2001
SEED PRODUCTION RESEARCH
AT OREGON STATE UNIVERSITY
USDA-ARS COOPERATING
Edited by William C. Young III

Page

(continued on inside front cover)

Department of Crop and Soil Science Ext/CrS 121, 4/02

*** 20th anniversary issue ***

This is the 20th year of publishing the Seed Production Research report. The first report summarizing current research work of interest to the Oregon seed industry was printed in 1982. The goal then was to make public the results of research work in progress, or to summarize recently completed studies. That goal has guided this effort since the beginning.

The seed research capability at Oregon State University is not a discrete unit, but is integrated through several departments on campus, at branch experiment stations, county Extension staff, and scientists with the United States Department of Agriculture. The success of this force is rooted in the cooperative spirit among all who are engaged in the study of seed science.

In addition to state and federal research funds, grants from business firms, commodity commissions, the Oregon Seed Council and the Oregon Seed Trade Association contribute support to specific projects. These extramural funds are greatly appreciated.

Special recognition is due to the OSC, the organization that for 20 years has support this publication with a grant to cover printing costs and distribution of the report to seed growers throughout the state. I would also remind readers that beginning with the 1996 report it has been possible to view this publication online at the Oregon Seed Extension Program web site: http://www.css.orst.edu/seed-ext.

Bill Young, Editor

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DEFINING OPTIMUM NITROGEN FERTILIZATION PRACTICES FOR FINE FESCUE AND ANNUAL REYGRASS SEED PRODUCTION SYSTEMS IN THE WILLAMETTE VALLEY

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

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

Results from the first two seed crops (1999 and 2000) indicated spring N levels above 30-50 lb N/a for fine fescue and above 135-180 lb N/a for annual ryegrass (2000 seed crop) did not statistically increase seed yield. Levels of soil NO_3-N increased at the highest (2 time normal) N rates used in this study (140 and 270 lb N/a respectively in fine fescue and annual ryegrass). Based on sampling in the fall, the potential for leaching losses of N from normal application rates of N fertilizer does not appear to be a problem. Results presented below are from the third year for fine fescue and the second year for annual ryegrass.

Procedure
Large scale on-farm plots averaging 5 acres per site were established at 4 locations (2 fine fescue and 2 annual ryegrass) prior to fertilizer applications. Specific information for each site is shown in Table 1.

Plots were approximately 22 ft wide by 275-600 ft long (depending on fit in the field and grower equipment size). Spring fertilizer treatment rates of 0, 45, 90, 135, 180, 225, and 270 lb N/a were applied to the annual ryegrass and treatment rates of 0, 30, 50, 70, 90, 110, and 140 lb N/a were applied to the fine fescue. The seven treatments were replicated three times in a randomized complete block. Data were analyzed using appropriate statistical analyses (e.g., ANOVA, Regression).

All sites were fertilized between March 19 and April 26 at the pre-determined rates in a single application. Applications were done between approximately 400 and 800 growing degree days (GDD) as is generally recommended. The 400 GDD and 800 GDD points were March 15 and April 30, 2001, respectively. Accumulated GDD using the T_{sum} method was calculated by summing the daily degree day values obtained by adding the maximum and minimum temperatures for the day, dividing by two and subtracting the base temperature, which for temperate grass is 0°C. Accumulated GDD was calculated beginning January 1. Additional details regarding calendar dates of N application and harvest at each site are shown in Table 2. Fertilizer was applied using a Gandy Orbit-air spreader pulled by a four-wheeler or small Kubota tractor. In addition to fertilizer N treatments, each site was also fertilized with 250 lb/a of 0-15-20-10 at the same time as the first N application to ensure there were no other nutrient limitations. The plots were managed the same as the rest of the field for all other cultural management practices (weed control, fall fertilizers, disease control, etc.) by the grower-cooperator.

Table 1. Site information for all locations, 2001.

Location	County	Planted	Year trial started	Soil type
		FINE FESCUE		
Sherman Farms	Marion	Spring 98	Spring 99	Jory silty clay loam
Taylor Farms	Marion	Spring 98	Spring 99	Nekia silty clay loam
		ANNUAL RYEGRASS		
Michael Hayes Farm	Linn	Fall 99	Spring 00	Dayton/Clackamas
Tim VanLeeuwen Farm	Linn	Fall 99	Spring 00	Dayton silt loam

Table 2. Dates of fertilization, windrowing, and combining for optimum N studies, 2001.

