germination are adequate, no difference in seed crop yield should be expected. In addition, the absence of portions of a stand in winter can be adequately made up by harvest time if conditions are right.

NURSE CROPS FOR EROSION CONTROL IN NEWLY-PLANTED GRASS SEED FIELDS

S. Aldrich-Markham and R.E. Peachey

Grass seed fields in the Willamette Valley of Oregon are vulnerable to soil erosion during their establishment period. Not only is the soil sediment from eroded fields detrimental to waterways, the herbicide diuron, which is typically applied at planting, can be carried to waterways attached to the soil particles. Fields are typically planted in October into a smooth seedbed in 10- to 14-inch rows. Rainfall is 40 inches or more per year, falling mostly during the winter when the crop plants are still small and there is little vegetation to hold the soil. Approximately 450,000 acres of grass for seed production are grown in the Willamette Valley. About 20% of these, or 90,000 acres, are newly-planted fields of perennial species.

Since excellent grassy weed control is required in grass seed production, the crop is typically carbon-band planted, with a one-inch wide band of activated charcoal applied as a slurry directly over the seed row. This is followed by an application of diuron over the field. Weed seedlings germinating between the rows are killed, while the charcoal band adsorbs the diuron and protects the crop seedlings. The seedbed must be smooth in order to precisely apply the charcoal band. Any practice for controlling erosion must be compatible with the carbon-band planting system.

This research investigated the feasibility of planting a nurse crop in the field just prior to planting the grass seed crop. A suitable nurse crop species would grow more quickly than the grass in the fall and provide both vegetative cover and root mass to hold the soil. Two requirements for this nurse crop are: 1) it must be able to survive the diuron applied with the carbon-band seeding and 2) it must be able to be removed, without injuring the grass, around the first of March, before it gets so large that it starts to choke out the grass. A nurse crop might be planted only across the sloping parts of a field in contour strips or planted in swales that are particularly susceptible to erosion.

Previous research by the authors had demonstrated that spring oats (planted 1.5 inches deep) can tolerate diuron and that even the least hardy spring oat varieties survive typical winter temperatures in the area. The most effective herbicide for removing an oat nurse crop, Horizon or fenoxaprop (which gave about 80% control), was taken off the market by the manufacturer in 2000 and is no longer labeled for use in grass seed. One goal was to find a labeled herbicide or combination that could remove spring oats without injuring the grass.

2001-2002 Methods

A nurse crop strip of Cayuse spring oats approximately 25 ft wide was planted in mid-October by the growers in each of three fields, two perennial ryegrass and one tall fescue, located in the Dayton and Rickreall areas. The seeding rate was approximately 100 lb/a. Before the nurse crop emerged, the growers carbon-band planted their grass seed crops and applied diuron. In December the growers also applied ethofumesate (Nortron) for grassy weed control. Ethofumesate has some activity on oats, but by this time the plants were so large (3-4 leaves) that the only effect was slight stunting.

A trial was conducted in one perennial ryegrass field to compare herbicides labeled for grass seed on both their ability to remove the nurse crop and on injury to the grass seed crop. The nurse crops stands in the other two fields were not uniform enough for conducting this type of trial. Plots were 10 feet by 25 feet. Three treatments with three replications – glufosinate (Rely), oxyfluorfen (Goal), and glufosinate plus oxyfluorfen – were applied on 23 February 2002 using a backpack CO_2 sprayer. After the final evaluation in early April, the oats remaining in the check plots, as well as the nurse crop stand in the other perennial ryegrass field, were sprayed with glufosinate to remove them. In the tall fescue field, where the grass and nurse crop were irrigated at planting, the oats were so large that they needed to be sprayed with glufosinate in early February then mowed two weeks later to reduce the competition with the crop.

Results and Discussion

The herbicide treatments were evaluated visually on 2 April 2002 for percent oat control (Table 1). The perennial ryegrass stand was not killed by any of the treatments (no sections of rows were missing), although the grass was stunted from the combination of herbicide injury and competition from the oat nurse crop. Glufosinate alone and glufosinate plus oxyfluorfen reduced the oat biomass by 85-90%, thus reducing the competition with the grass seed crop to an acceptable level. However, the oat plants that survived still produced seedheads. Small seeds from these stunted plants (so-called "pin oats") are difficult to clean out of grass seed, so they are a worse contaminant than regular-sized oats. Based on a visual estimate of the number of oat plants either alive or dead, glufosinate alone and glufosinate plus oxyfluorfen gave only 65% control. Because of the seed contamination problem, this level of control is less than acceptable.

The serendipitous occurrence of a stand of volunteer meadowfoam (*Limnanthes alba*) from seed left in this field after the previous crop gave the idea for another possible nurse crop species. This meadowfoam had survived the diuron and was thick enough to provide even more vegetative cover than the oats. Another herbicide treatment added to the plots showed that meadowfoam could be 100% controlled with carfentrazone (Aim), already labeled for grass seed, at

Table 1. Percent control of the spring oats nurse crop on 4/2/02 in a perennial ryegrass seed field.

Herbicide	Rate	Date applied	Oat growth stage	% Oat control (biomass)	% Oat control (living plants)
Glufosinate	0.375 lb a.i./a	2/28/02	6-in, 5 leaves	85	65
Oxyfluorfen	0.375 lb a.i./a	2/28/02	6-in, 5 leaves	45	5
Glufos + oxyfluor	0.375 + 0.375 lb a.i./a	2/28/02	6-in, 5 leaves	90	65
Check				0	0

0.025 lb a.i./a, with no crop injury. An easy-to-kill nurse crop would make the nurse crop practice more readily adoptable by growers.

2002-2003 Methods

Nurse crop trials comparing meadowfoam, Regreen (a sterile wheat/rye hybrid) and no cover were established with three replications in four growers' fields, located in the Dayton, Newberg and Suver areas. The nurse crops were planted by the researchers using a seed drill. The seeding rate was 25 lb/a for the meadowfoam and 40 lbs/a for the Regreen. The plots, approximately 35 feet wide by 40 feet deep, were laid out in a contour strip across the slope. Slopes were uniform in each field, ranging from about 5 to 8%. Each grower then carbon-band planted perennial ryegrass and applied diuron before the nurse crops emerged.

In one field, planted in early October, both the grass seed crop and nurse crops failed because of lack of rain. In the other three fields, planted in late October, they germinated successfully. The amount of erosion was estimated by measuring the change in soil surface level on 12 "erosion pins" installed in each plot at the beginning of the season. The erosion pins were made from 0.25-inch wooden dowels, cut 18 inches long and sharpened at one end. These were pushed into the soil in each plot one foot apart in a line across the slope, with six pins placed inside the nurse crop strip and six placed about one foot below the strip. The distance from the top of each pin to the surface of the soil was measured with a ruler. In early April, after the erosion data was collected, the Regreen was sprayed with glufosinate at 0.375 lb a.i./a, using a CO_2 backpack sprayer, to reduce competition with the grass seed crop.

Results and Discussion

The idea behind trying Regreen was that even if it could only be partially removed with herbicide, at least it would not make seed to contaminate the grass seed crop. The Regreen plants stayed relatively small in the fall, and this growth habit made them less suitable as a nurse crop than spring oats, which grow more vigorously in the fall. In order to get enough fall cover with Regreen, the seeding rate would have to be increased from the 40 lb/a used in this study to at least 100 lb/a. At the current price of about $1.00/lb for the seed, this would be too costly for most growers.

Establishment of the meadowfoam was marginal at all sites because of diuron injury. The meadowfoam plants remained yellow and stunted, then finally disappeared by early January, though they did fairly well in the carbon bands where they were protected from the diuron. The Regreen was not injured by the diuron, and it performed better than the meadowfoam at all three sites.

Erosion pin measurements at two of the three sites in 2002-03 indicated more soil deposition if nurse crops were planted. Data from the Suver site is shown in Figure 1. There also was more soil loss outside the nurse crop strips than inside, indicating that the nurse crop was slowing water movement in the nurse crop strip, causing soil to settle from the runoff.

The glufosinate used to remove the Regreen did not perform as well as in the herbicide trial the previous year, possibly because it was sprayed almost a month later and the Regreen was 8-12 inches tall. The Regreen plants turned yellow but did not die, while the grass seed stand was injured.

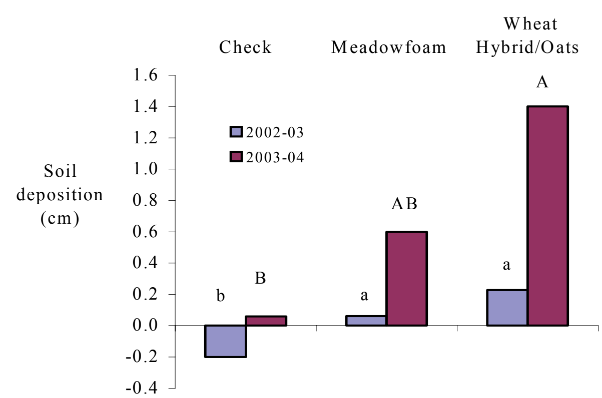

Figure 1. Effect of nurse crops on soil deposition near the lower slope of plots through December (2002-03) and January (2003-04) in two perennial ryegrass fields near Suver, OR. The cereal nurse crop was sterile wheat hybrid in 2002-03 and Monida oats in 2003-04. Bars with the same case letter in the same year do not differ (LSD, P=0.10).

2003-2004 Methods

A trial was established at the Horticulture Research Farm in Corvallis to evaluate strategies for improving the survival of a meadowfoam nurse crops under a diuron application and to evaluate the potential use of phacelia (*Phacelia tanacetifolia*) as a nurse crop species. The meadowfoam was planted with a drill at three seeding depths (0.5, 1.0, and 1.5 inches). Across these treatments, diuron was applied at three rates (1.5, 2.0 and 2.5 lb a.i./a), giving nine combinations of seeding depth and herbicide rate. Phacelia was planted 0.5 inches deep and got the same three rates of diuron. Plots were 20 by 30 feet.

Nurse crop trials comparing meadowfoam, Monida spring oats and no cover were established with three replications in three growers' perennial ryegrass fields, located in the Dayton, Monmouth and Suver areas. The nurse crops were planted by the researchers in mid-October using a seed drill, in plots approximately 35 by 40 feet, laid out in a contour strip across the slope. The seeding rate was 40 lb/a for the meadowfoam and 100 lb/a for the oats. Each grower then carbon-band planted his perennial ryegrass before the nurse crops emerged. In two fields, diuron was applied 2.0 lb a.i./a, and in the third field it was applied at 2.4 lb a.i./a (the rate typically used by growers). Slopes were approximately 3 to 5% and uniform in each field.

Erosion was estimated in two ways: 1) by measuring the change in soil surface level on 10 erosion pins installed in each plot at the beginning of the season; and 2) by collecting samples of runoff from the plots, then drying and weighing the sediment. The runoff samples were collected from a bordered one-square-meter area within each plot (Figures 2 and 3). The runoff was pumped from the tubs and measured every 1 to 2 weeks. After a thorough stirring to suspend the sediment, a 1000 ml subsample was taken from each sample, and the soil sediment was dried and weighed.

To remove the nurse crops, they were sprayed at all sites in late March using a CO_2 backpack sprayer. Fenoxaprop at 0.25 lb a.i./a was used on the oats rather than glufosinate in order to avoid damaging the grass seed crop, and carfentrazone at 0.025 lb a.i./a was used on the meadowfoam. One site was mowed in addition.

Results and Discussion

In the Horticulture Research Farm trials, there was a slight but insignificant improvement in meadowfoam and phacelia survival with deeper planting depths. However, both species were injured by the diuron. By early spring, the meadowfoam plants had all disappeared, but the phacelia made a comeback, possibly due to hard seed that germinated after the diuron had dissipated. Because the phacelia did not provide significant cover during the critical winter months, it was judged to have little value as a nurse crop with carbon-band seeding.

In one grass seed field, the Suver site, where the diuron had been applied at the lower rate of 2.0 lb a.i./a, the meadowfoam produced a good stand. The meadowfoam and the spring oats significantly reduced erosion by a similar amount, based on the sediment samples from the one-meter-square plots. By mid-February the cumulative soil loss was about 2,500 lb/a with no cover and only about 1,500 lb/a with the nurse crop (Figure 4A). This demonstrates that even where the nurse crop stand becomes well-established, it cannot completely eliminate erosion because it is planted at the same time as the grass seed crop. There is very little vegetative cover on the soil during late October and November. Meaurements of the cumulative rainfall (22.3 inches) and runoff (4.2 inches) showed that about 19% of the water ran off the field. The water runoff was not significantly different between the treatments, even though the soil loss was higher in the no cover than nurse crop treatments.

The meadowfoam at the other two sites was injured by the diuron, as had happened 2003. The plants remained small, then finally disappeared by early January, except in the carbon rows. At the Dayton site there was no significant

Figure 2. Runoff collector in an oat plot at the Suver site (22 Nov 03). Water and soil was collected from an area one meter square.

Figure 3. Runoff collector in a meadowfoam plot at Suver site (6 Feb 04). Even with a sparse stand, meadowfoam cut the runoff of soil sediment by almost half.

difference in soil loss between the check plots without nurse crops and either of the nurse crop treatments (Figure 4B). The nurse crops were planted late (29 October 2003), and through December and January the oats were too small to provide much vegetative cover. The cumulative soil loss by mid-February was 6,000 to 7,000 lb/a – much higher than the Suver site even though the plots were not on a steeper slope, due possibly to soil type and previous management. At the Monmouth site, the oats did poorly because of flooding. The plots had inadvertently been located on an area of the field with a permanent seep. In a spray skip, where the meadow-foam had escaped the diuron, it grew well with half an inch of water standing on the surface all winter.

The erosion pin data measured soil loss or deposition at the lower end of the plots, giving a measure of the effectiveness of the nurse crop plots as filter strips for sediment. Erosion pin measurements indicated that at the Suver site the oat cover crop significantly increased soil deposition compared to the check without a nurse crop (Figure 1, 2003-04). A similar trend noted at the Dayton site was statistically insignificant. This deposition measurement is in contrast to the soil loss measurement within the soil enclosures (Figure 3), which estimated the potential of nurse crops to prevent soil from dislodging during rainfall.

Conclusions

We demonstrated that under the best circumstances, nurse crops can reduce erosion potential by almost half. We were unable, however, to develop a reliable recipe for using a nurse crop successfully in every field.

Spring oats always survived the diuron, because they were planted at least 1.5 in deep, but they were difficult to completely control at the appropriate early-March timing. The herbicides labeled for grass seed either allowed some oats to survive and produce seed, or they caused unacceptable crop injury, or both.

Meadowfoam seemed like a promising nurse crop species because it was easy to remove with a labeled herbicide, carfentrazone. However, meadowfoam is sensitive to diuron. It escaped the diuron and produced a good stand in certain situations, probably because of some combination of factors – high organic matter and/or high clay content in the soil, deep planting, and lower rates of diuron. As long as diuron herbicide is used, however, there is a risk of stand failure. It is possible that if diuron is not used in a new grass seed planting, a meadowfoam nurse crop may provide enough competition to significantly reduce weeds. The weed-control side benefits of a meadowfoam nurse crop were not investigated here, but would be a good topic for future research.

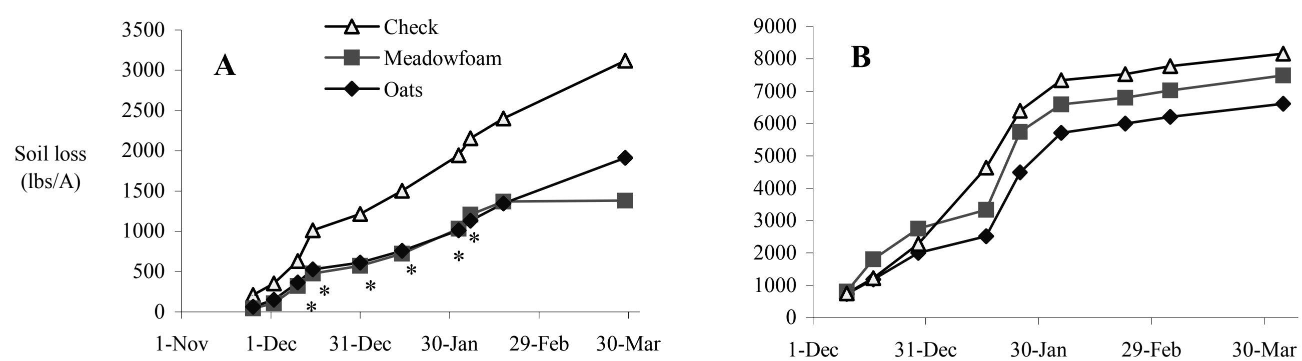

Figure 4. Effect of nurse crops on cumulative soil loss in perennial ryegrass Suver (A) and Dayton (B), OR 2003-04. Soil loss estimates were based on measurments of the total water and sediment runoff from one-square-meter bordered plots. Cumulative values for the oat and meadowfoam nursecrops followed by * for the same date differ from the check at P=0.10. Note difference in scale between the two charts.