Location	Variety	Fertilizer application dates	Windrow	Combine
		FINE FESCUE		
Sherman Farms	Brittany	3/19	7/8	7/17
Taylor Farms	Shademark	3/21	7/11	7/19
		ANNUAL RYEGRASS		
Michael Hayes Farm	Gulf	4/5	6/27	7/11
Tim VanLeeuwen Farm	Gulf	4/26	6/29	7/20

Plant samples were taken at maturity (during June). Yield components samples were obtained at or following pollination. Plots were swathed into windrows between June 27 and July 11 and combined between July 11 and July 20 using grower equipment (Table 2). Seed yield from each plot was measured using a Brent YieldCart and adjusted for clean seed yield following an assessment of percent cleanout from sub-samples taken at harvest. Sub-samples taken at harvest were also used to determine seed size. Purity and germination analyses were done at the OSU Seed Testing Laboratory.

Results and Discussion

Crop yield and response

Fine fescue: Seed yield responded to low spring nitrogen rates at both sites. Optimum yield was obtained with the 30-50 lb spring N/a rate (Table 3). Yield at the Sherman site peaked at around 70 lb N/a but was not statistically above the 50 lb/a rate. Higher applications did not increase seed yield and even showed a decline in yield as the application rate exceeded 70 lb N/a as was the case in prior years. The Taylor site was optimized at 30 lb N/a and the Sherman site at 50-70 lb N/a. Seed yield at both locations was well above average yields for these species. Fertile tiller densities (Tables 4 and 5) were improved by the increased N rates as was floret number at the Sherman site. Seed size was not affected by the different N rates. Total biomass substantially increased up to the highest N rates. This increase in biomass did not result in higher seed yield and caused a decrease in harvest index. The cause of decreased yield from higher N rates may be from excessive plant growth resulting in early lodging and shading of the crop thereby diminishing the realized yield potential. Tissue N concentration and N uptake both reflected increased N application rates (Table 6). The 0 spring N rate averaged 25 lb N/a uptake in the plant as a result of soil mineralization and fall applied fertilizer.

Table 3. Seed yield (lb/a) of fine fescues following varied rates of spring applied N, 2001.

Spring N rate (lb/a)	Sherman Farms	Taylor Farms	2-site average
0	799 c	1111 d	955
30	1286 ab	1433 a	1359
50	1691 ab	1377 ab	1534
70	1749 a	1324 abc	1537
90	1745 ab	1220 cd	1482
110	1693 b	1331 abc	1512
140	1661 b	1266 bc	1464
LSD 0.05	153	126	----

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

Table 4. Statistical summary of yield component responses to varied spring applied nitrogen for all locations, 2001.

Location	Total above ground biomass	Harvest index	1000 seed weight	Fertile tiller density	Spikelets per inflorescence	Florets per spikelet
FINE FESCUE						
Sherman Farms	**[1]	*	NS	**	(*)	**
Taylor Farms	**	**	NS	NS	(*)	(*)
ANNUAL RYEGRASS						
Michael Hayes Farm	NS	NS	*	NS	NS	NS
Tim VanLeeuwen Farm	**	NS	NS	*	NS	NS

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

Table 5. Average aboveground biomass, 1000 seed weight, spikelet number per inflorescence, and floret number per spikelet of fine fescue (2 sites) following varied rates of spring applied N, 2001.

Spring N rate	Total biomass	Fertile tillers	1000 seed weight	Spikelets per infl.	Florets per spikelet
(lb N/a)	(tn/a)	(no./sq ft)	(g)	(no.)	(no.)
0	2.1	220	1.09	18.3	4.8
30	3.6	280	1.14	21.7	5.4
50	5.1	358	1.12	23.8	5.3
70	5.5	384	1.14	24.1	6.0
90	5.3	330	1.14	24.6	5.3
110	6.3	360	1.19	25.3	5.2
140	8.0	441	1.17	26.8	5.8

Table 6. Average tissue N concentration (%) and equivalent N uptake (lb N/a) in above ground biomass at maturity in fine fescue following varied rates of spring applied N, 2001.

Spring N rate	Tissue N Concentration	N uptake
(lb N/a)	(%)	(lb N/a)
0	0.6	25
30	0.5	39
50	0.9	91
70	1.0	108
90	1.0	103
110	1.0	132
140	1.5	236

Annual ryegrass: This is the second year in a two year trial with annual ryegrass. Seed yield responses to spring N in annual ryegrass was similar to perennial ryegrass. (reported in Seed Production Research reports 1998-2000). Optimum seed yield resulted by the use of 90 or 180 lb N/a depending on the location (Table 7). At the Hayes site, 1000 seed weight was the only yield component measured that was affected by Spring N (Tables 4 and 8). In contrast, at the VanLeeuwen site, both total biomass and fertile tiller density were increased. The response to higher than expected N rates at the Vanleeuwen site may have been a result of a late replanting (March) of areas where the stand had been lost by too aggressive use of row-spraying.

Table 7. Seed yield (lb/a) of annual ryegrass following varied rates of spring applied N, 2001.

Spring N rate (lb/a)	Michael Hayes Farms	Tim VanLeeuwen Farms	2-site average
0	1647 b	1214 c	1431
45	2097 a	2219 b	2158
90	2213 a	2293 b	2253
135	2118 a	2518 ab	2318
180	2119 a	2934 a	2527
225	2241 a	2660 ab	2451
270	2140 a	2832 a	2486
LSD 0.05	158	458	----

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

Table 8. Average aboveground biomass, 1000 seed weight, spikelet number per inflorescence, and floret number per spikelet of annual ryegrass (2 sites) following varied rates of spring applied N, 2001.

Spring N rate	Total biomass	Fertile tillers	1000 seed weight	Spikelets per infl.	Florets per spikelet
(lb N/a)	(tn/a)	(no/sq ft)	(g)	(no.)	(no.)
0	3.0	140	2.65	21.5	7.8
45	4.4	158	2.82	20.4	8.3
90	4.3	187	2.74	20.6	8.2
135	4.6	165	2.71	21.1	8.4
180	4.7	177	2.77	21.5	9.3
225	4.8	171	2.77	20.0	9.2
270	4.4	140	2.70	21.5	8.6

Table 9. Average tissue N concentration (%) and equivalent N uptake (lb N/a) in above ground biomass at maturity in annual ryegrass following varied rates of spring applied N, 2001.

Spring N rate	Tissue N Concentration	N uptake
(lb N/a)	(%)	(lb N/a)
0	0.9	51
45	1.0	84
90	1.1	93
135	1.1	99
180	1.4	132
225	1.4	138
270	1.6	136

Crop nitrogen uptake

The data presented here are from tissue uptake levels obtained in samples taken during pollination or shortly thereafter. Tissue N% (Tables 6 and 9) varied from 0.5% to 1.6%. As expected, N concentrations closely followed N application rates. The average amount of nitrogen in the aboveground biomass by species is reported in Tables 6 and 9. The highest N application rates resulted in N uptake ranging from 136 to 236 lb N/a uptake in the above ground biomass demonstrating the ability of these grasses to take up a large amount of N. Mineralized N is available for uptake by the plant in the spring as indicated with the 0 N rate. The 0 spring applied N still resulted in N uptake levels in the plant ranging from 25 lb N/a (fine fescue) to 51 lb N/a (annual ryegrass).