SPRING POTASSIUM AND CHLORIDE APPLICATION FOR GRASS SEED PRODUCTION IN THE WILLAMETTE VALLEY

J.M. Hart, M.E. Mellbye, G.A. Gingrich, W.C. Young III, T.B. Silberstein and N.W. Christensen

When grass straw was burned, most of the potassium used by the crop was recycled in the ash and immediately available for plant use. Few fields are now burned and many have straw removed after baling. Straw contains seven to ten times the amount of potassium as seed. Changes in potassium management were needed with the change in straw management.

When straw was burned, small amounts of potassium were routinely applied in the fall. Many growers still use a traditional fall potassium application in addition to applying potassium in the spring. Spring potassium application generated substantial interest with growers, especially after reports of yield increases from spring application.

Growers focused questions and discussion on spring vs fall potassium timing, disregarding the possibility a yield increase might come from a spring addition of chloride.

Spring potassium chloride (KCl) application to grass grown for seed was initially investigated when chloride application was found to reduce yield loss from take-all root rot of wheat. In the mid-1980s, KCl was applied to Ovation perennial ryegrass on small plots at Hyslop Farm. Seed yield was significantly increased from a Cl application two of five times and the thousand seed weight increased three of five times (Turner, 1989).

To explore the need for spring application of chloride, a multi-year effort at several locations for several species was initiated in 2003. The spring application of chloride in 2003 increased chloride concentration in flag leaf samples of all species with each increment of added chloride. In contrast to chloride application, added potassium only increased flag leaf potassium concentration in annual ryegrass. Weight of 1000 seeds increased with chloride application for annual ryegrass and tall fescue, but not perennial ryegrass (Hart et al., 2004).

Seed yield was not increased by application of potassium in 2003 and was not expected to do so as soil test potassium was adequate at all sites. When compared to no chloride application, treatments receiving chloride produced a seed yield increase in annual ryegrass, made no change in tall fescue and decreased the yield of perennial ryegrass.

As a continuation of the project, in 2004, spring potassium and chloride were applied to grass grown for seed.

The objectives were to: 1) determine if a seed yield increase from spring KCl application is due to potassium or chloride; 2) explore the relationship of soil test Cl, tissue Cl, and grass seed yield; and 3) determine if 1000 seed weight or test weight is increased by the application of chloride containing fertilizer in the spring.

In 2004, three on-farm trials were organized in a randomized complete block design with three replications in a field of annual ryegrass and two perennial ryegrass fields. Potassium and chloride rates are provided in Table 1. Treatments were applied on March 12, 2004 in the perennial ryegrass fields and on April 4, 2004 in the annual ryegrass field.

Table 1. Potassium and chloride application rates from fertilizer sources used in replicated sites during 2004.

Fertilizer material	Potassium rate	Chloride rate
	(lb/a)	(lb/a)
None	0	0
K_2SO_4	88	0
KCl	44	35
KCl	88	70
KCl	176	140

In addition, non replicated treatments were applied in three tall fescue and one perennial ryegrass field. Treatments are provided in Table 2. Application was made on March 11, 2004 in the Charger II perennial ryegrass and Adams Valley tall fescue. Jessup and Reserve tall fescue fields received treatments April 15, 2004.

Table 2. Potassium and chloride application rates from fertilizer sources used in non-replicated sites during 2004.

Variety	Potassium rate	Chloride rate
	(lb/a)	(lb/a)
Jessup	0	0
	44	35
Reserve	0	0
	44	35
Adams	0	0
Valley	44	35
Charger II	0	0
	88	70
	176	140

The treated area was 20 feet wide, allowing a single swath through the middle of each plot for harvest. Fertilizer was applied with a Gandy Orbit-air spreader pulled by a small tractor. The plot length was 250 to 400 feet long allowing plots to be harvested with grower's swathers and combines. Seed from each plot was transferred from the combine to a Brent Yield cart for weighing. A sub sample of seed was collected from each plot at harvest. The sample was cleaned and the clean seed yield determined for each treatment. Weight of 1000 seeds was determined on this sample. Management information and soil series are listed in Table 3.

Soil samples were taken February 20, 2004 and submitted to the OSU Central Analytical Laboratory for analyses. Flag leaf samples were obtained by walking the length of the plots and randomly selecting 60 to 75 fully open flag leaves. Soil test potassium, chloride and flag leaf sampling date are given in Table 4. Analysis of variance and mean separation were performed using the "Statistix" program.

Table 3. Management information and soil series from all sites in 2004.

Grass species	Variety	Stand age	Straw management	Site location	Soil type
		(years)			
Annual Ryegrass	Gulf	Continuous Gulf	Disked	Junction City	Bashaw
Perennial Ryegrass	Paragon	2	Full straw	Tangent	Amity Dayton
Perennial Ryegrass	Icon	2	Baled	Mt. Angel	Amity Woodburn
Tall Fescue	Jessup	5	Baled	Harrisburg	Coburg
Tall Fescue	Reserve	3+	Chopped	Peoria	Woodburn
Tall Fescue	Adams Valley	2	Baled	Sauvie Island	Rafton Sauvie
Perennial Ryegrass	Charger II	2	Baled	Gervais	Amity

Chloride application increased flag leaf chloride concentration at all locations (Tables 5, 6, and 7). The flag leaf tissue data demonstrates that spring applied chloride is assimilated or "taken up" by the crop.

Flag leaf tissue potassium concentration was above 1% for all samples and not limiting to grass growth or seed production. Potassium tissue concentration was regulated by potassium application rate and potassium soil test level. When soil test potassium was between 150 and 200 ppm in the surface six inches of soil, potassium application increased tissue potassium concentration, but application rates greater than 44 lb K_2O/a were required. At the locations where soil test potassium in the surface six inches of soil was less than 150 ppm, application of 44 lb K_2O/a increased tissue K concentration (Tables 4, 5, 6, and 7).

Table 4. Potassium and chloride soil test data and flag leaf sampling dates for 2004.

Grass variety	Soil test: Chloride	Soil test: Potassium		Flag leaf sampling date
	Sampling depth (inches)			
	0 to 12	0 to 6	6 to 12	
	(lb/a)	(ppm)	(ppm)	
Gulf	38	141	104	May 12
Paragon	65	175	115	May 25
Icon	68	220	232	May 25
Jessup	48	447		May 6
Reserve	45	185		May 6
Adams Valley	87	145		May 10
Charger II	43	88		June 1

Table 5. Flag leaf tissue chloride and tissue potassium after spring application of potassium fertilizers to annual and perennial ryegrass at sites with replicated treatments, 2004.

Treatment K_2O	Treatment Cl	Gulf annual ryegrass Tissue Cl	Gulf annual ryegrass Tissue K	Paragon perennial ryegrass Tissue Cl	Paragon perennial ryegrass Tissue K	Icon perennial ryegrass Tissue Cl	Icon perennial ryegrass Tissue K
(lb/a)	(lb/a)	(ppm)	(%)	(ppm)	(%)	(ppm)	(%)
0	0	3108a	1.28a	2258a	1.51a	3359a	2.04a
88	0	3154a	1.50b	2196a	1.70b	3121a	2.06a
44	35	4503b	1.42ab	4722b	1.65ab	6402b	2.17a
88	70	6880c	1.54b	8502c	1.75b	9602c	2.19a
176	140	11340d	1.77c	147405d	1.92c	13697d	2.22a

Table 6. The influence of chloride application on tall fescue seed yield, flag leaf chloride and whole plant chloride concentration, flag leaf potassium and 1000 seed weight, 2004.

Variety	Chloride rate	Seed yield	Tissue chloride: Flag leaf	Tissue chloride: Whole plant	Flag leaf potassium	1000 seed weight
	(lb/a)	(lb/a)	(ppm)	(ppm)	(%)	(grams)
Jessup	0	1730	2074	4089	1.04	2.46
	35	1914	3278	4674	1.13	2.55
Reserve	0	2271	1789	2833	1.47	2.26
	35	2243	2467	4823	1.48	2.27
Adams Valley	0	2406	2061	4597	1.09	2.43
	35	2422	2977	8170	1.15	2.36
Average	0	2136a	1975a	3836a	1.20a	2.38a
	35	2270a	2907b	5889a	1.25a	2.39a

Table 7. Charger II perennial rye grass, seed yield, flag leaf chloride, whole plant chloride, flag leaf potassium and 1000 seed weight as influenced by potassium and chloride application.

Variety	Chloride rate	K_2O rate	Seed yield	Tissue chloride Flag leaf	Tissue chloride Whole plant	Flag leaf potassium	1000 Seed wt.
	(lb/a)	(lb/a)	(lb/a)	(ppm)	(ppm)	(%)	(g)
	0	0	1310	4382	3684	1.21	1.61
Charger II	70	88	1165	7641	6026	1.47	1.56
	140	176	1117	13657	7944	1.62	1.53

Table 8. Seed weight and yield after spring application of potassium fertilizers for perennial and annual ryegrass.

Treatment		Gulf annual ryegrass		Paragon perennial ryegrass		Icon perennial ryegrass	
K_2O	Cl	1000 seed wt.	Seed yield	1000 seed wt.	Seed yield	1000 seed wt.	Seed yield
(lb/a)	(lb/a)	(g)	(lb/a)	(g)	(lb/a)	(g)	(lb/a)
0	0	2.90	2630	1.71	1996	1.94	1588
88	0	2.85	2758	1.61	1966	1.87	1570
44	35	2.91	2696	1.70	1908	1.90	1527
88	70	2.97	2777	1.75	1878	1.92	1590
176	140	2.93	2638	1.63	1947	1.85	1633
LSD 0.10		NS	NS	NS	NS	NS	59

Neither application of chloride or potassium increased seed yield or seed weight in 2004 (Tables 6, 7 and 8). Average seed yield increase from chloride application on tall fescue may be economically feasible, but was not statistically significant ($p=0.15$). The seed yield increase in tall fescue was consistent with whole plant tissue chloride concentration guidelines for wheat. Engel et al. (1998) reported that whole plant tissue concentration from boot to heading of less than 4,000 ppm is inadequate for top yield. Whole plant tissue chloride was less than 4,000 ppm at sites where non replicated treatments of chloride application seemingly produced a seed yield increase.

Some soil test potassium values at sites were low and would prompt a potassium application recommendation, especially when straw is removed. Even so, seed yield was not increased by potassium application.

Summary/conclusions

Research demonstrated few and unpredictable seed yield and seed weight increase from chloride application even though chloride application routinely increased tissue chloride concentration. When soil test chloride is between 31 and 60 lb/a in the surface foot of soil, flag leaf chloride less than 2,000 ppm or whole plant chloride at heading less than 4,000 ppm, a chloride fertilizer application may increase wheat yield in the great plains. Our limited testing in situations with these criteria provided an increase in grass seed yield at half of the sites. In South Dakota, wheat grain yield increase occurs in less than 31% of these situations (Franzen and Goos, 1997).

Potassium application did not increase yield or test weight, and only increased tissue potassium concentration when soil test for potassium was near the level where a potassium application is recommended.

When soil test potassium level is adequate, the need for potassium chloride fertilizer to supply either potash or chloride to Willamette Valley grass seed fields appears to be limited. When soil test potassium is above 150 ppm, maintenance application of potash fertilizer is not necessary to produce top grass seed yield.

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IMPACT ON SEED YIELD OF NEW THRIPS PEST IN BENTGRASS SEED PRODUCTION FIELDS IN THE WILLAMETTE VALLEY

S. Rao and S.C. Alderman

Introduction
Insect pests of bentgrass, *Agrostis* spp., in North America feed on the foliage, roots or the crowns (Hale 1999, Cook and Johnson 2003). The exception is the grass thrips, *Anaphothrips obscurus* (Müller) (Thysanoptera: Thripidae) which feeds on the inflorescence. Kamm (1971) reported that *A. obscurus* damages reproductive tillers of bentgrass in Oregon, resulting in sterile bleached panicles, which he referred to as silvertop. No pest has so far been reported feeding on seeds of *Agrostis* spp. in Oregon or elsewhere in the world. Thrips (singular and plural) have rasping mouth parts - they scrape the surface and then feed on the juice that is extruded.

In July 2004, during a survey of grasses for diseases in the Willamette Valley, we detected pupae of a thrips species within individual florets of bentgrass. There was no external indication of the presence of the thrips. However, each floret that had a thrips produced no seed. The direct correlation of infestation with seed loss raised concerns about potential impacts on yield. We initiated a survey to determine whether the thrips was present in commercial *Agrostis* seed production fields, and, if so, to estimate its impact on seed yield.

Material and Methods
Field survey: We surveyed 13 bentgrass seed production fields in the Silverton area: eight of Highland bentgrass, four of creeping bentgrass (Crenshaw, Princeville, Pennlinks and Penncross) and one of colonial bentgrass (Alistar) (Table 1). In each field, 17 to 50 panicles were collected at random along each of four transects in a diamond pattern. Each floret (= spikelet) was examined under a stereo microscope using dark field illumination with transmitted light. The number of thrips in each panicle was recorded, and the data were used to estimate percent panicles infested.

Seed Loss: Seeds from each panicle were carefully threshed by hand to avoid seed loss. Caryopses were separated from the lemma and palea using a scarifier, and debris was removed with an air column as previously described (Alderman et al., 2003). Total seed weight from each transect was determined. The weight of a subset of 200 seeds from each transect (= 800 seeds per field) was also recorded to estimate the total number of seeds in panicles collected from each transect. Percentage seed loss was estimated by: [number of thrips/(number of thrips + number of seed)] x 100, based on our observation of one thrips per floret, and destruction of a single seed by each thrips.

Results
Field Survey: Thrips were observed infesting florets of bentgrass in 11 out of the 13 seed production fields surveyed in western Oregon. Both male (wingless) and female (winged) thrips were present within the florets. Overall, out of 2,310 panicles from 13 fields that were examined, 32.5% were infested.

In infested fields, there was a wide range in infestation levels as 0.5 to 88% of the panicles were observed to be infested (Table 1). Infestation levels ranged from 5.4 to 22.6 thrips/panicle in Highland bentgrass, and from 1.4 to 4.8 thrips/panicle in creeping bentgrass (Table 1). In one Highland bentgrass field we observed an average of 26.8 thrips/panicle in one of the four transects, with an estimated seed loss of 9.1%. In the 198 panicles examined from the single colonial bentgrass field included in the survey, we detected 5 thrips, all in the same panicle.

Individual florets contained a single thrips adult or pupa, with its head towards the base of the floret. The thrips were enclosed firmly between the lemma and the palea, and were not easily dislodged (Figure 1).

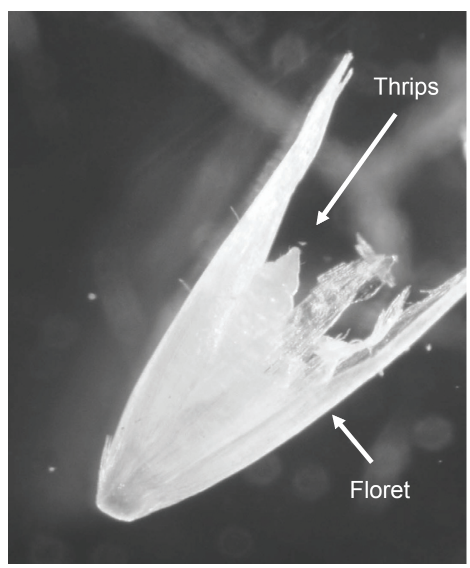

Figure 1. Pupa of thrips in floret of Bentgrass.

In florets where a thrips was present, organic debris was visible but there was no trace of the caryopsis. In grasses, the pericarp or ovary wall is fused with the seed coat, and the fruit (= caryopsis) is commonly termed the seed. Hence the presence of one thrips in a floret represented the loss of one *Agrostis* seed.

Seed loss: In fields of Highland bentgrass seed loss ranged from 0.8% to 5.1% (Table 1). The highest infestation was observed in Field 1 where we estimated 9.1% seed loss in one transect (40 panicles). Infestation and seed loss were low in creeping bentgrass fields (from 0.02 to 0.03%), and in the colonial bentgrass field (0.01%) (Table 1).

Discussion

The thrips has not been reported earlier from bentgrass,. However, our study indicated that it is fairly widespread in the Silverton area in bentgrass seed production fields, occurring in 11 of the 13 fields surveyed. However, infestation levels varied with the host crop. Seed loss was consistently higher in Highland bentgrass than in either creeping or colonial bentgrass. Hot spots of infestation can occur. In one Highland bentgrass field, we observed an average of 26.8 thrips per panicle in one of the four transects, with an estimated seed loss of 9.1%.

Economic damage by the thrips appears to be dependent on the host plant host. It is abundant in the heads of timothy in North America, but does not cause economic damage (Andre 1939). Flowers of cereals, clover and carrot are also listed as host plants (Hind 1902), but there is no information about economic impacts on these plants. However, in New Zealand, *C. manicatus* is known as a pest of orchardgrass (Doull 1956a). A study by Doull (1956b) indicated that a population density of 20 thrips per inflorescence resulted in 32% seed loss. On average, for every 1% increase in infestation in orchardgrass there was a corresponding 0.76% loss in yield (Morrison 1961). In the current study, in the field with the highest infestation, an average population density of 22.6 thrips per panicle resulted in 5.1% seed loss in bentgrass. The large difference in seed loss between bentgrass and orchardgrass, for the same number of thrips per panicle, is a reflection of the difference in the numbers of seeds per panicle. However, low infestation levels in bentgrass can be of considerable economic importance as it is a high cash value crop in Oregon. Infestation was highest in Highland bentgrass, the most common cultivar raised commercially in Oregon.