Soil NO_3-N

Soil samples were obtained in the fall from three treatments: 0, 135, 270 lb N/a (0, 70, 140 in fine fescue) and at three depths: 0-1, 1-2, 2-3 ft. These results are detailed in Tables 10 and 11. At the fine fescue sites the highest fertilizer rate (twice a normal rate) increased the levels of NO_3-N in the soil profile. The top one-foot concentrations averaged 12.7 ppm at fine fescue site and 23.2 ppm at the annual ryegrass sites. There was no significant difference in the soil NO_3-N at either annual ryegrass site. The normal rates of N (fine fescue–70 lb N/a and annual ryegrass–135 lb N/a) were all around 10 ppm or less except at the Vanleeuwen site. The shortened time for crop growth and development at the Vanleeuwen site due to the late replanting may have resulted in less uptake of N, thus, more N being left in the soil at the end of harvest. In addition, the lower soil profiles also increased in NO_3-N at most locations from the 2X rate. However, the amount of NO_3-N in the lower two feet was very minimal with the highest concentration at 12.4 ppm and most < 5 ppm. According to OSU guidelines[1] actual residual concentrations are considered low (<10 ppm), medium (10 to 20 ppm), high (20-30 ppm) or excessive (>30 ppm) levels. Using this criteria, all the sites had low levels at normal rates of N fertilization except the Vanleeuwen site. Even though there is efficient soluble nitrogen removal by the fibrous root systems of these perennial grass seed crops during crop growth, excessive levels of applied nitrogen can increase the concentrations of NO_3-N in the soil following harvest and be subject to leaching in the fall if the plant is unable to utilize it when the rains start. Use of recommended N rates will result in little potential for leachable N being available in the soil after harvest.

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

Table 10. Soil NO_3-N concentrations (ppm) at three soil depths of fine fescue following varied rates of spring applied N, 2001.

Spring N Rate (lb/a)	Post harvest sample depth 0-12 in.	13-24 in.	25-36 in
	SHERMAN FARMS		
0	1.5	0.9	2.0
70	5.3	2.3	2.0
140	20.1	12.4	7.2
LSD 0.05	12.5	6.4	3.2
	TAYLOR FARMS		
0	1.9	0.9	0.6
70	1.4	1.0	0.8
140	5.2	2.4	1.8
LSD 0.05	1.7	0.8	0.6
	AVERAGE		
0	1.7	0.9	1.3
70	3.4	1.7	1.4
140	12.7	7.4	4.5

Table 11. Soil NO_3-N concentrations (ppm) at three soil depths of annual ryegrass following varied rates of spring applied N, 2001.

Spring N Rate (lb/a)	Post harvest sample depth 0-12 in.	13-24 in.	25-36 in
	MICHAEL HAYES FARMS		
0	11.8	5.0	2.3
135	25.9	6.5	3.0
270	26.7	8.1	5.4
LSD 0.05	NS	NS	NS
	TIM VANLEEUWEN FARMS		
0	6.3	2.3	1.1
135	7.3	2.1	2.3
270	19.7	7.2	3.8
LSD 0.05	NS	NS	NS
	AVERAGE		
0	9.1	3.7	1.7
135	16.6	4.3	2.7
270	23.2	7.7	4.6

Summary
Optimum levels of spring applied N for seed production were 90-180 lb N/a in the annual ryegrass and 30-70 lb N/a in the fine fescue. Applying more than the optimum rates did not ensure increased yield and it is difficult to predict if the added input will result in a better yield. The high N response at the Vanleeuwen may have been from shorting the growing season available for the crop to take up and assimilate the N available. Very dry conditions occurring during the spring of 2001 may also have played a part at this site. Seed yields at the normal N rates were above 2001 state averages of 1700 lb/a (annual ryegrass) and 900 lb/a (fine fescues) as reported in estimates by OSU. Soil test results show efficient crop use of applied N and very low potential for leaching losses at recommended rates. These results from multi-year trials will be used to establish better economic and production recommendations for optimizing inputs in grass seed crops.

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EVALUATING NITROGEN FERTILIZATION RATES ON GRASS PLANT GROWTH USING NEAR-EARTH AND GROUND-LEVEL PHOTOGRAPHY

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Introduction
A study to define optimum nitrogen fertilization practices for grass seed production systems in the Willamette Valley was initiated in 1997. During the 1999-2000 and 2000-2001 crop years, we used aerial and ground-truth verification photography to evaluate photographic analysis as a potential technique for assessing residual nitrogen influence on early-season perennial ryegrass growth. We also measured seed yield in 2000 and 2001.

Procedure
Large-scale on-farm plots were established prior to fertilizer applications. Field trials were conducted with perennial ryegrass (*Lolium perenne*) variety SR 4200. The field was seeded fall 1997. Plots were approximately 22 ft wide by 300 ft long. Spring fertilizer treatment rates of 0, 45, 90, 135, 180, 225, and 270 lb N/a were used. The seven treatments were replicated three times in a randomized complete block. In addition to fertilizer N treatments, the plots were also fertilized with 275 lb/a of 0-15-20-10 at the same time as the first N application to ensure there were no other nutrient limitations. The plots were

managed the same as the rest of the field for all other cultural management practices by the grower-cooperator. In the 2000-01 crop year, all plots were given a uniform application of 250 lb/a 9-12-24-8 and a split-applied spring N application totaling 183 lb N/a.