The development of the thrips in orchardgrass in New Zealand was described by Doull (1956b). Females lay one kidney-shaped, translucent egg per floret near the top of the developing ovule embedded to about half their length in the tissue. It was speculated that there is a close relationship between egg laying and floret development, as eggs are only observed in fertilized florets. Eggs hatch in 5-7 days and newly hatched thrips are found head down on the base of the developing ovule. The developing larvae feed on the floret, and by the time a larva reaches the pupal stage, the seed is destroyed. Feeding larvae do not move from floret to floret hence one thrips represents one lost seed.

Doull (1956b) indicated the thrips was highly adapted to orchardgrass, and that small seeded plants were unlikely to be attacked because the larvae needed a large seed for completion of development. However, our study provided evidence to the contrary. The caryopsis is 0.6 to 1.5 mm in length in bentgrass, while in orchardgrass it is 1.8-3 mm (Tsvelev 1976). In bentgrass, 1000 seeds weigh 0.06-0.1 g while 1000 seeds of orchardgrass weigh 0.8 to 1.4 g (Peeters 2004). Yet only one thrips develops on one seed of orchardgrass and of bentgrass.

It is not known how long the thrips has been present on bentgrass in Oregon. As there is no external indication of the thrips within bentgrass florets, its presence could have remained undetected for a considerable period of time. However, infestation levels may have built up in recent years because of the phase-out of field burning in the late 1980's. Infested florets harboring overwintering females, which are likely to have fallen during or prior to harvesting, may have been destroyed by field burning.

Currently infestation levels are low in bentgrass fields, but population build-up could result in widespread adult dispersal if management tactics are not in place. Due to its concealed nature, the thrips could be distributed worldwide relatively easily through seed trade. In addition, there are concerns about potential impacts of thrips infestations in other grass seed crops in the state, particularly orchard grass, on which is has been reported to cause considerable seed loss in New Zealand.

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Table 1. Incidence of new thrips pest in bentgrass seed production fields in the Willamette Valley.

Field	Cultivar	Panicles examined	Thrips per panicle[1]	% panicles with thrips[2]	Seeds per panicle[3]	% seed loss due to thrips[4]
1	Highland	135	22.6 ± 2.1	87.9 ± 4.1	452 ± 105	5.1 ± 1.4
2	Highland	199	6.8 ± 0.9	49.8 ± 7.3	426 ± 53	0.9 ± 0.2
3	Highland	194	10.3 ± 1.5	60.0 ± 5.7	526 ± 55	1.1 ± 0.4
4	Highland	130	5.4 ± 2.5	26.2 ± 5.4	233 ± 20	1.3 ± 0.7
5	Highland	151	17.9 ± 2.3	80.5 ± 7.1	375 ± 11	4.1 ± 1.8
6	Highland	161	12.5 ± 3.2	32.9 ± 4.3	471 ± 10	1.0 ± 0.4
7	Highland	191	17.6 ± 2.0	64.8 ± 10.1	467 ± 9	2.8 ± 0.5
8	Highland	155	6.0 ± 0.7	38.0 ± 7.8	277 ± 22	0.8 ± 0.3
9	Crenshaw	198	4.8 ± 2.5	2.0 ± 1.4	528 ± 44	0.02 ± 0.01
10	Princeville	200	1.4 ± 0.1	9.5 ± 3.1	452 ± 22	0.03 ± 0.01
11	Pennlinks	200	0	0	321 ± 11	0
12	Penncross	198	0	0	292 ± 12	0
13	Alistar	198	5*	0.5 ± 0.5	425 ± 13	0.01 ± 0.01

[1] mean ± standard error, total number of thrips in field / number of infested panicles
[2] mean ± standard error based on up to 50 panicles from each of four transects from each field
[3] mean ± standard error, total seeds divided by total panicles for each of four transects per field
[4] mean ± standard error, based on ((total thrips/(total thrips + total seeds)) x 100 for each of 4 transects per field
* single panicle

SPHENOPHORUS SPP., A COMPLEX BILLBUG COMMUNITY INFESTING KENTUCKY BLUEGRASS SEED FIELDS IN THE GRANDE RONDE VALLEY OF NORTHEASTERN OREGON

D.L. Walenta, S. Rao, C.R. McNeal, B.M. Quebbeman and G.C. Fisher

Introduction

Research efforts are currently underway to study the billbug complex which infests grass seed fields in the Grande Ronde Valley of northeastern Oregon. Billbugs belonging to the genus *Sphenophorus* (Coleoptera: Curculionidae) are native to North America, and include several species known to be problematic in turfgrass such as the bluegrass billbug (*S. parvulus*), hunting billbug (*S. venatus vesticus*), Denver billbug (*S. cicatristriatus*), and the Phoenix billbug (*S. phoenician*) (Shetlar, 1995). Presently, there is no information on the species-specific phenology of billbugs which infest grass seed crops produced in the Grande Ronde Valley. This information is critical for development of management strategies that optimize insecticide use by timing application to periods that will provide maximum benefit.

During the last several years, late summer detection surveys have shown increased frequency of billbug presence in Kentucky bluegrass and fine fescue seed production fields in the Grande Ronde Valley (Figure 1). Billbugs have been associated with increased damage to Kentucky bluegrass seed production fields in this area. Adult billbug specimens collected during Grand Ronde Valley surveys were identified by Glenn Fisher, OSU Entomologist, Lynn Royce, OSU Insect Identification Specialist, and Jim LaBonte, Taxonomic and Survey Entomologist, Oregon Department of Agriculture. Examination of specimens from several locations indicated the presence of a complex community of billbug species including the bluegrass billbug (*S. parvulus*), Denver billbug (*S. cicatristriatus*), and a third species that lacks a common name (S. sayi). These species differ from the Western orchardgrass billbug (*S. venatus confluens*) which has caused extensive damage to orchardgrass in the Willamette Valley since the 1960s (Kamm and Robinson, 1974; Fisher and Rao, 2001; Fisher and Umble, 2004).

A study was initiated in the fall of 2003 to determine the seasonal phenology and abundance of different billbug species and lepidoptera (larvae) pests in Kentucky bluegrass seed production in northeast and central Oregon. Information obtained from this study will facilitate the development of effective pest monitoring and management strategies for these insect pests. In addition, the study compared the impacts of thermal (bale + propane) and non-thermal (bale + flail) residue management methods on pests in Kentucky bluegrass seed production in the Grande Ronde Valley of northeastern Oregon. This paper reports results specific to the billbug component of the study conducted in the Grande Ronde Valley.

Methods and Materials

Study Sites: Three study sites (sites 1, 2, and 3) were located in commercial Kentucky bluegrass seed production fields in the Grande Ronde Valley and split into thermal (bale + propane) and non-thermal (bale + flail) treatments. Separate fields of each residue management method served as replications.

Insect Pest Sampling: Billbug larvae, pupae, and adults were collected during the fall of 2003 and spring of 2004. Insect pest sampling procedures included both sod-soil core and pitfall trap sampling methods.

<u>Sod-Soil samples</u>: Uniformly distributed sod-soil core sampling grids were established with a hand-held GPS unit for each residue management treatment at each site. Sixteen sod-soil core samples were collected from each residue management treatment at each sampling date in late August, late September, and late March. Samples were collected by cutting a circular sample (0.6 ft dia.) of sod approximately 1.5 inches thick plus 2.5 inches of soil below the sod (4 inch total sample depth). The sampling grid enabled samples to be uniformly collected from individual grid points across each treatment, thus, removing any potential bias from sample site selection. Berlese funnels were used to extract pests from the sod and sieves were used to collect pests from the soil.

<u>Pitfall trap samples</u>: Six pitfall traps were established for each residue management treatment at each site. Pitfall traps consisted of a 16 oz plastic cup placed in the soil with the top of the trap at surface level. A cover was suspended above the trap to deflect moisture from irrigation and precipitation events. In fall 2003, traps were established in late August and examined weekly until the first week in November (7 weeks). In spring 2004, the traps were re-established and monitored from mid-March until early July (16 weeks).

Results and Discussion

<u>Sod-soil samples</u>: Seasonal abundance data (total of adult, pupae, and larvae life stages) obtained from sod-soil sampling conducted in fall 2003 (August 26 and September 22) and spring 2004 (March 24) are presented in Figure 2. Results indicate that, while all billbug life stages were present in samples collected in late August and late September, only adults and larvae were collected in spring samples. Overall, the larval stage was the dominate life stage detected in the soil portion of the samples. Larvae and pupae were found in the root zone to a depth of approximately 3 inches. During the late August sampling, 65% of billbug adults found were located in the sod portion of the samples, whereas, 100% of the adults were detected in the sod portion in late September (data not shown).

Fall and spring sampling data indicate variation in billbug abundance between study sites. Billbug numbers were lowest in sod-soil samples collected from site 3. However, interestingly, billbug abundance did not appear to be influenced by residue management treatments.

<u>Pitfall trap samples</u>: Pitfall trap data collected in fall 2003 are presented in Figure 3. Higher numbers of billbug were recorded from two propane + bale treatments, however, these appear to be related to variation in overall abundance levels between sites (Figure 3). Billbug adults were most active in early to mid-September 2003 as indicated by the numbers of adults captured in pitfall traps. Billbug adult activity rapidly diminished in October. Data from spring 2004 (Figure 4) indicate that billbug adult activity began in early May and continued to increase through late June. Pitfall traps were removed after the July 2 sampling date due to crop maturity. In fall and spring, neither residue management treatment method had a significant impact on adult billbug abundance.

Conclusions

The study provided valuable information on seasonal phenology of billbugs in Kentucky bluegrass in the Grand Ronde Valley in northeastern Oregon. Both adults and larvae are present in fall and spring, while pupae are present primarily in fall. Larvae and pupae can be sampled by collecting sod-soil samples that include the root zone to a depth of approximately 3 inches. Adults can be sampled using pitfall traps and/or the sod-soil core sampling method. Pitfall traps are advantageous as the traps are relatively easy to install, inexpensive, and facilitate monitoring of billbug activity over time. However, pitfall traps are only effective when adult billbugs are active. In contrast, the sod-soil sampling method is labor-intensive but facilitates detection of inactive billbug life stages. Sites vary in billbug abundance, therefore, further investigation is needed to determine why these differences exist. In contrast, residue management methods that include thermal (bale + propane) and non-thermal (bale + flail) methods do not appear to affect billbug abundance. Further research is critical for identification of billbugs at the larval stage and determination of which species in the complex are responsible for damage to Kentucky bluegrass in northeastern Oregon.

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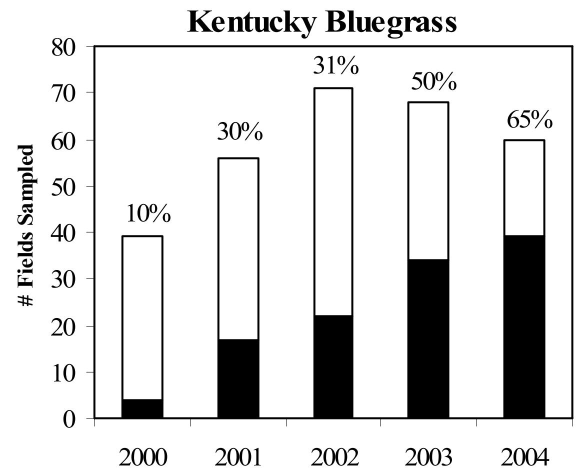

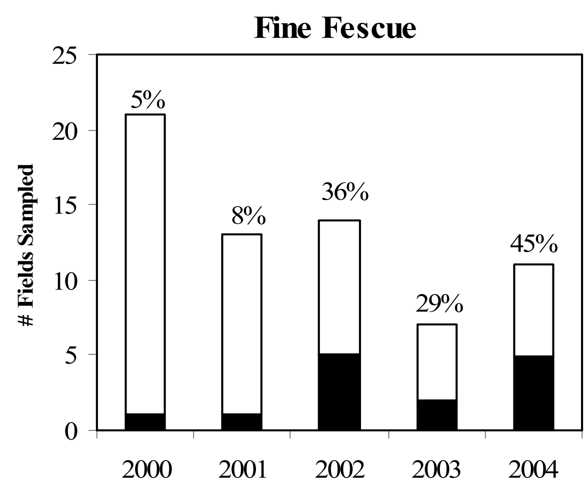

Figure 1. Detection of billbug presence in grass seed production fields in the Grand Ronde Valley of northeastern Oregon. Filled areas represent the number of infested fields. Numbers above bars represent the percentage number of fields infested with billbugs.

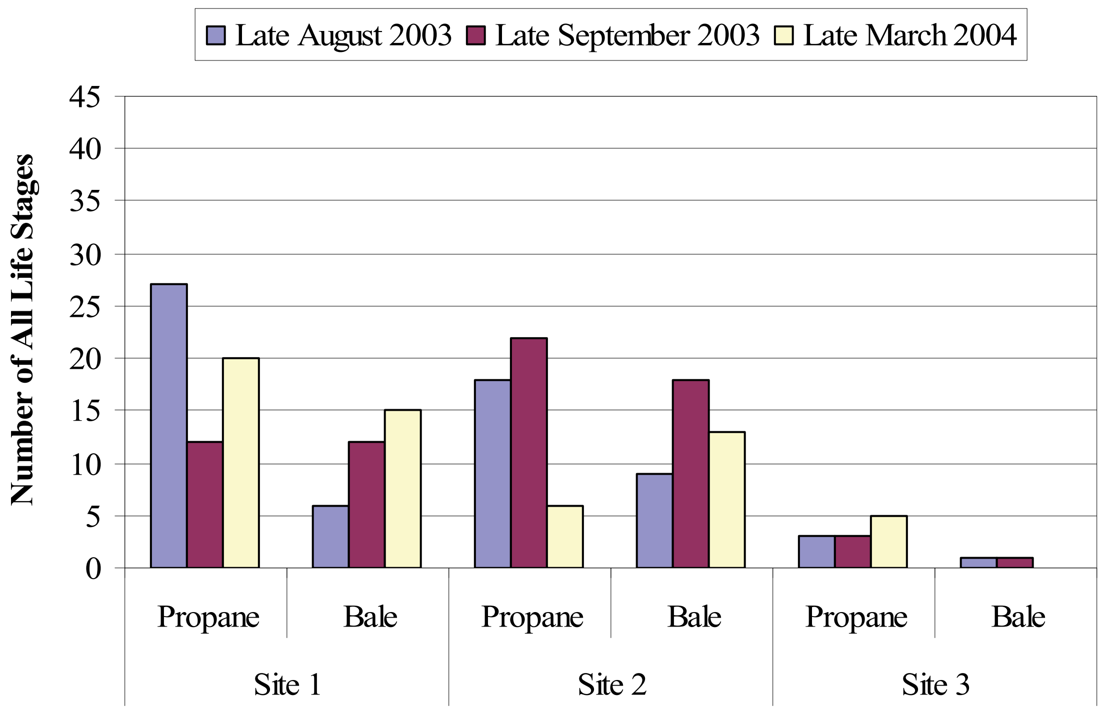

Figure 2. Seasonal abundance of all billbug life stages (adult, pupae, and larvae) collected from sod-soil core samples taken from each site during fall 2003 and spring 2004.

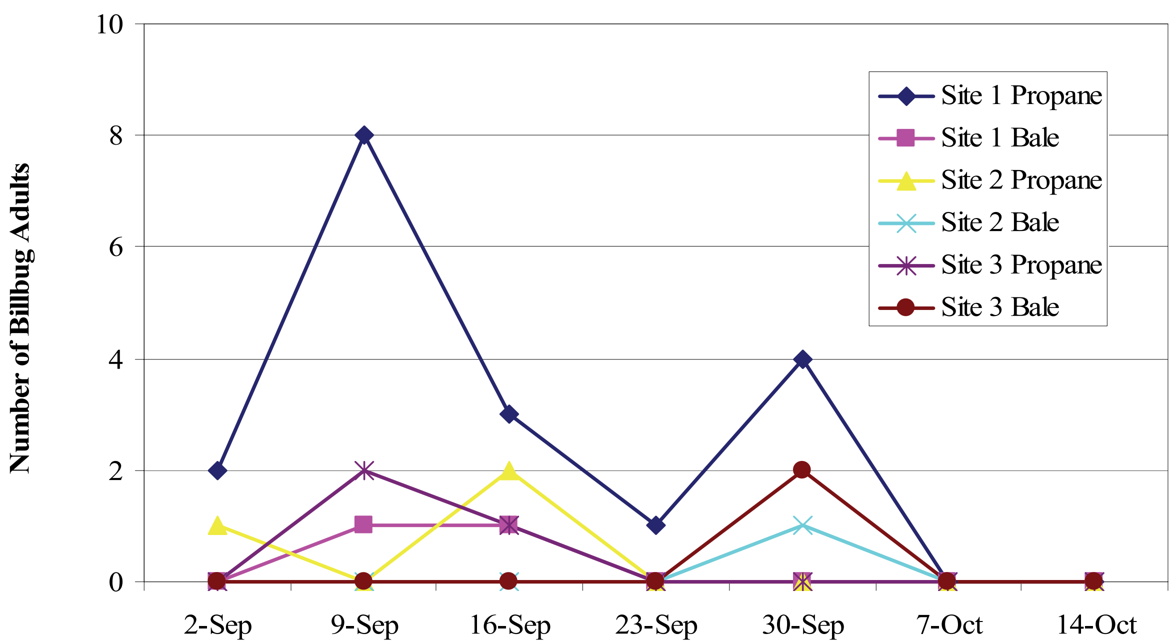

Figure 3. Fall 2003 - number of billbug adults collected in 6 pitfall traps per residue management treatment at each study site in the Grande Ronde Valley.

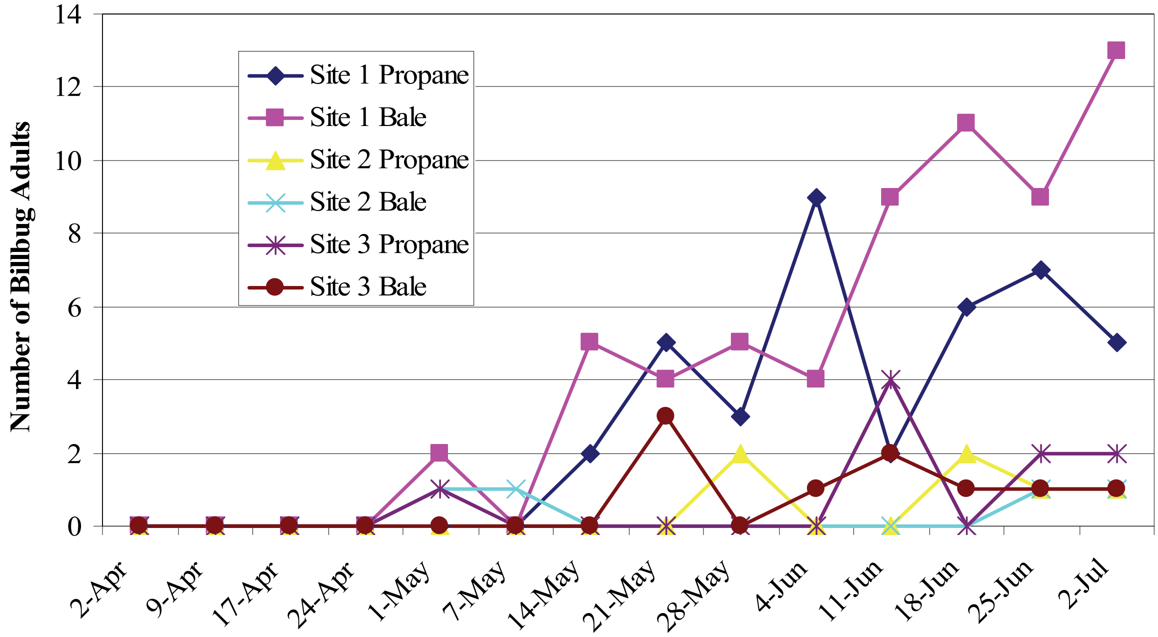

Figure 4. Spring 2004 – number of billbug adults collected in 6 pitfall traps per residue management treatment at each site in the Grande Ronde Valley.

EFFECT OF P AND K FERTILIZATION STRATEGIES ON KENTUCKY BLUEGRASS SEED PRODUCTION

G.L. Kiemnec, D.L. Walenta and C.R. McNeal

Introduction

Agricultural Water Quality Management Area Rules for the Upper Grande Ronde River Subbasin (OAR Chap. 630, Division 95) state that "By January 1, 2003 nutrient application rates and timing shall not exceed specific crop requirements." Nutrient levels on soils used for grass seed production in the Grande Ronde Valley often test high or very high for phosphorus (P) and potassium (K) . If P and/or K fertilizer applications were reduced or temporarily halted, knowledge of how these reductions will be manifested in changing soil test levels and seed yield is critical. With the switch to non-thermal residue management, the rate of reduction in soil test K levels increases. Oregon Department of Environmental Quality has established a loading capacity target of 10 ug P/L for portions of the Grande Ronde River and Catherine Creek. Since movement of P to surface waters is predominantly through surface runoff, the use of a spoke wheel applicator to reduce surface soil P concentrations was investigated.

Methods and Materials

In a commercial, irrigated Kentucky bluegrass field (1st year) five, fall fertilizer treatments were applied: 1) P_0K_o (Check), 2) P_0K_+, 3) P_+K_0, 4) P_+K_+, 5) P_+K_+ (spoke wheel). All P and K fertilizers were applied broadcast (except treatment five), where P was applied via spoke wheel; P_+ = 30 lb P_2O_5/acre and K_+ = 30 lb K_2O/acre. Plot size was 9 ft by 60 ft with 4 replications. A plot combine was used to harvest grass seed. Whole plant samples were taken from 6 lineal feet (2, 3 feet samples) and analyzed for P and K concentrations to determine P and K uptake. Soil samples were taken at 0-2, 2-4, and 4-6 inches before fertilizer treatments in the fall of 2003, and after 2004 harvest and analyzed for available P and K. The soil was an Alicel fine sandy loam, a member of the fine-loamy, mixed, superactive, mesic Pachic Haploxerolls.

Results

Fertilizer applications had no effect on clean seed yields or P and K uptake (Table 1). Initial soil test levels for P and K were above levels at which fertilizer is recommended. Thus, results were as expected. Soil K levels were not affected by treatments, years, or sampling depth. The average soil test K level was 357 ppm K. Soil P (Table 2) was affected by years (P= 0.10) and depth (P=0.05), but not by treatments. Averaged over all treatments, the soil P increased with depth. It is speculated that moldboard plowing prior to planting was responsible for this observation. Treatments with added P increased the soil test P by an average of 4 ppm P in the top 6 inches of soil. Treatments without added P reduced the soil test P by an average of 2 ppm P in the top 6 inches of soil.

Table 1. Kentucky bluegrass clean seed yields and phosphorus and potassium uptake for 2004.

Treatment	Yield	P uptake	K uptake
	(lb/a)	(lb P_2O_5/a)	(lb K_2O/a)
P_0K_0	1080	47	212
P_0K_+	1070	46	208
P_+K_0	1010	44	204
P_+K_+	1010	48	203
P_+K_+ (spoke)	1120	46	214
P = 0.05)	NS	NS	NS

Table 2. Soil P levels in 2003 and 2004.

	Treatment									
	P_0K_0		P_0K_+		P_+K_0		P_+K_+		P_+K_+ (spoke)	
Depth	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
inches	(ppm P)									
0-2	58	54	53	53	59	62	56	58	58	66
2-4	60	61	56	62	56	62	55	62	60	60
4-6	62	61	68	63	61	62	58	64	60	65

WILD OAT CONTROL IN SEEDLING KENTUCKY BLUEGRASS GROWN FOR SEED

D.A. Ball, L.H. Bennett and S.M. Frost

Introduction
Northeastern Oregon grass seed producers may encounter problems with wild oats when rotating grass seed after wheat. Currently, there are no herbicides registered for control of wild oats in fall seeded, seedling Kentucky bluegrass. This study was conducted at the Hermiston Agricultural Research and Experiment Station, OR to evaluate wild oat (*Avena fatua*) control with flucarbazone-sodium (Everest®) in seedling Kentucky bluegrass grown for seed production under Columbia Basin, irrigated conditions.

Procedure
Kentucky bluegrass (var. Brilliant) was planted August 29, 2003. Tame oats were seeded with a hand rotary seeder on September 17, 2003 and used to simulate a wild oat infestation. Early post-emergence (EPOST) treatments were applied October 9, 2003 to Kentucky bluegrass at 5-6 leaf stage and to oats at the 2-3 leaf stage. Late post-emergence (LPOST) treatments were applied on October 17, 2003 to Kentucky bluegrass at the 7-8 leaf stage and oats at the 4-8 leaf stage. Spring treatments were applied April 6, 2004 to Kentucky bluegrass at the pre-joint, 3-5 inch stage and to oats at the 4-7 leaf stage. Spring applications were repeated, all at one time, to the fall treatments. All treatments were made with a hand-held CO_2 sprayer delivering 16 gpa at 30 psi. Plots were 6 ft by 35 ft in size, in an RCB arrangement, with 4 replications. Soil at the site was a sandy loam (65.6% sand, 30.5% silt, 3.9% clay, 1.0% organic matter, 6.7 pH, and CEC of 8.7 meq/100g). Conditions at time of treatment are summarized in Table 1. Evaluations of crop injury were made on October 31, 2003 and February 18 and April 29, 2004. Visual estimates of wild oat control were made on October 31, 2003 and April 29, 2004 (Table 2). Kentucky bluegrass was swathed on June 17, 2004 with a small plot swather and combined on June 29, 2004. Harvested seed was cleaned with a 'Clipper' cleaner, weighed, and yield converted to lb/a.

Table 1. Application conditions on seedling Kentucky bluegrass.

	10/9/03	10/17/03	4/6/04
Kentucky bluegrass (lf)	5-6	7-8	pre-joint
Timing	EPOST	LPOST	SPRING
Air temp (F)	48	64	64
Relative humidity (%)	72	50	51
Wind velocity (mph)	3	5	2
Soil temp 1 inch (F)	44	48	70

Results
Oat control with flucarbazone-sodium was good (86-91%) with all treatments when evaluated after the SPRING application timing. Seed yield was unaffected by treatment. Seed yields in this trial were unusually low due to sub-optimal fertility, therefore it is difficult to draw any definite conclusions regarding crop injury. Further testing is required to assess crop injury potential with flucarbazone-sodium.

Susceptibility to flucarbazone-sodium injury varies with crop species. In another study at Hermiston, flucarbazone-sodium was very injurious to seedling tall fescue at early and late timings and crop yield was very low due to the severe crop injury (Table 3 and 4). Data from this trial indicated that flucarbazone-sodium is not a viable candidate for oat control in tall fescue due to a lack of selectivity. Flucarbazone-sodium, currently registered for use in wheat, is not registered for use in grass seed production and is being evaluated on an experimental basis, only. Mention of products used in this trial should not be considered to be a recommendation for commercial use.

Table 2. Herbicide treatment effects on wild oat control in seedling Kentucky bluegrass.

Treatment[1]	Rate	Timing	KBG injury 10/31/03	KBG injury 2/18/04	KBG injury 4/29/04	Oats control 10/31/03	Oats control 4/20/04	KBG yield 6/29/04
	(product/acre)		---------------------------------(%)--------------------					(lb/a)
Untreated control			0	0	0	0	0	339
Everest/Everest	0.4 oz/0.4 oz	EPOST/ SPRING	2	0	1	79	91	398
Everest/Everest	0.6 oz/0.6 oz	EPOST/ SPRING	2	0	4	85	87	365
Everest/Everest	0.4 oz/0.4 oz	LPOST/ SPRING	0	0	1	48	89	331
Everest/Everest	0.6 oz/0.6 oz	LPOST/ SPRING	3	0	5	66	86	334
LSD (0.05)			NS	NS	NS	24	8	NS

[1]All treatments contained non-ionic surfactant (NIS) at 0.25% v/v. NS = not significant.

Table 3. Application conditions on seedling tall fescue.

	10/9/03	10/17/03
Tall fescue (lf)	4-5	7-9
Timing	EPOST	LPOST
Air temp (F)	48	64
Relative humidity (%)	72	50
Wind velocity (mph)	3	5
Soil temp 1 inch (F)	44	48

Table 4. Herbicide treatment effects on wild oat control in seedling tall fescue.

Treatment[1]	Rate	Timing	Crop injury 10/13/03	Crop injury 5/13/04	Crop yield 7/6/04
	(prod/a)		----(%)----		(bu/a)
Untreated			0	8	1154
Everest + NIS	0.4 oz	EPOST	25	90	122
Everest + NIS	0.6 oz	EPOST	26	94	72
Everest + NIS	0.4 oz	LPOST	8	73	353
Everest + NIS	0.6 oz	LPOST	9	79	263
LSD (0.05)			5	9	223

[1]All treatments contained non-ionic surfactant (NIS) applied at 0.25% v/v .

INTERRUPTED WINDGRASS CONTROL IN ESTABLISHED KENTUCKY BLUEGRASS GROWN FOR SEED

D.A. Ball, L.H. Bennett and S.M. Frost

Introduction
A study was conducted in a commercial field of established Kentucky bluegrass (KBG) var. 'SR2100' grown for seed production, planted in April of 2001 near Imbler, OR in Union County to evaluate flucarbazone-sodium, (Everest®) a potential herbicide for control of certain winter annual grass weeds, including interrupted windgrass (*Apera interrupta*).

Procedure
Herbicide treatments were applied on April 6, 2004 to KBG in the prejoint stage, about 3-5 inches in height, and windgrass in the 4 to 6 leaf stage. Treatments were applied with a hand-held CO_2 sprayer delivering 16 gpa at 30 psi. Weather conditions at time of application are summarized in Table 1. Plots were 9 ft by 25 ft, in an RCB arrangement, with 3 replications. Soil was a sandy loam (68.6% sand, 19.2% silt, 12.2% clay, 5.4 pH, 2.6% organic matter, with CEC of 15.4 meq/100g). Visual evaluation of crop injury and windgrass control were made on April 29 and May 26, 2004.

Table 1. Application conditions on April 6, 2004

Air temp (°F)	45
Relative humidity (%)	86
Wind velocity (mph)	4
Soil temp 1 inch (°F)	44

Results
Results indicate that flucarbazone-sodium was highly effective at controlling windgrass without any early evidence of crop injury. Because of variability in crop stand, no seed yield estimates were made. Flucarbazone-sodium , currently registered for use in wheat, is not registered for use in grass seed production and is being evaluated on an experimental basis, only. Mention of products used in this trial should not be considered to be a recommendation for commercial use. This research is supported, in part, by Arvesta Corporation, the Washington State Commission on Pesticide Registration, and a USDA-CSREES Grass Seed Cropping Systems grant. Special thanks to Sam Royes and Craig McNeal for their cooperation on this trial.

Table 2. Windgrass control in established Kentucky bluegrass, Imbler, OR.

Treatment[1]	Rate	KBG injury 4/29/04	KBG injury 5/26/04	Windgrass control 4/29/04	Windgrass control 5/26/04
	(product/acre)	----------	---------- (%)	----------	----------
Untreated check		0	0	0	0
flucarbazone-sodium	0.4 oz	0	0	55	92
flucarbazone-sodium	0.6 oz	0	0	57	94
flucarbazone-sodium + AMS	0.4 oz + 17 lb	0	0	62	94
flucarbazone-sodium + AMS	0.6 oz + 17 lb	0	0	75	96
flucarbazone-sodium + MSO	0.4 oz + 1.5 pt	0	0	70	96
flucarbazone-sodium + MSO	0.6 oz + 1.5 pt	0	0	77	98
LSD (0.05)		NS	NS	25	5

[1] All herbicide treatments included a non-ionic surfactant (NIS) at 0.25% v/v. AMS = ammonium sulfate. MSO = methylated seed oil. NS = not significant.

FIELD EVALUATION OF RETAIN AND PALISADE FOR ROUGH BLUEGRASS SHATTER CONTROL IN CENTRAL OREGON, 2004

M.D. Butler, T.G. Chastain, C.K. Campbell and C.J. Garbacik

Seed shatter is one of the major causes of low and unpredictable yields in grasses and may decrease yields by 30 to 50 percent or more. Decreasing shatter losses would increase efficiency and profitability of grass seed production, and reduce volunteer plants in fields. Furthermore, decreasing shatter would facilitate production of native range grasses, an alternative crop for grass seed growers. Blocking ethylene action could arrest abscission layer development and keep the seed attached to the plant. Perennial ryegrass (*Lolium perenne*), bottlebrush squirreltail (*Elymus elymoides*), and rough bluegrass (*Poa trivialis*) differ in localization of the abscission layer. Thus, these three species were evaluated in a concurrent trial at Corvallis, Oregon. Greenhouse research was conducted in all three species from 2001 through 2003, with one field evaluation conducted on perennial ryegrass during 2002.

In central Oregon, he growth regulators ReTain and Palisade were each applied at three rates to 10 ft x 25 ft plots in a commercial field of 'Laser' rough bluegrass near Madras, Oregon. ReTain is used by fruit growers to prevent apples and pears from falling from trees prior to harvest. Palisade has been used by grass seed growers to increase yields, possibly due in part to reduced shatter.

Plots were replicated four times in a randomized complete block design. Palisade was applied at 1.5, 2.1 and 2.8 pt/acre on May 12 when heads were first visible. ReTain was applied 200, 300 and 400 ppm on June 23 at full inflorescence and at 300 ppm on July 13 just prior to swathing. In addition, a combination of Palisade at 2.1 pt/acre and Retain at 300 ppm was applied at full inflorescence.