During harvest 2000, seed yield from each plot was measured using a Brent YieldCart and adjusted for clean seed yield following an assessment of percent cleanout from sub-samples taken at harvest. During harvest 2001, seed yield for each plot was measured with a John Deere® GreenStar Yield-Mapping System®, and is reported on a dirt-weight basis.

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

<u>Global Positioning Data</u>
We mapped treatment plot boundaries using a Trimble® Pathfinder Pro® XL GPS equipped with a data logger. Positions were differentially corrected using a local base station (Portland, OR) and averaged using Trimble® navigation software (Trimble, 1996).

<u>Color Aerial Photography</u>
We photographed the research plots on December 19th, 1999 for the 2000 crop year, and on February 1, 2001 for the 2001 crop year. We used Kodak® Royal Gold® ISO 400 film in a 35-mm camera fitted with a 28-mm wide-angle lens, mounted on a single-engine fixed-wing aircraft. A mosaic of the images was scanned and saved as 24-bit tagged image format (TIF) files. These images were imported into Picture Publisher® software and converted into red, green, and blue digital images. Each of these images were then imported into IDRISI®, an image processing/GIS software package (Eastman, 1997).

Image Rectification and Classification
Images were rectified using a minimum of 10 ground control points and a linear, nearest-neighbor algorithm (Richards, 1986). Pixels were resized to 1 m and UTM zone 10 North, WGS84 Datum coordinate system. The root mean square error (Richards, 1986) for this operation was kept at less than one meter.

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

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

<u>Ground level Photography</u>
To obtain higher resolution information at known locations within the field, we used a light-weight platform of polyvinyl chloride (PVC) tubing on which we mounted a 35-mm camera fitted with a 28-mm, wide-angle lens (Louhaichi et al., 2001). The camera was pointed vertically downward 1.7 m above the ground. A 1-m^2 frame was central in the photograph, which provided an estimate of scale and allowed us to measure objects and calculate surface areas in the photo. Photographs taken with this camera arrangement were scanned and converted to digital format. Three uniformly spaced ground-level photographs were taken within each plot on or close to the day of overflight.

<u>Ground Level Image Analysis</u>
We were interested in determining the percent green leaf cover of perennial ryegrass. Cover is defined as the vertical projection of the crown or shoot areas of a plant species on the ground surface, expressed in percent or fraction of the area measured (Stoddart et al., 1975). We measured cover in 1-m^2 quadrats at ground level by analyzing digital, color images. We observed that pixels in the digital RGB (red, green, blue) images of plant leaves and stems had higher green digital numbers than red or blue. Soil, rocks, litter, and dead leaves tended to have lower values for green than for red or blue. This is to be expected since chlorophyll absorbs red (centered about 0.67μm) and blue (centered about 0.45μm) light and reflects green (centered about 0.55μm). We therefore classified images by determining if the average of red and blue digital numbers were greater or less than the green digital number.

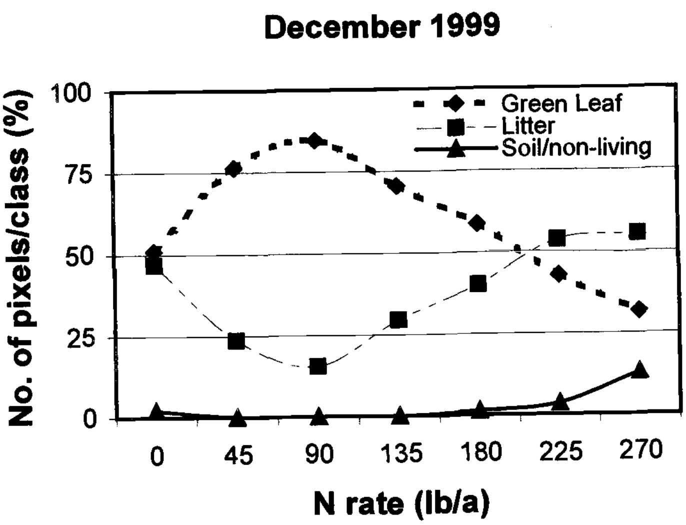
The resultant image had pixel values between −1 and +1. Negative values tended to be soil/nonliving while positive values were green leaves and stems. We calculated percentage leaf cover. The classification process was programmed in Visual Basic® so classification of 72 photographs could be completed in about 15 minutes.