Treatments were applied with a CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal/acre 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 plot on July 13. Samples were placed in large canvas bags and hung in an equipment shed to dry, then transported to Corvallis for combining with a Hege 180 at the Hyslop Research Farm. Thousand seed counts were conducted at the seed-conditioning lab with the National Forage Seed Production Research Center in Corvallis, and germination testing was done at the Central Oregon Agricultural Research Center near Madras. There were no significant difference in 1000 seed weight; germination testing is in progress.

Palisade at 1.5 and 2.1 pt/acre significantly increased seed yields compared to the untreated check (Table 1). Yield increases were 20 percent, similar to previous research evaluating Palisade on rough bluegrass in central Oregon. ReTain did not significantly increase yields compared to the untreated check. There was no change in effectiveness when ReTain was applied just prior to swathing. A combination of Palisade at 2.1 pt/a plus ReTain at 300 ppm produced a 25 percent increase in seed yield. Unless there is a synergism between the two products, one would expect that the yield increase was the result of the Palisade with little effect from the ReTain.

Table 1. Effect of Palisade and ReTain on yields of rough bluegrass, near Madras, Oregon, 2004.

Treatment	Timing	Seed yield		Percent check
		----(lb/a)----		----(%)----
(Product/acre)				
Palisade 1.5 pt	Heads 1st visible	1124	ab[1]	120
Palisade 2.1 pt	Heads 1st visible	1130	ab	120
Palisade 2.8 pt	Heads 1st visible	1022	abc	109
Retain 400 ppm	Full infloresence	1013	abc	108
Retain 200 ppm	Full infloresence	1003	abc	107
Retain 300 ppm	Full infloresence	873	c	93
Retain 300 ppm	Swathing	983	abc	105
Palisade 2.1 pt	Heads 1st visible			
+ Retain + 300 ppm	Full infloresence	1174	a	125
Untreated	----	938	bc	100

[1]Mean separation with Least Significant Difference (LSD) $P \leq 0.05$.

EFFECT OF RESIDUE MANAGEMENT AND PALISADE ON KENTUCKY BLUEGRASS SEED PRODUCTION IN CENTRAL OREGON, 2004

M.D. Butler and C.K. Campbell

Fred Crowe and Dale Coats of the Central Oregon Agricultural Research Center conducted initial research on non-thermal residue management for Kentucky bluegrass seed production during 1991 to 1996. This was followed by an evaluation by Central Oregon Seeds, Inc. (COSI) using commercial-sized plots to compare "bale and flail" and open field burning during 1998-2000.

The objective of the project is 1) to evaluate the effect of the non-thermal residue management of "bale and flail" and "bale only" compared to open field burning on seed yield and the economically productive lifetime of Kentucky bluegrass stands, and 2) to evaluate the interaction with the growth regulator, Palisade, to compensate for the negative effect of non-thermal residue management on seed yield.

Two commercial Kentucky bluegrass seed fields were chosen to compare open field burning with the two non-thermal residue treatment of "bale and flail" and "bale only". The "bale and flail" treatment had the straw baled and removed from the field, followed by pulverization of the remaining stubble using a flail mower from Rear's Manufacturing. "Bale only" had no follow-up treatment after baling and removing the straw from the field. Open field burning as commonly practiced in central Oregon is preceded by baling and removing the straw.

Grower cooperators on the project were 3-H Farms with a fourth-year 'Geronimo' field and Ickler Farms with a third-year 'Kelly' field. A multi-acre portion of each field was treated with each of the non-thermal treatments, while the remaining portion of the fields were treated with open field burning.

Two Palisade treatments were made to 10 ft x 25 ft sub plots replicated four times within the larger residue management plots. Treatments included 1.5 pt/acre, 2.0 pt/acre and an untreated check. Applications were made when heads were first visible on May 4, 2004.

A Jari mower was used to cut three-foot alleyways across the front and back of each row of the Palisade plots. A research-sized swather was used to harvest a 40-inch by 22-foot portion on June 25 at the 'Geronimo' location and July 1 at the 'Kelly' location. Samples were placed in large canvas bags and hung in an equipment shed to dry, then transported to Corvallis for combining with a Hege 180 at the Hyslop Research Farm. Thousand seed counts were conducted at the seed-conditioning lab with the National Forage Seed Production Research Center in Corvallis, and germination testing was done at the Central Oregon Agricultural Research Center near Madras. The larger residue management plots and remainder of each field were harvested by the grower cooperator using commercial equipment, with seed cleaning and yield data provided by Central Oregon Seeds, Inc.

Open field burn increased yields over both non-thermal residue management plots at the 'Kelly' location, and over bale only at the 'Geronimo' location (Tables 1). The effect of Palisade across residue management treatments appears to be mixed, with no statistical significance between treatments (Tables 2 and 3). However, at the 'Kelly' location the trend was for Palisade at 2.0 pt/acre to generate the largest yield for both burn and bale and flail residue treatments. Yield comparisons across treatments at this location were consistently larger following burning than bale and flail treatments. There were no significant differences in 1000 seed weight or percent germination (data not shown).

Table 1. Effect of residue management options on 'Kelly' and 'Geronimo" Kentucky bluegrass yields when applied to multi-acre plots near Culver and Madras, Oregon, 2004.

	'Kelly' Kentucky bluegrass		'Geronimo' Kentucky bluegrass	
Management	Yield	Percent of burn	Yield	Percent of of burn
	(lb/a)	(%)	(lb/a)	(%)
Burn	1765	100	1365	100
Bale & Flail	1343	76	1386	102
Bale Only	829	47	1137	83

Table 2. Effect of Palisade on 'Kelly' Kentucky bluegrass yields when applied to open field burn and bale and flail plots near Culver, Oregon, 2004.

Treatment	Rate	Yield	Percent Check
	(product/a)	(lb/a)	(%)
<u>Burn</u>			
Untreated	----	1842	100
Palisade	1.5 pt	1729	94
Palisade	2.0 pt	2118	115
<u>Bale & Flail</u>			
Untreated	---	1371	100
Palisade	1.5 pt	1497	109
Palisade	2.0 pt	1738	127
		NS[1]	

[1]Mean separation with Least Significant Difference (LSD) $P \leq 0.05$.

Table 3. Effect of Palisade on 'Geronimo' Kentucky bluegrass yields when applied to bale and flail and bale only plots, near Madras, Oregon, 2004.

Treatment	Rate	Yield	Percent Check
	(product/a)	(lb/ac)	(%)
<u>Bale & Flail</u>			
Untreated	---	978	100
Palisade	1.5 pt	1062	109
Palisade	2.0 pt	983	101
<u>Bale Only</u>			
Untreated	---	984	100
Palisade	1.5 pt	954	97
Palisade	2.0 pt	943	96
		NS[1]	

[1]Mean separation with Least Significant Difference (LSD) $P \leq 0.05$.

USE OF HERBICIDES AND TILLAGE TO REMOVE COMMERCIAL PLANTINGS OF ROUNDUP READY CREEPING BENTGRASS IN CENTRAL OREGON, 2004

M.D. Butler, R.P. Crockett and C.K. Campbell

The Oregon Department of Agriculture established a control area for the production of Roundup Ready creeping bentgrass (*Agrostis stolonifera*) seed north of Madras, Oregon. This area east of the Cascade mountain range was chosen because of its isolation from the Willamette Valley. The 50,000 acres of irrigated agriculture in this arid, high desert region are surrounded by sagebrush and juniper and includes Kentucky bluegrass (*Poa pratensis*) and rough bluegrass (*Poa trivialis*) seed production. Commercial plantings of Roundup Ready creeping bentgrass were made within the control area in 2002.

Herbicide plus tillage treatments were evaluated for removal of commercial plantings of creeping bentgrass. Treatments were applied May 7, 2004 to plots 10 x 55 ft replicated four times in a commercial field of Roundup Ready creeping bentgrass. Applications were made using a CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal/acre water. Plots were evaluated for control of Roundup Ready creeping bentgrass June 24. This was followed by a double disking across the plots, with a second evaluation conducted September 3. The trial was rotovated to dislodge random plants missed during disking, and will be evaluated during the spring of 2005 for new growth following winter precipitation.

Treatments of Select 2 and Select 2 plus Habitat provided 73 and 71 percent control of Roundup Ready creeping bentgrass. This was followed by Fusilade with 65 percent control, Select 2 plus Beacon and Assure II with 61 percent control and Habitat plus Sinbar with 60 percent control. Beacon and Habitat in combination with Select 2 did not appear to increase efficacy. After disking there was 100 percent control of creeping bentgrass, including the untreated check that received no herbicide treatment.

The final column in Table 1 indicates the percent of plants not dislodged during the initial disking operation. It does not appear that these data provide any additional insights into treatment performance. Alternative trade names for Select 2 are Envoy and Prism, an alternate for Rely is Finale, and Habitat is the same as Arsenal.

Table 1. Effect of herbicide and tillage control on Roundup Ready bentgrass, near Madras, Oregon, 2004.

Treatment	Product/a	Herbicide control	Herbicide + tillage control	Plants not dislodged
		(%)	(%)	(%)
Select 2	34 fl oz	72.9 a[1]	100	1.5 cd
+COC	1.0 % v/v			
Habitat	4 fl oz	71.0 a	100	1.0 d
+Select 2	34 fl oz			
+COC	1.0 % v/v			
Fusilade	24 fl oz	64.5 b	100	1.3 d
+COC	1.0 % v/v			
Beacon	0.38 oz	60.9 b	100	2.8 bcd
+Select 2	34 fl oz			
+NIS	0.25 % v/v			
Assure II	16 fl oz	60.9 b	100	3.8 abc
+COC	1.0 % v/v			
Habitat	4 fl oz	60.0 b	100	1.3 d
+Sinbar	0.5 lb			
+NIS	0.25 % v/v			
Poast	32 fl oz	41.9 c	100	1.5 cd
+Sinbar	0.5 lb			
+COC	1.0 % v/v			
Rely	6 qt	13.8 d	100	1.0 d
+Sinbar	0.5 lb			
+NIS	0.25 % v/v			
Beacon	0.38 oz	0.0 e	100	6.0 a
+Harness	37 oz			
+NIS	0.25 % v/v			
Beacon	0.38 oz	0.0 e	100	2.3 cd
+Sinbar	0.5 lb			
+NIS	0.25 % v/v			
Beacon	0.38 oz	0.0 e	100	2.3 cd
+Diuron	2.0 lb			
+NIS	0.25 % v/v			
Beacon	0.76 oz	0.0 e	100	2.5 cd
+NIS	0.25 % v/v			
Untreated	----	0.0 e	100	5.0 ab
			NS	

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

CONTROL OF ROUNDUP READY CREEPING BENTGRASS IN KENTUCKY BLUEGRASS SEED PRODUCTION IN CENTRAL OREGON, 2003-2004

M.D. Butler, J.L. Carroll and C.K. Campbell

The Oregon Department of Agriculture established a control area for the production of Roundup Ready creeping bentgrass (*Agrostis stolonifera*) seed north of Madras, Oregon. This area east of the Cascade mountain range was chosen because of its isolation from the Willamette Valley. The 50,000 acres of irrigated agriculture in this arid, high desert region are surrounded by sagebrush and juniper and includes Kentucky bluegrass (*Poa pratensis*) and rough bluegrass (*Poa trivialis*) seed production. Commercial plantings of Roundup Ready creeping bentgrass were made within the control area in 2002.

Herbicides were evaluated for control of potential creeping bentgrass escapes in Kentucky bluegrass seed fields. Treatments were applied October 6 and November 10, 2003 to plots 10 x 25 ft replicated three times in a complete block design. The trial was conducted in commercial fields of Roundup Ready creeping bentgrass and Kentucky bluegrass near Madras, Oregon. Applications were made using a CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal/acre water. Plots were irrigated following the October 6 applications.

Plots were evaluated for control of seedling and established plants in Roundup Ready creeping bentgrass March 26 and June 4, 2004. Kentucky bluegrass was evaluated for phytotoxicity March 26 and reduction in seed set June 4, 2004.

A split application of Beacon at 0.38 oz/acre plus Sinbar at 0.5 lb/acre provided 100 percent control of Roundup Ready creeping bentgrass, but reduced seed set in Kentucky bluegrass by eight percent. Beacon at 0.38 oz/acre followed by Beacon at 0.38 oz/acre plus Sinbar at 0.5 lb/acre provided 98 percent control of creeping bentgrass with no effect on seed set for Kentucky bluegrass. Sinbar at 0.5 lb/acre on 10 November provided 95 percent control of creeping bentgrass with no reduction in Kentucky bluegrass seed set. Despite the lack of injury at relative high rates of Sinbar and diurion in these evaluations, fieldmen generally recommend rates near 0.5 lb/acre for Sinbar and 2.0 lb/acre for diuron to ensure crop safety on the Kentucky bluegrass. No crop injury attributable to treatments was observed on Kentucky bluegrass during the March 26 evaluation.

Table 1. Control of established Roundup Ready bentgrass, near Madras, Oregon, 2004.

Treatment[1]	Product/acre	Application timing[2]	Reduction in biomass (%) March	Reduction in biomass (%) June
Beacon + Sinbar	0.38 oz + 0.5 lb	Oct	98.0 a[3]	100.0 a
Beacon + Sinbar	0.38 oz + 0.5 lb	Nov		
Diuron	3.0 lb	Oct	96.3 a	98.3 a
Diuron + Beacon	3.0 lb + 0.38 oz	Nov		
Beacon	0.38 oz	Oct	88.0 a	98.0 a
Beacon + Sinbar	0.38 oz + 0.5 lb	Nov		
Sinbar	0.5 lb	Nov	60.0 bc	95.7 a
Beacon + Diuron	0.38 + 2.0 lb	Oct	94.7 a	95.3 a
Beacon + Diuron	0.38 oz + 2.0 lb	Nov		
Beacon + Sinbar	0.38 + 0.5 lb	Nov	40.0 cd	90.7 a
Diuron + Goal	2.0 lb + 12 fl oz	Oct	92.0 a	90.3 a
Beacon	0.38 oz	Oct	78.7 ab	83.3 ab
Beacon + Diuron	0.38 oz + 2.0 lb	Nov		
Diuron	3.0 lb	Nov	50.0 cd	60.0 bc
Goal + Sencor DF	12.0 fl oz + 0.33 lb	Oct	87.0 a	43.3 cd
Beacon + Diuron	0.38 oz + 2.0 lb	Nov	38.3 cd	36.7 cde
Beacon	0.38 oz	Oct	35.0 d	21.7 def
Beacon	0.38 oz	Nov		
Prowl + Goal	4.0 pt + 12.0 fl oz	Oct	30.0 de	13.3 ef
Define	9.0 oz	Oct	11.7 ef	1.7 f
Prowl	5.0 pt	Oct	3.3 f	0.7 f
Untreated	----	----	0.0 f	0.0 f

[1]Rivet applied at 1 qt/100 gal with all treatments.
[2]Applications were made on October 6 and November 10, 2003.
[3]Mean separation with Student-Newman-Kuels Test at $P \leq 0.05$.

Table 2. Effect of herbicides for control of Roundup Ready bentgrass on seed set in Kentucky bluegrass, near Madras, Oregon, 2004.

Treatment[1]	Product/acre	Application timing[2]	Reduction in seed set (%)
Diuron	3.0 lb	Oct	41.66 a[3]
Diuron + Beacon	3.0 lb + 0.38 oz	Nov	
Goal + Sencor DF	12.0 fl oz + 0.33 lb	Oct	28.33 b
Define	9.0 oz	Oct	25 b
Diuron + Goal	2.0 lb + 12.0 fl oz	Oct	10 c
Beacon + diuron	0.38 oz + 2.0 lb	Oct	8.33 c
Beacon + diuron	0.38 oz + 2.0 lb	Nov	
Beacon + Sinbar	0.38 oz + 0.5 lb	Oct	8.33 c
Beacon + Sinbar	0.38 oz + 0.5 lb	Nov	
Beacon + Sinbar	0.38 oz + 0.5 lb	Nov	5 c
Beacon	0.38 oz	Oct	0 c
Beacon + diuron	0.38 oz + 2.0 lb	Nov	
Beacon	0.38 oz	Oct	0 c
Beacon	0.38 oz	Nov	
Prowl + Goal	4.0 pt + 12.0 fl oz	Oct	0 c
Prowl	5.0 pt	Oct	0 c
Beacon	0.38 oz	Oct	0 c
Beacon + Sinbar	0.38 oz +0.5 lb	Nov	
Diuron	3.0 lb	Nov	0 c
Sinbar	0.5 lb	Nov	0 c
Beacon + Diuron	0.38 oz + 2.0 lb	Nov	0 c
Untreated	----	----	0 c

[1]Rivet applied at 1 qt/100 gal with all treatments.
[2]Applications were made on October 6 and November 10, 2003.
[3]Mean separation with Student-Newman-Kuels Test at $P \leq 0.05$.