<u>Incorporation of Geographic Information Systems</u>
Our objective was to evaluate photographic analysis as a potential technique for assessing residual nitrogen influence on early-season plant growth and plant survival as a function of nitrogen application rates. We combined information in aerial photographs with platform photography and ground-truth data within a GIS to classify the response of each treatment. Three main steps summarize our methodology. In step 1, we scanned, rectified, and classified color aerial photography. This separated treatments into units with similar reflectance. In step 2, image processing of platform photography generated percent green leaf cover in each treatment. Since all themes were geo-referenced, we were able to overlay ground-truth data points on the color aerial image and double check our output in step 3. In addition, we were able to seek relationships between

computer classification of aerial photography and ground-level platform photography.

Results and Discussion

Specific results were somewhat different, but trends were substantially similar between the two years. Based on aerial photography, class 1 (greener) increased through 45 to 90 lb N/a, then decreased with greater rates of N during fall 1999 (Figure 1). During early 2000-01 growing season, class 1 increased to 45 lb N/a, but then decreased through 225 lb N/a (Figure 1). The reason for the increase in class 1 between 225 and 270 lb N/a is not readily apparent. However, percentage of class 1 (green) was approximately equal at 270 lb N/a as at 0 lb N/a, which suggests that the increase had no significance for management.



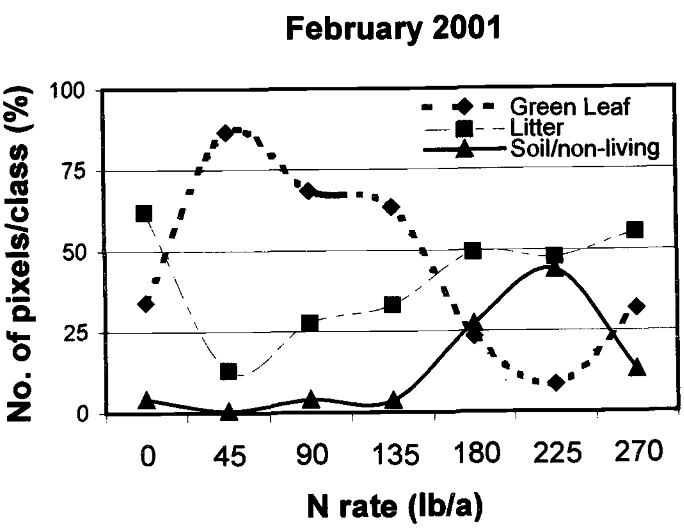


Figure 1. Computer classification of aerial photography taken on December 19, 1999 and February 1, 2001. Classes are Green Leaf, Litter, and Soil/non-living.

Based on platform photography, the trend for plant cover was the same between the two years (Figure 2). Cover increased from 0 to 45 lb N/a, but then steadily decreased at higher rates. Above 135 lb N/a in December 1999 and 90 lb N/a in February 2001, cover was progressively lower than at 0 lb N/a. In both years, the lowest percent leaf cover occurred at 270 lb N/a.