EVALUATION OF FUNGICIDES FOR CONTROL OF POWDERY MILDEW IN KENTUCKY BLUEGRASS SEED PRODUCTION IN CENTRAL OREGON, 2004

M.D. Butler, L.L. Welch 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. Products have included the historic industry standard Bayleton, along with Tilt, Tilt plus Bravo, new products such as Laredo and Folicur, and alternative materials like Microthiol (sulfur) and stylet oil.

Fungicides were evaluated for control of powdery mildew in a commercial field of 'Merit' Kentucky bluegrass grown for seed near Madras, Oregon. The following fungicides of choice were included in the project: Bayleton, Tilt, Laredo alone and in combination with Microthiol. In addition, two Valent numbered compounds were evaluated.

A pre-application evaluation was conducted April 14. Fungicide treatment were applied using Tee Jet 8002 nozzles on a 9-ft, CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal of water/acre. The first application was made on April 16, with the first post-application evaluation conducted April 23. Powdery mildew levels then declined throughout the trial area until May 24 when there was enough disease so a second evaluation could be conducted. A second application was made May 25 and disease levels remained high enough for a series of evaluations on June 1, June 10 and June 23. Plots were evaluated using a rating scale from 0 to 5, with 0 being no mildew present and 5 indicating total foliar coverage.

Powdery mildew levels remained relatively low throughout the duration of the evaluation. A week after the first application there was less disease in the untreated plots and no significant differences between treated and untreated plots. There were no differences between treated and untreated plots again for the May 24 evaluation, but disease levels were similar to the pre-treatment evaluation. Following the second application made on May 25 there were no significant differences a week later, but by June 10 Laredo significantly reduced disease levels compared to the untreated. Bayleton and Laredo plus Microthiol significantly reduced powdery mildew compared to the untreated on the final evaluation on June 23. Other treatments that significantly reduced powdery mildew on the final evaluation June 23 include Laredo, Tilt and a combination of the numbered compounds V-10118 plus V-10116. Interestingly, Laredo plus Microthiol provided the best disease control (although not statistically significant) at the final observation in the 2003 evaluation.

Table 1. Severity of powdery mildew on Kentucky bluegrass near Madras, Oregon following fungicide applications on April 16 and May 25, evaluated on April 15 and April 23, June 1, June 10 and June 23.

	Application	Pre-evaluation		Post evaluation								
Treatments	April 16 and May 25	April 14		April 23		May 24		June 1	June 10		June 23	
Bayleton	4 oz	0.67	ab	0.21	ab	0.67	ab	0.44	0.50	ab	0.15	c
Laredo + Microthiol	8 oz + 3 lb	0.67	ab	0.33	a	0.52	b	0.67	0.42	ab	0.15	c
Laredo	8 oz	0.69	ab	0.08	b	0.79	ab	0.44	0.29	b	0.27	bc
V- 10118 + V-10116	7.8 + 7.0 oz	0.54	b	0.08	b	0.65	ab	0.46	0.42	ab	0.29	bc
Tilt	4 oz	0.63	ab	0.13	b	0.69	ab	0.44	0.33	ab	0.29	bc
V-10116	7.0 oz	0.60	b	0.04	b	0.73	ab	0.44	0.62	ab	0.50	abc
V-10118	7.8 oz	0.71	ab	0.33	a	0.83	a	0.63	0.67	ab	0.83	ab
V-10118	15.6 oz	0.75	ab	0.08	b	0.63	ab	0.54	0.63	ab	0.85	ab
Untreated	---	0.88	a	0.17	ab	0.75	ab	0.58	0.73	a	0.94	a
								NS				

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

SURVEY OF INSECT PESTS IN KENTUCKY BLUEGRASS SEED PRODUCTION IN CENTRAL OREGON, 2004

M.D. Butler, C.K. Campbell and S. Rao

An initial survey of insect pests in Kentucky bluegrass fields was conducted in central Oregon and the Grande Ronde Valley during 2003-2004. Results indicated the presence of sod webworm and cutworms in central Oregon. The winter grain mite is considered the major insect pest in Kentucky bluegrass seed production in central Oregon, but was not the focus of the project. No billbugs were collected in central Oregon, despite being considered a developing new pest in the Grande Ronde Valley. No differences were observed in two fields with multi-acre non-burned and open field burned plots. The objective of this project was to collect a second year of data during 2004-2005.

Seven commercial bluegrass seed production fields were included in the 2004-2005 survey. One of the fields from the previous year was included to compare the effect of non-burn and open-field burn on insect pest populations a year later. Five additional fields with potential for insect problems were chosen for the survey. Sixteen sod samples one-foot in diameter by four inches deep were collected at each location October 12 and November 22, 2004. Six pitfall traps were placed at each location to collect insects moving about the field. Insects were collected from the traps more or less weekly from October 18 to December 15, 2004.

Comparing results from the fall of 2003 with the fall of 2004, it appears that October may be the best time for taking sod samples. September appears to be early, while November may be too late. The number of sod webworms collected was 163 in October and 21 in November. Cutworms were evenly split with 76 in October and 79 in November. Slightly more sod webworms were collected from sod samples than cutworms. The number of winter grain mites increased through the fall. Although billbugs were not collected in the fall of 2003, fourteen were collected in October and another 3 in November 2004. There was significant variability between fields, with insects often in higher numbers in a few fields rather than spread more evenly across sampling locations.

The number of insect pests collected in pitfall traps was significantly lower across all four species compared to sod samples. Use of pit fall traps will be discontinued during the spring of 2005, with the project focusing on sod samples.

Table 1. Insect pests collected from sod samples in Kentucky bluegrass seed fields during the fall of 2004.

Insect pests	Sampling dates October 12	November 22	Total
	---------(Number of insects/location)---------		
Sod webworm			
Loc 1	132	1	133
Loc 2	26	3	29
Loc 3	3	17	20
Loc 4	0	0	0
Loc 5	0	0	0
Loc 6	1	0	1
Loc 7	1	0	1
Cutworm			
Loc 1	1	0	1
Loc 2	8	3	11
Loc 3	9	16	25
Loc 4	1	4	5
Loc 5	16	7	23
Loc 6	18	24	42
Loc 7	23	25	48
Winter Grain Mite			
Loc 1	0	0	0
Loc 2	0	7	7
Loc 3	0	0	0
Loc 4	0	0	0
Loc 5	0	0	0
Loc 6	2	1	3
Loc 7	1	9	10
Billbug			
Loc 1	4	3	7
Loc 2	9	0	9
Loc 3	0	0	0
Loc 4	0	0	0
Loc 5	1	0	1
Loc 6	0	0	0
Loc 7	0	0	0

Table 2. Insect pests collected from pitfall traps in Kentucky bluegrass seed fields during the fall of 2004.

Insect pests	Sampling dates: Oct. 18-20	Oct. 25-27	Nov. 4-8	Nov. 15-16	Nov. 24	Dec. 15	Total
	(Number of insects/sample date)						
Cutworm	3	5	24	16	4	16	68
Sod webworm	9	0	1	0	1	0	11
Winter Grain Mite	1	2	2	4	2	0	11
Billbug	1	0	0	0	0	0	1

OF GENES AND THINGS: ROAD MAPS TO DISCOVERY

R.E. Barker, S.E. Warnke and R.N. Brown

Unless you are intimately familiar with a town, locating an address with street names is often more difficult than in towns where streets are numbered. Numbered streets are consecutive going north or south, east or west from a central point. So finding an address near, say 50th S and 200th E can be quite easy. Named streets, on the other hand, may not be in any particular order or sequence. Without a good map, or being with someone who has already been there, it is easy to get lost, and as hard as it is for some of us to ask for directions, we may stay lost for some time.

The grass seed industry has supported our research to find the genes that control whether a ryegrass plant is an annual or a perennial. This seems like a simple question and it may be easy to compare one type of variety with a variety of another plant type, but without a map, finding the answer based on genetic relationships is very difficult. Discovery of differences between varieties that had already been classified as one plant type or the other would be like taking all the red cars from one town and mixing them with all the blue cars from another town, then trying to find a specific make of car. Put another way, you could mix all the Fords from one town with all the Fords from another town together and then try to identify the yellow one. Either the make or the color may be easy to recognize, but without further investigation, you would not know where it was manufactured or who owned it. There are even more things that cause differences among ryegrasses.

Knowing there were obvious visual differences, but not knowing what caused those differences was the situation faced when we started the quest to find the genetic basis for annual and perennial plant types. In reality, we were even farther removed from an answer to the question because the desired outcome was to develop a test based on genetic differences that more accurately predicted plant type than that of the seedling root fluorescence (SRF) test. There was no road map for us to follow. Inheritance of ryegrass characteristics was known for very few, and really none of practical value. Thus, we decided to start with the most basic of genetic research approaches, that of determining inheritance patterns using genetic linkage maps.

Segregating Ryegrass Population Development

Inheritance can be observed only though having progeny that segregate for specific characteristics of their two parents. If no segregation for a characteristic occurs, the parents would have the same genetic makeup for that particular characteristic. But if there is variation among the progeny, and the parents appear different, analysis of the variation can reveal inheritance for the characteristic. So we started the project by crossing perennial-type plants with annual-type plants, then crossing two of their progeny to produce a population that maximized the segregating variation. Visually all of the plants in the population were intermediate between the original perennial and annual grandparents with no individuals being fully perennial nor fully annual as might be expected.

There was, however, considerable variability within the population for many morphological characteristics. We found that we could manipulate reproductive development (flowering) by changing the length of the day (photoperiod) and duration of cold treatment (vernalization). Data from this study provided the basis for the maturity grow-out test (GOT) that was refined by OSU and is now accepted for labeling ryegrass purity. None of the morphological data, however, provided information for the genetic basis that could predict a specific characteristic in a mature or developing plant. Further, morphological characteristics are targets, not predictive *per se*. To be predictive, we needed a molecular-based genetic linkage map and none were available for the ryegrasses.

Genetic Linkage Mapping

Genetic linkage is the tendency of two characteristics to be inherited together. The more tightly they are linked, the more strongly they will be inherited together. In recent years, many molecular markers (DNA addresses) and molecular analysis systems have become available. We used four different DNA analysis systems, each having many inherited markers, to molecularly probe each individual in our segregating (mapping) population. From these data collected across all individuals in the population, we were able to detect which markers were inherited together (genetically linked) and then construct a genetic linkage map for ryegrass (Figure 1). This was the first ryegrass map that had perennial and annual type plants in their parentage.

A linkage map can be used similar to a geographic map where you are trying to find a specific address on a specific street in a specified town. You can easily find your way around town with a map, or if the map is not accurate, you can ask someone who has been to the address for directions. Usually they will direct you from a landmark you both know (a school, a church, etc.) to the address for which you are looking. It turned out, we discovered, that our ryegrass genetic linkage map was very similar to maps developed in more heavily studied crops like wheat, barley, and rice. From those well-developed maps we were able to anchor (find landmarks) and prove that many of the genes in ryegrass are in the same location as found in the cereal grasses.

Gene Discovery

With the molecular map in hand, we were next able to add to it the morphological data and find candidate DNA regions (genes) that are genetically linked to the plant characteristics of interest. We believed that the primary difference between annual and perennial types was a response to the environmental stimulation from vernalization and photoperiod. Most perennial types require a cold treatment and a long- to short- to long-day conversion, where annual types do not. We focused on the main vernalization gene (*vrn-1*), and in late 2003, it was finally discovered and reported in wheat by a large team of scientists. Using their published DNA sequences, we were able to specifically address DNA primers to identify the same gene in three ryegrass species, *Lolium perenne* (perennial type), *L. multiflorum* (both Italian and Westerwolds annual types), and *L. temulentum* (a true inbreeding annual). The DNA sequences for the *vrn-1* gene, however, were nearly identical in the ryegrasses and of itself did not provide a genetic basis to predict annual or perennial types.

Current scientific theory is that the *vrn-1* gene (on our chromosome 4) is always ready to let a grass plant flower, but another gene, *vrn-2*, (on our chromosome 7) is blocking it. This is kind of like OSU in Corvallis (chromosome 4) always being ready to do grass seed research, but unable to do so until someone from an address in Salem (chromosome 7) provides the funding. Using the data from our flowering response study (GOT), we found that genes located on chromosomes 1, 4, and 7 primarily control ryegrass flowering. The flowering control gene on chromosome 1 appears to be a photoperiod response related to earliness (like Eugene, doing whatever it wants if the environment is agreeable) and is genetically linked to SRF and the enzyme phosphoglucose isomerase (*pgi-1*) that we have used successfully to predict annual types. This makes sense because it appears that many genes related to annualness are located on chromosome 1.

We have also used the enzyme superoxide dismutase (*sod-1*) to predict perennialness and it is located on chromosome 7 close to the second *vrn-2* gene. We are now identifying reproducible DNA addresses that are specific to each of the three important areas related to flowering control located on chromosomes 1, 4, and 7. We expect that combining three addresses (DNA markers) will make it possible to accurately and quickly predict ryegrass growth types, but the alternate forms of the genes at those addresses still need to be identified. After we are able to consistently return to the same specific addresses (and the correct form of the gene), a dependable laboratory procedure can be developed for seed testing purposes.

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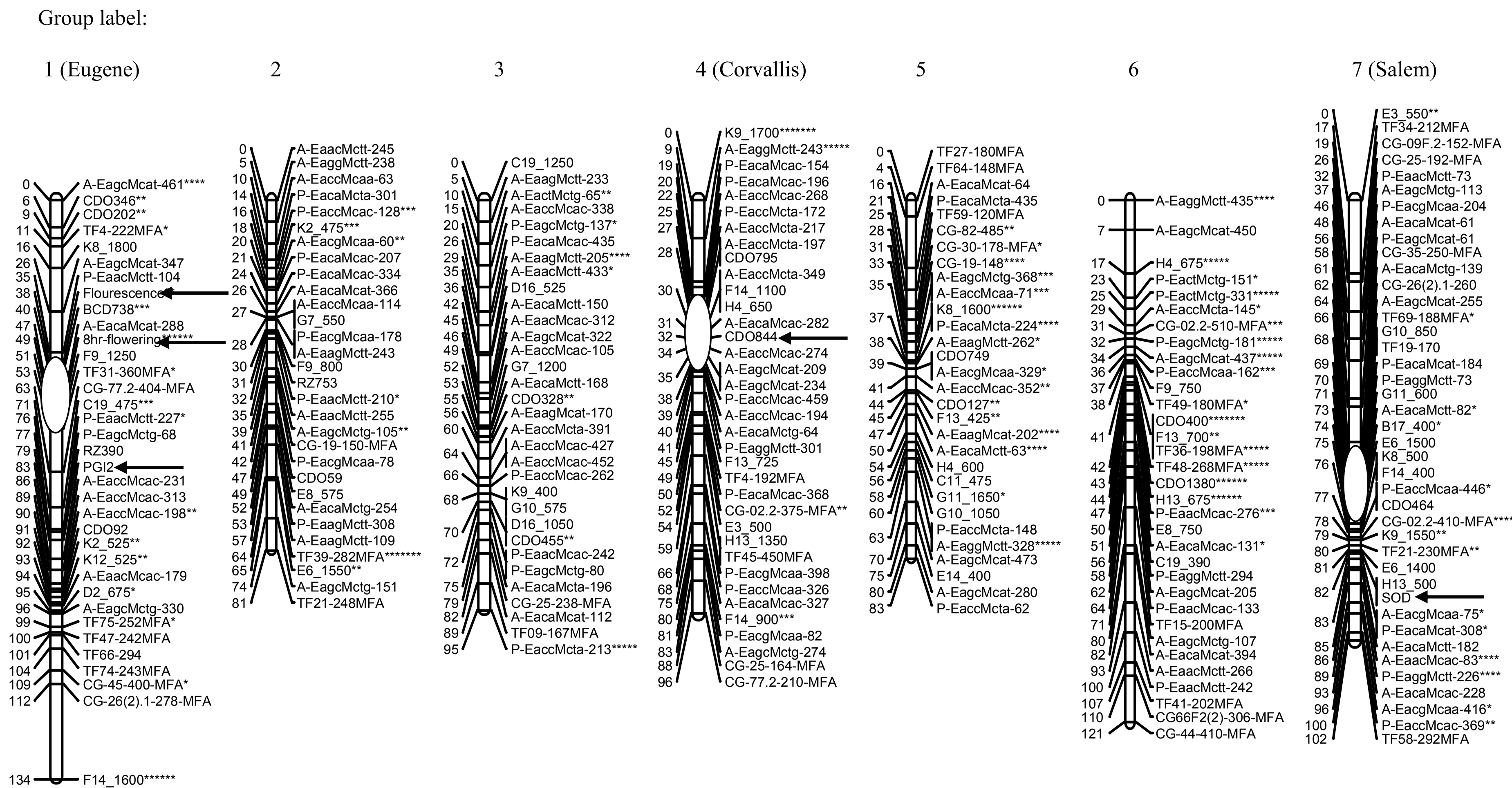

Figure 1. Annual/perennial ryegrass genetic linkage map. Specific DNA addresses are indicated by coded name on the right of each group and genomic distance from the end of the linkage group (chromosome) on the left. Distance between two markers is determined by the tendency of the two markers to be inherited together. Arrows indicate morphological markers and the flowering control regions (placement not exact) are indicated by open ovals ⬯ . (adapted from Warnke et al., 2004)

POTENTIAL FOR ON-FARM CONVERSION OF STRAW TO BIOENERGY IN SEED PRODUCING OPERATIONS

G.M. Banowetz, J.J. Steiner, A. Boateng and H. El-Nashaar

Introduction

National support for developing renewable fuel sources has rekindled interest in bioenergy production from agricultural products. As a part of the USDA Agricultural Research Service national mission, the Bioenergy and Bioproducts National Program was established to create jobs and economic activity in America and reduce the Nation's dependence on foreign oil. As a part of this national effort, the National Forage Seed Production Research Center and Eastern Regional Research Center have initiated a research partnership with Taylor Energy in Irvine, California and the Western Research Institute in Laramie, Wyoming to develop a farm-scale gasification reactor to convert straw to energy products as a way to provide value-added revenue for Pacific Northwest seed producers.