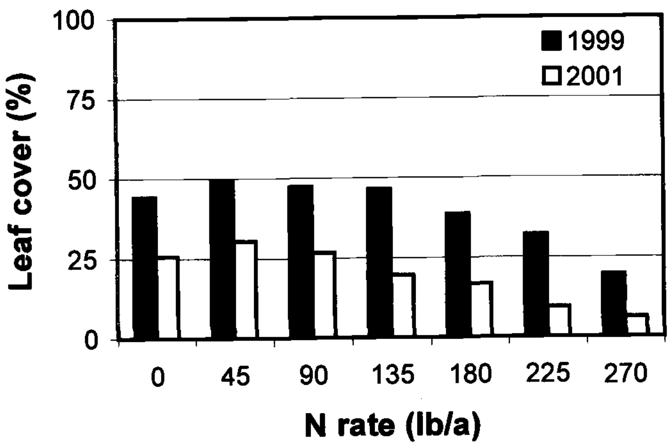
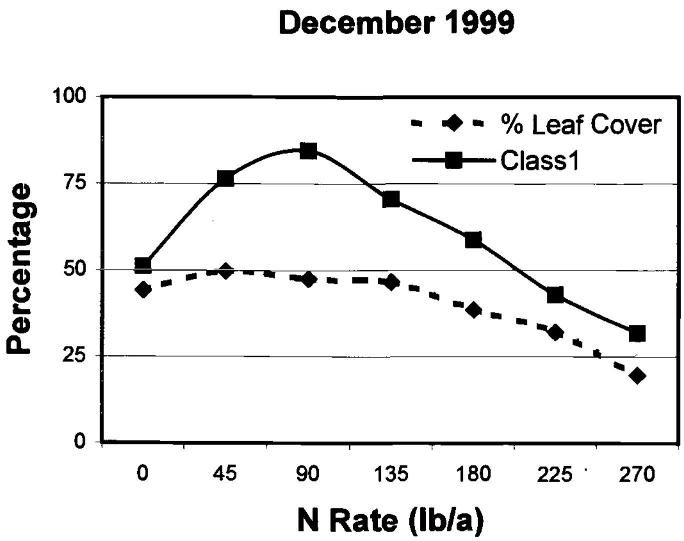


Figure 2. Overall percent leaf cover based on platform photograph analysis. Platform photographs taken within three days of aerial photography, during mid-December 1999 and early February 2001.

When comparing the response of percent leaf cover based on platform photography and computer classification of aerial photography, there was a correlation of 89% in December 1999 and 76% in February 2001 (Figure 3). The unexplained increase in green (class 1) from 225 to 270 lb N/a in February 2001 decreased the correlation. In general, these reasonably high correlations would suggest that for large areas we can use aerial photography and computer classification to stratify fields into classes based on the amount of green cover. Platform photography should be used to collect ground-truth data to help calibrate and interpret information from aerial photographs.



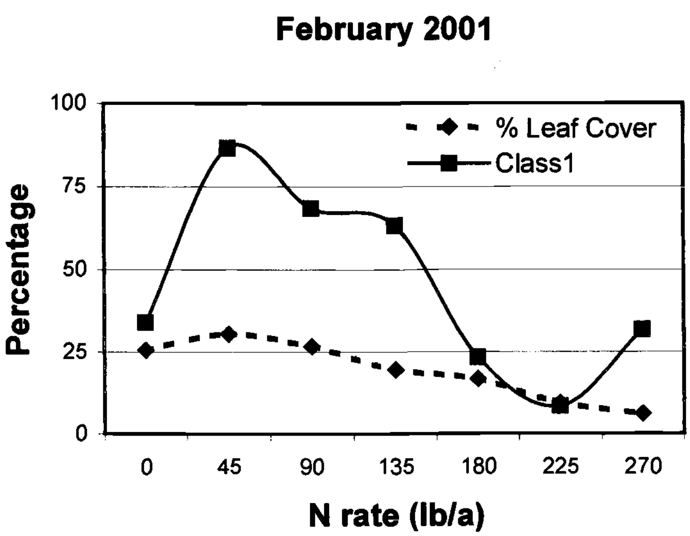


Figure 3. Comparison between percent Leaf Cover and Class 1 (green leaf). Percent leaf cover was obtained from platform photograph analysis. Class 1 was obtained from aerial photograph analysis. Photographs were taken mid-December 1999 and early February 2001.

Precipitation during October through December 1999 was 94% of the long-term average (1961-1990). Precipitation during October 2000 through January 2001 was only 48% of the long-term average. The lower rates of N application appeared to be beneficial to early-season plant growth, especially during the very dry fall 2000. Higher rates of N application during the first three years appear to have damaged the stand of perennial ryegrass during its third and fourth years. During the very dry fourth crop year, three years of higher rates of N substantially reduced plant cover.