The concept of local-grown transportation fuels is not new. Efforts during the 1980s to find alternative uses for straw without open field burning included the conversion of straw to energy (Conklin, Young and Youngberg, 1989; CH_2M Hill, 1991). At that time, available technologies could not produce energy from straw at costs competitive with existing energy sources so much of that work was abandoned.

Since that time, demand has increased for electrical generation capacity and transportation fuels with regional population growth and the rise in energy prices. These two factors have made straw-to-energy conversion an attractive strategy for value-added revenue because there are existing markets for energy, and the value of energy from existing sources has risen so alternative energy production is becoming more competitive.

Based on our current research, we discuss the potential for using straw biomass as feedstock for production of electricity or liquid fuel, the current limitations in conversion technologies when using straw, and our research to develop an affordable gasification reactor for on-farm use. Our business model for on-farm energy product production is based on the assumption that a suitable farm-scale gasification reactor will be developed that converts straw to a mixture of carbon monoxide and hydrogen gases called synthesis gas. Our analyses assume that revenues from seed sales will continue to provide the primary income source for farmers and treat bioenergy as a value-added revenue source when using straw already produced from existing profitable seed production enterprises.

Available straw feedstock

The current prevalent use of Willamette Valley straw from seed fields is as animal feed to Pacific Rim export markets valued at $25-million. Assuming straw worth $45-50 per ton, these receipts are spread among straw brokers, straw storage, compression, and transportation enterprises. In most cases, seed producers receive minimal if any payment for straw from their fields. Limited markets are available for Kentucky bluegrass straw produced east of the Cascades in Oregon, Washington and Idaho.

The value of energy products produced on the farm will be dependent upon the amount of straw available, the efficiency of conversion to energy, and end product market value. Our conservative estimate of available straw for energy conversion is 1 ton of straw per acre after leaving a minimal 1-ton per acre to meet the NRCS conservation requirement. ARS research in western Oregon determining straw production amounts from three grass species over a 10-year period showed that this assumption is very conservative (Table 1). Extending the1-ton per acre estimate to include straw from the approximate 486,000 acres of grass seed production in Oregon and 100,000 acres in Washington and Idaho provides a total of 586,000 tons of straw. The energy content of straw is approximately 12,000,000 BTU/ton (NREL, 2005 a). Converting straw to electricity using gasification technology for synthesis gas production and using an internal combustion engine to power an electrical generator provides 350 kWH per ton at 10% conversion efficiency. Assuming a market value of $0.04 per kWh, electricity production from PNW straw has an apparent gross value of $8.2-million that translates to $14 per ton of straw.

An alternative straw-to-energy conversion strategy would be to produce liquid fuels. Assuming a conservative yield liquid fuel yield of 60 gallons per ton of straw (NREL, 2005 b) with a wholesale value of $1 per gallon provides gross regional revenues in excess of $35-million at $60 per straw ton. Electricity production could provide producers more value if used as on-farm replacement power since retail prices are greater than wholesale prices and for enterprises that consume large amounts of electricity.

Limitations to straw-based bioenergy production

Despite a long-term interest and efforts to convert straw into value-added energy products, two factors have proven to be major obstacles to success. First, the cost of transporting low-density straw to an energy conversion facility usually exceeds the value of the energy produced (Graf and Koehler, 2000; Kerstetter and Lyons, 2001). Therefore, farmers need to nearly give the straw away for energy producers to make a profit. Second, previous kinds gasification reactor technologies based on air-blown designs were not suitable for use with straw because of slagging and durability of the reactors due to corrosive constituents found in straw (Miles et al., 1996). Air-blown designs also introduce large quantities of atmospheric nitrogen that dilute the quality of the synthesis gas which reduces its heating value and decreases the efficiency of synthesis gas conversion to liquid fuel.

Our approach is to significantly reduce straw transportation costs by developing a farm-scale gasification reactor suitable for economic production of on-farm energy. Technology already exists to produce liquid fuel from synthesis gas, but currently is scaled and priced for large centralized conversion centers. Alternative processes based on fermentation also are available to produce liquid fuel from straw, but these rely on large-scale, high-capitalized centralized plants to which straw must be transported. Idaho Biorefinery Corp., a subsidiary of Iogen (Ottawa, Ontario, Canada) is planning construction of a plant near Idaho Falls to convert wheat straw to ethanol (Cavener, 2005). This centralized straw conversion approach is different than our small-scale, on-farm conversion concept.

Progress in gasification-based energy production from straw

Through a cooperative research agreement with Western Research Institute, we are evaluating the suitability of a new concept dual-stage gasification unit (Figure 1) for producing synthesis gas suited for fueling an internal combustion engine to power an electrical generator or be used in a thermal catalytic reactor to produce liquid fuel. Our research gasification reactor is based on a design that separates the pyrolysis and combustion reactions into two stages (Pletka et al., 2001). The reactor has been constructed at Western Research Institute and is being tested for thermal stability and gas quality using Kentucky bluegrass straw as feedstock. Because the unit is currently utilizing air to circulate heat transfer media, preliminary gas analyses show relatively high nitrogen content (Table 2). The nitrogen content of the synthesis gas will be reduced in the next phase of testing by injecting steam instead of air into the combustion stage of the reactor.

After our initial research is complete and has shown that the reactor design is suited for further testing, Farm Power, a Washington State non-profit organization will conduct on-farm trials using the experimental technology to evaluate the feasibility of on-farm electrical generation from synthesis gas produced from straw.

As shown in our estimates above, synthesis gas used to power a generator for electricity production will provide value-added revenue, but it is likely that conversion of synthesis gas-to-liquid fuels will significantly increase the value of the straw. Western Research Institute in conducting research to develop catalytic conversion reactors that would be suited for use with a farm-scale gasification reactor. The next phase of this research will evaluate the feasibility of farm-scale liquid fuel production utilizing these new technologies.

Conclusions

There is great potential to convert straw produced by already profitable seed producing operations into energy products and provide value-added revenue directly to seed producers. To make this feasible, we are doing research to develop gasification reactor technology scaled for on-farm use to reduce the costs of transporting the straw and make farmers energy producers. New dual-stage gasification technologies have promise utilizing straw as feedstock, although more testing is needed to evaluate the amounts of slagging and corrosion associated with straw that occur in our reactor compared to other technologies. Emerging thermo-catalytic technology for conversion of synthesis gas to liquid fuels promises the greatest economic returns at this time.

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Table 1. Comparison of straw yield for three grasses during establishment and three harvest years in direct seeded and tilled fields. Yields presented for harvest years represent combined data from direct seeded and tilled fields because there were no significant differences between establishment methods.

	pounds/acre			Harvest year (pounds/acre)			
Straw phytomass	Direct	Tillage	*P*	1	2	3	*P*
Perennial ryegrass	7259	7548	NS[1]	6640 b	8214 a	7405	ab ***[2]
Tall fescue	10956	10958	NS	11851a	10662 b	8265	c ***
Creeping red fescue	5472	6398	***	4654 b	6563 a	6748	a ***

[1]NS Not significant at $P \leq 0.05$.
[2]*** Significant at $P \leq 0.001$.

Table 2. Preliminary analysis of synthesis gas produced by dual stage gasification of Kentucky bluegrass straw at 900 F. Numbers represent volume % of total gas at specified time points following start-up of gasification operation.

Sample #	Time	H_2	N_2	O_2	CO	CH_4	CO_2
B	215	0.5	54.4	0.0	10.5	0.9	32.8
C	235	0.9	59.5	0.5	9.5	1.6	28.0
D	255	2.7	31.1	2.1	17.0	4.7	42.9
E	275	3.5	44.4	2.7	11.8	5.7	32.3
F	300	1.6	37.3	3.0	15.5	3.6	39.4

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Figure 1. Taylor/WRI dual stage gasification unit used to convert straw to synthesis gas.

SANTIAM CANAL WATER QUALITY ANALYSIS FOR ORGANIC AND INORGANIC NITROGEN AND OTHER CHEMICAL CONSTITUENTS

S.M. Griffith

Background

The source of drinking water for the city of Albany, OR is the Santiam Canal. This water is diverted from the Santiam River east of the city of Lebanon, OR. It then passes through the city of Lebanon, across an agricultural landscape, and then through the city of Albany before arriving at the Albany Treatment Plant. Routinely, as part of the water purification process, chlorine is added to reduce levels of certain undesirable contaminates and to help maintain high water quality. On several occasions in the spring of 2003, the Albany Water Treatment Plant had to add higher than normal amounts of chlorine to maintain their drinking water standards. Representatives from the Oregon Department of Agriculture and the Albany Water Treatment Plant suggested at a public meeting in February 2004 that the abnormal additions of chlorine were required to remove urea nitrogen fertilizer that resulted from off-site movement from agricultural fields into the canal upstream from Albany. Due to the lack of any water quality data that would show/indicate that urea nitrogen was actually contaminating the Santiam Canal, USDA-ARS volunteered (at the February 2004 public meeting) to measure concentrations of organic and inorganic nitrogen in the canal during the months of March and April 2004. This is the final report of those findings.

Objective

To determine the concentrations of nitrate-N, ammonium-N, total nitrogen, and organic-N (total N - total inorganic-N) in water sampled from the Santiam Canal during March and April 2004. Levels of turbidity, pH conductivity, suspended solids, total organic carbon, and ortho-phosphate were also measured to broaden the scope of understanding of the canal's water quality.

Water Sampling and Analysis Procedures:

Sampling Locations

Site #1: Albany Water Treatment Plant, 300 Vine St. SW, Albany, OR

Site #2: Fry Rd. just south of Grand Prairie Rd. (east of Albany, OR)

Site #3: O.F. Cemetery (north of the Lebanon Hospital, Lebanon, OR)

Sampling Frequency and Duration

Water samples were taken from the Santiam Canal at Site 1 everyday from February 23 to April 29, 2004 and every other day from Sites 2 and 3 from February 24 to April 28, 2004.

Chemical Analyses

All water analyses were performed by USDA-ARS, Corvallis, OR. The following water quality parameters were measured: nitrate-N, ammonium-N, and total nitrogen (organic-N + inorganic-N), turbidity, pH, conductivity, suspended solids, total organic carbon, and ortho-phosphate. organic-N (urea nitrogen is a component of) was determined by the following calculation: Total N – Total inorganic-N (nitrate-N and ammonium-N). Total N and total organic carbon were analyzed using a Shimadzu TOC/TN analyzer. The measurement principal is by thermal decomposition / NO detection (chemiluminescence method). This method yields the determination of total organic-N plus inorganic-N. Other methodologies and a copy of our QC-QA Plan are available from USDA-ARS if desired.

Findings

Water chemical analyses data are within acceptable environmental limits.

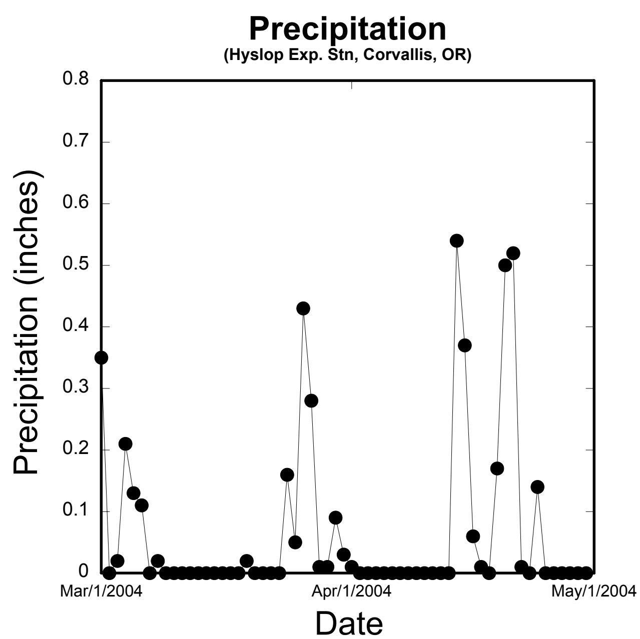


Figure 1. Daily precipitation recorded at Oregon State University Hyslop Farm Experiment Station, Corvallis, OR.

Table 1. Water quality data of the Santiam Canal at three locations during the spring of 2004. Computations were made using the combined data for each location for all sample dates. The units mg/L equals parts per million (ppm).

Location Sample was Taken	Turbidity	pH	Conductivity (uS)	Sediment (mg/L)	TOC (mgC/L)	TN (mg N/L)	TON (mg N/L)	NH_4-N + NO_3-N (mg N/L)	NH_4-N (mg N N/L)	NO_3-N (mg N/L)[4]	Ortho-P (mgP/L)
Lebanon O.F. Cem.[1]											
Mean	6.4	7.3	38.6	10.9	3.9	0.23	0.16	0.04	0.01	0.03	0.01
Median	6.5	7.3	39.0	10.6	3.5	0.19	0.15	0.00	0.00	0.00	0.01
Max	14.0	7.6	52.0	25.0	8.3	0.67	0.50	0.21	0.07	0.19	0.09
Min	2.5	7.0	34.0	0.6	0.2	0.06	0.00	0.00	0.00	0.00	0.00
Fry Rd.[2]											
Mean	7.7	7.4	41.5	13.3	4.2	0.25	0.15	0.08	0.01	0.06	0.01
Median	7.5	7.4	41.0	13.0	3.7	0.22	0.15	0.05	0.00	0.00	0.00
Max	15.0	7.8	54.0	25.0	9.9	0.67	0.35	0.32	0.11	0.30	0.18
Min	2.5	7.0	34.0	2.4	2.8	0.12	0.00	0.00	0.00	0.00	0.00
Albany WT Plant[3]											
Mean	7.9	7.3	42.2	15.8	4.4	0.27	0.15	0.10	0.01	0.08	0.01
Median	7.5	7.3	41.5	14.6	3.8	0.24	0.15	0.07	0.00	0.05	0.00
Max	22.0	7.7	63.0	37.4	11.3	0.70	0.41	0.33	0.08	0.32	0.09
Min	2.2	7.1	33.0	1.2	1.9	0.11	0.00	0.00	0.00	0.00	0.00

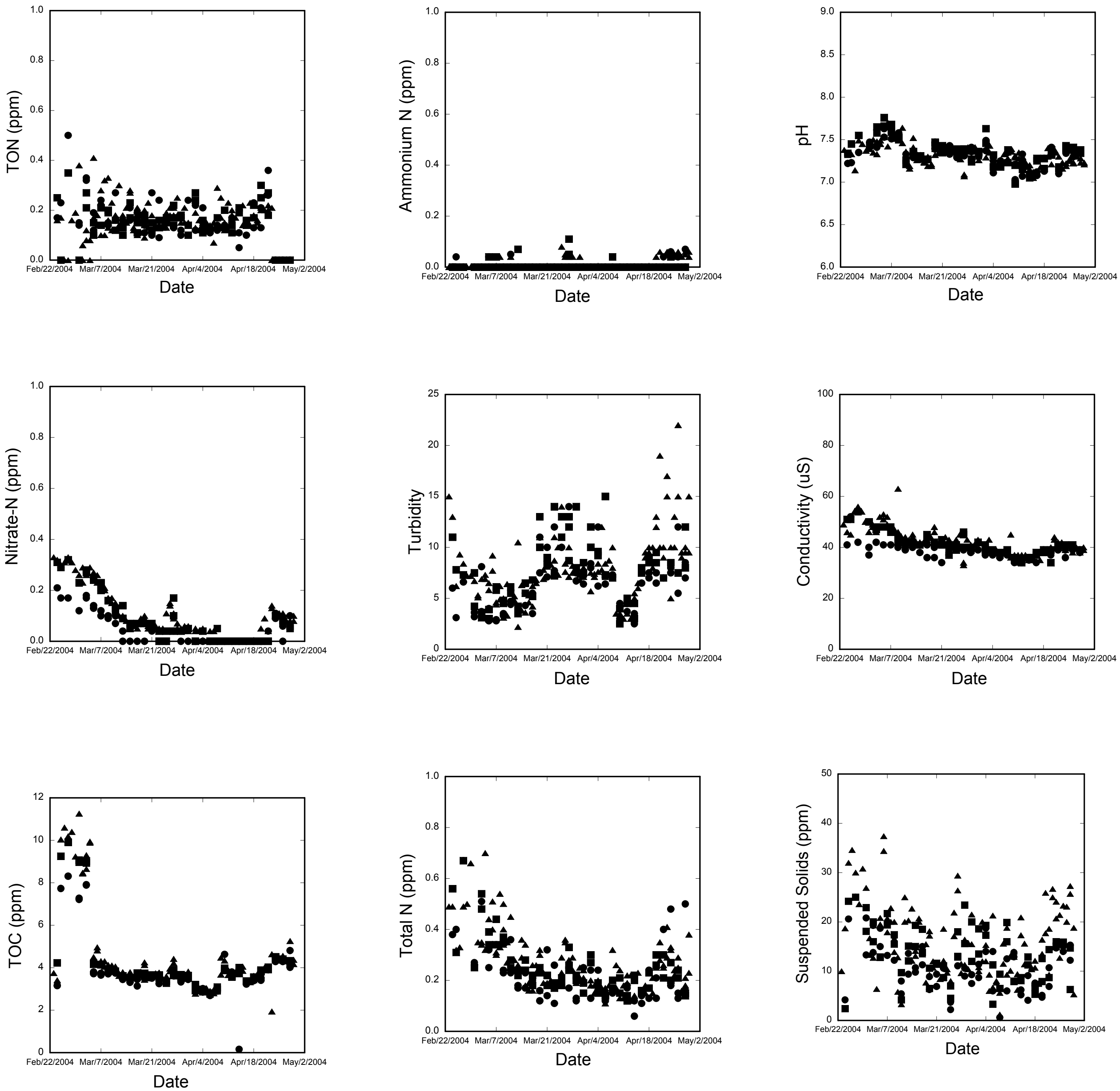
[1] Cumulative data from Feb. 24 to April 28, 2004

[2] Cumulative data from Feb. 24 to April 28, 2004

[3] Cumulative data from Feb. 23 to April 29, 2004

[4] The USEPA drinking water standard for nitrate-N is 10 mg N/L or 10 ppm

Figure 2. Water analysis data for total organic nitrogen (TON), total organic carbon (TOC), nitrate-N, ammonium-N, turbidity, pH, total N, conductivity, and suspended solids. Water samples were collected on specific dates near the O.F. Cemetery (north of the Lebanon Hospital, Lebanon, OR) (●), at Fry Rd. just south of Grand Prairie Rd. (east of Albany, OR) (■), and at the Albany Water Treatment Plant (300 Vine St. SW, Albany, OR) (▲).



IDENTIFICATION OF GRASS SEED CROPS OF LINN COUNTY, OREGON, THROUGH REMOTE SENSING

G.W. Mueller-Warrant, G.W. Whittaker, J.J. Steiner, S.M. Griffith and G.M. Banowetz

Grass seed agriculture occupies over 560,000 acres in the Pacific Northwest, constituting a significant portion of the regional cultivated landscape. If available, Geographic Information System (GIS) data on agricultural practices, production constraints, and environmental variables might reveal relationships that could be used to model the effects of proposed conservation practices at the landscape level. As an example of the need for such georeferenced information, the National Resources Inventory of the Conservation Effects Assessment Program (CEAP) is currently conducting a multi-million dollar nationwide farmer survey to identify crops grown, tillage practices used, and conservation practices implemented on 30,000 cropland sample points scattered across the United States in an effort to quantify the environmental and economic benefits of conservation practices paid for by the American taxpayer.

The primary objective of our research was to develop a public GIS of grass seed cropping system practices in 2004 in the Willamette Valley of western Oregon. Specific goals were to identify: (i) fields that were bare of vegetation at some time during the late-spring to early-fall period due to disturbance by tillage, non-selective herbicide treatments, or field burning, (ii) previously established perennial grass seed stands kept in production from one growing season to the next, (iii) crop species grown in those established perennial stands, specifically tall fescue, perennial ryegrass, and orchardgrass, and (iv) any stand establishment or residue management practice of grass seed cropping systems amenable to detection through remote sensing.

Data from Landsat images taken on July 26, August 11, and October 14, 2004, were combined with field boundary information from the USDA-Farm Service Administration field office in Tangent, OR, to develop remote sensing classification procedures. A drive-by, ground-truth census of all grass seed fields in Linn County within the Calapooia River watershed was conducted on 19 different days from September 22 through November 23, 2004. Data collected for each field in the ground-truth census included current crop species (classified as tall fescue, perennial ryegrass, orchardgrass, annual (Italian) ryegrass, bentgrass, other infrequently grown crops, or no currently identifiable crop), disturbance/residue removal practices (classified as conventional tillage, field burning, nonselective herbicide treatment, full straw chop *in situ*, residue baled and removed, other infrequently used practices, or unknown), and stand establishment status (classified as fallow, spring planting, established perennial crop, fall carbon planting, fall conventional drill, fall no-till, volunteer crop, or unknown). A simplified version of the ground-truth census results is displayed in Figure 1.

A total of 2,677 fields in Linn County, OR, were assigned values for 2003-04 growing season crop species, 2004-05 growing season crop species, residue management, stand establishment status, and other management practices. In 968 cases, crops grown in the 2003-04 growing season could not be determined because tillage had destroyed them. In 1,059 cases, crops growing in 2004-05 could not be determined because they had not yet been planted, had not yet emerged, or were too small to reliably identify from the road. For the 2004-05 growing season, identifications included 448 established tall fescue fields, 112 established orchardgrass fields, 288 established perennial ryegrass fields, 6 fields of other established perennial grasses, 603 annual ryegrass fields, 49 spring plantings, and 89 fields of other crops. Among the 603 identified annual ryegrass fields, 180 were in the full straw chop volunteer stand reseeding system, while another 60 had been field burned. Among the 1,253 fields disturbed by tillage, field burning, and nonselective herbicide treatment, 344 were identified as having been in annual ryegrass, two were field burned tall fescue, and one was field burned perennial ryegrass. It is likely that many of the additional 909 fields with unidentified 2003-04 crops had been used for either annual ryegrass or perennial ryegrass seed production.

Validity of the ground-truth survey was evaluated by comparison with OSU Extension estimates of grass seed acreage by crop species. Established stands of tall fescue were found on 15.8% of the field area in the ground-truth census, slightly below the Extension estimate of 17.8% for all of Linn County. Established stands of orchardgrass were found on 2.7% of the field area in the ground-truth census, close to the Extension estimate of 2.4%. Combined areas representing stands of established perennial ryegrass, 2004-05 growing season annual ryegrass, and disturbed ground lacking identified crop was 71.2% of the field area in the ground-truth census, slightly below the OSU Extension estimate of 78.3% for perennial and annual ryegrasses. It is logical that the OSU Extension estimates were higher than the ground-truth census results because the Extension numbers did not include projections of fallowed land, acreage in a nonproductive establishment year, or land in minor acreage crops. Addition of approximately 19,800 acres of fallow fields, nonproductive first year stands, and minor acreage crops to the Extension estimates would generate very close agreement between ground-truth census results and Extension estimates.

The July Landsat image was best at identifying tall fescue and perennial ryegrass. The August image identified orchardgrass in addition to tall fescue and perennial ryegrass. The October image was best at separating bare ground and spring plantings from established crops. In addition to these five categories, full straw annual ryegrass fields could also be detected. Some failures to detect bare/disturbed fields were probably caused by herbicide applications, tillage operations, or field burning performed after a satellite imaging date. Misclassifications of bare/disturbed ground from the ground-truth census as established perennial ryegrass, tall fescue, or orchardgrass averaged 784 cases in July, 525 cases in August, and 387 cases in October. Much of the decline in misclassification from July to October probably represents established grass seed fields that had just been harvested in July but not yet tilled, treated with herbicides, or burned. Our inability to distinguish orchardgrass and perennial ryegrass from tall fescue in October was likely a consequence of the favorable growing conditions and abundant rainfall of late-summer and early-fall that led to near complete canopy closure for all established perennial grass seed crops by October.

A multi-step composite classification scheme using data from all three dates was developed that correctly identified an average of 74.3% of fields into the six categories. This process was 85.6% accurate for bare/disturbed fields, 80.1% accurate for established tall fescue, 63.9% accurate for established perennial ryegrass, 44.4% accurate for full straw annual ryegrass, 26.8% accurate for established orchardgrass, and 14.3% accurate for spring plantings. Results from the multi-step classification scheme are displayed in Figure 2. Comparison of this map with the ground-truth census results (Figure 1) highlights one limitation of our procedures, namely that we only matched remote sensing classifications to six of the major classes from the ground-truth census. These six categories covered 2,330 fields, leaving 13.0% of the 2,677 fields in the ground truth census from any attempt at being correctly identified by remote sensing classification procedures. Omitted fields included established legume stands, pastures, hay crops, and annual ryegrass fields with unidentified residue management practices (10.8% of all fields).

Future development of the grass seed cropping system GIS will focus on overcoming several of its current limitations. One priority will be to separate annual ryegrass from other grass seed crops through differences in their spectral reflectance in winter, spring, or early summer images. A second priority will be to extend the classification spatially across the entire Willamette Valley through combined use of the current composite classification procedure and limited ground truth surveys of areas not included in the current census. A third priority will be to extend the classification temporally through limited future ground truth surveys and through access to historical records of grass seed production data. A fourth priority will be to improve our efficiency in detecting residue management practices and other conservation activities through remote sensing. Shapefile data layers for this evolving public GIS of Willamette Valley grass seed cropping practices will be available on-line at ftp://nfsprc.usda-ars.orst.edu/pub. No proprietary business information has been or will be used in developing this database.

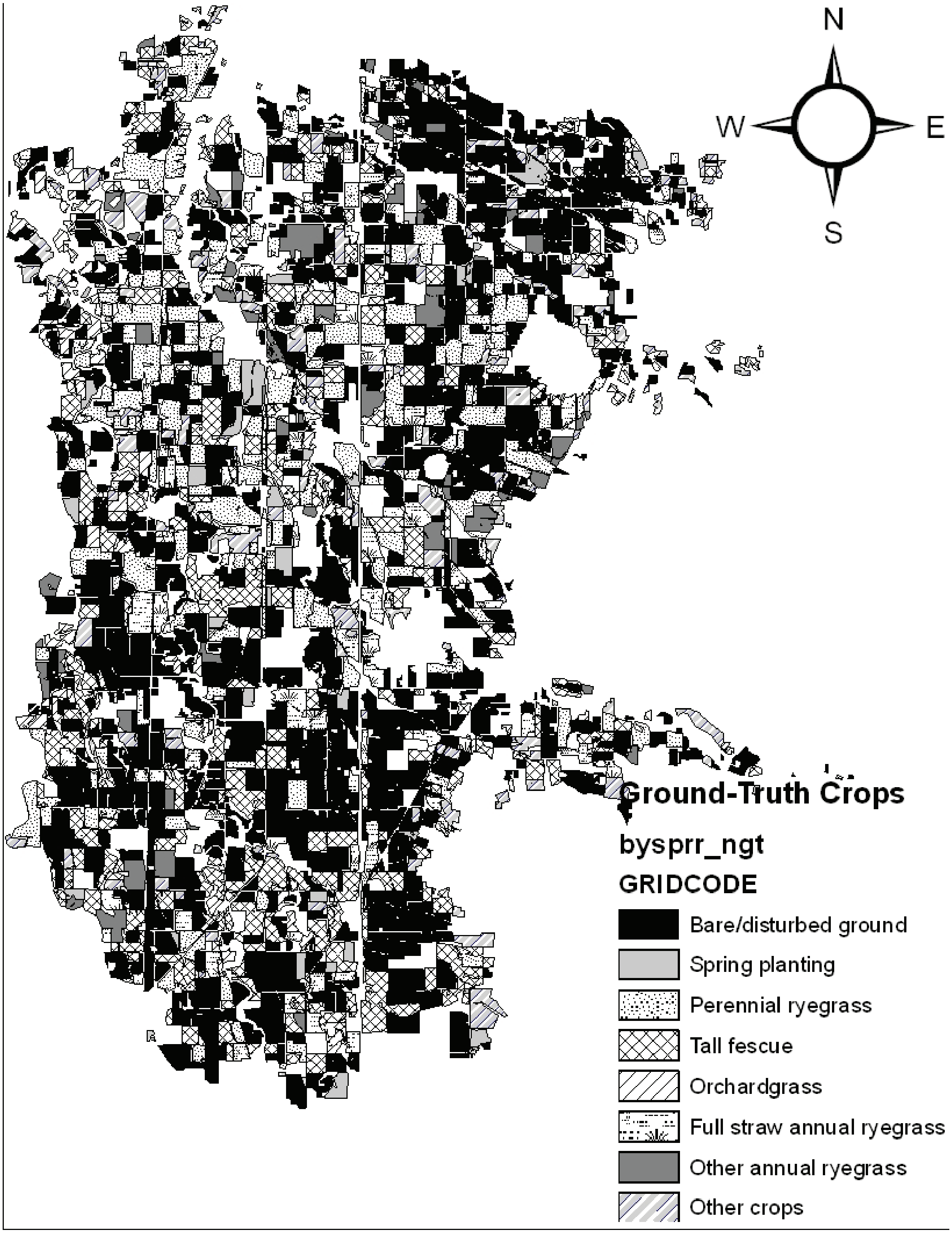


Figure 1. Ground-truth census of crops in Linn County, OR, 2004.

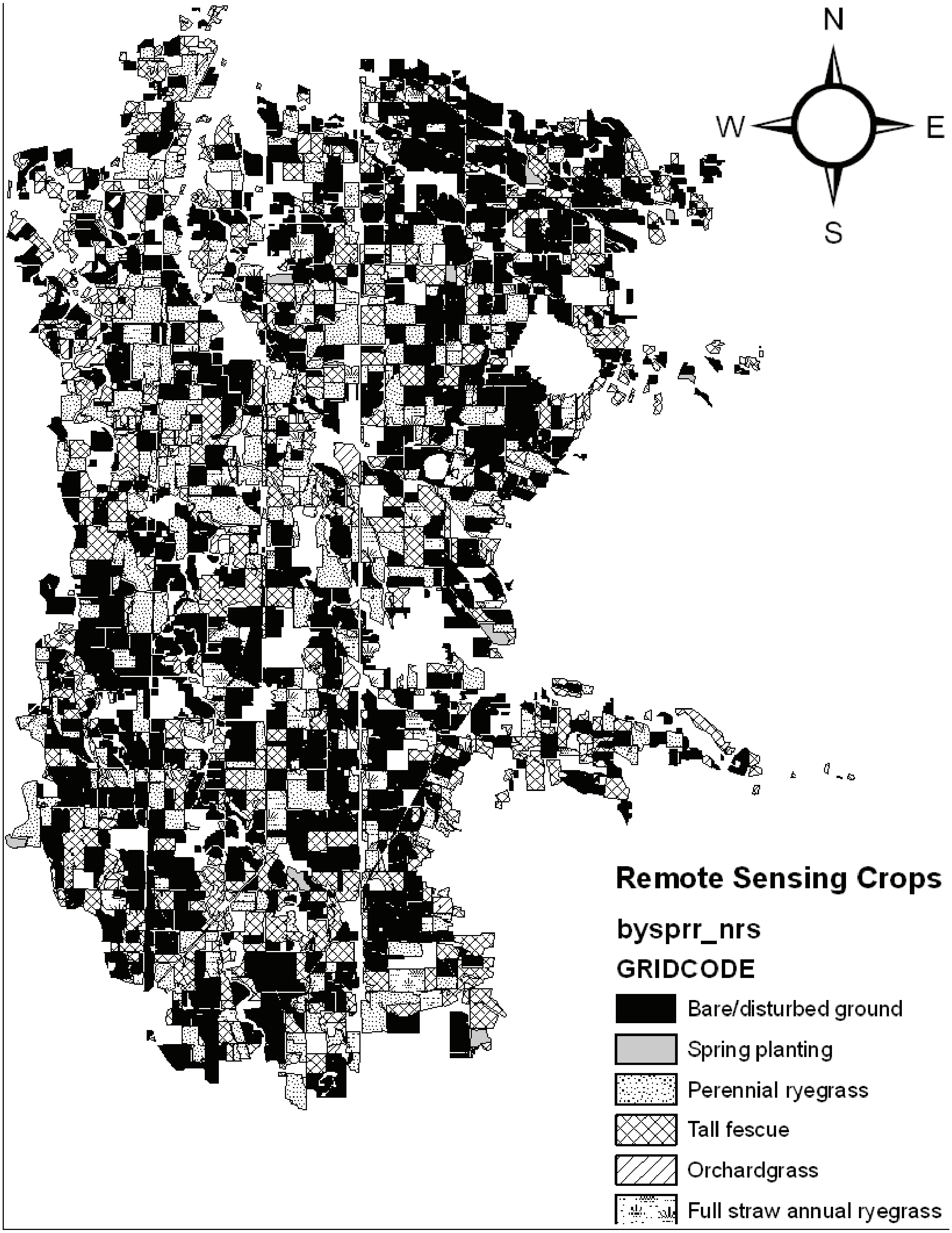


Figure 2. Remote sensing classification of crops in Linn County, OR, 2004.

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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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