Clean-seed yield (Table 1) in 2000 increased as fertilizer rates increased up to the 135 lb N/a rate at this site. Dirt-weight seed yields in 2001 were similar across all prior-year application rates (P=0.93). Spring 2001 N application rates were the same across all plots. Perennial ryegrass appears to be very plastic with respect to seed production. Fewer plants produced more seed per plant. Higher rates of N did not benefit seed production.

Table 1. Perennial ryegrass seed yield (lb/a) following varied rates of spring applied N, 2000 (clean weight) and 2001 (dirt weight).

Spring N rate (lb/a)	2000	2001
0	506 d*	1388 a
45	1038 c	1467 a
90	1484 b	1388 a
135	1736 a	1446 a
180	1662 ab	1392 a
225	1634 ab	1424 a
270	1470 b	1469 a

*Means in columns followed by the same letter are not significantly different at P=0.05.

Conclusion

Our research demonstrates that using GPS-located ground photographs, geo-positioned field observations, and ortho-rectified aerial photography in concert, we were able to map the response of nitrogen application on early-season growth in grass seed production fields. This approach should provide farmers and researchers with reliable information to evaluate results of different crop management strategies.

In this case study, higher N application rates did not benefit seed yield and did result in more bare ground by the third and fourth crop years of a perennial ryegrass stand.

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RESPONSE OF COOL SEASON GRASSES TO FOLIAR APPLICATIONS OF PALISADE® (TRINEXAPAC-ETHYL) PLANT GROWTH REGULATOR, 2001

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

Introduction

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

Recent development of foliar applied PGR type chemicals that readily breakdown in the environment and are effective at controlling rapid stem elongation are being studied to assess their potential for use in grass seed production systems. Initial trials using Palisade (trinexapac-ethyl), a foliar applied PGR manufactured by Syngenta Crop Protection, Inc., were conducted in 1997 and 1998 on older perennial ryegrass stands. The trials resulted in substantial yield improvement (see 1998 Seed Production Research report). How well this compound works on different age stands of perennial ryegrass as well as other cool season grasses (primarily tall fescue and fine fescue) grown for seed in the Willamette Valley was not known. The trials summarized in this report are for the third crop year in perennial ryegrass, creeping red fescue, and Chewings fescue and a second crop year in tall fescue. Previous years data are reported in the annual Seed Production Research report (1999 and 2000).

Procedure

Established stands of Cutter perennial ryegrass (Hyslop Research Farm), Brittany Chewings fescue (Joe Schumacher Farm) and Silverlawn creeping red fescue (Ioka Farms) entering the third seed crop year were used for this experiment. In addition, a spring 1999 planted stand of Velocity tall fescue (Hyslop Research Farm) in the second year of seed production was included. A factorial experimental design with rate and date as main factors was used. PGR treatments were applied at walking speed using a bicycle-type 10-foot wide boom sprayer with nozzles at 18 inch spacing. The sprayer operated at 20 psi with XR TEEJET 8003VS nozzles (approx. 20 gal/a water). Treatments at all sites were applied at several rates of trinexepac-ethyl (100, 200, 400, and 600 g a.i./ha) in single treatments on several dates. Treatment dates were selected to coincide with defined plant growth stages. Application dates (see Table 1) for perennial ryegrass coincided with the onset of internode expansion (1st date), 2 node stage (2nd date), flag leaf emerging (3rd date), and early heading (4th date). Tall fescue and fine fescue applications coincided with the onset of rapid node expansion (1st date), flag leaf emergence (2nd date) and early heading (3rd date). Plot size ranged from 10 ft x 30 to 50 ft depending on location. Stem elongation and nodal development was assessed using a weighted average of tiller size and node development from random plant samples to determine treatment dates.

Plots were sampled at early bloom for fertile tiller counts, length measurements, and above ground biomass dry weights. Inflorescences were also randomly sampled for yield component analysis and inflorescence length measurements. Harvesting was done using a 6 ft wide swather for windrowing and a Hege 180 small plot combine for harvest (see Table 1 for harvest dates). Combine harvested seed samples were cleaned using an M2-B clipper cleaner for final cleanout; sub-samples from combine run seed were taken for 1000 seed weights.

Results

Perennial Ryegrass

Seed yield increases from the PGR treated plots averaged 25 percent above the untreated check (Table 2). Increased rates of PGR application resulted in increased seed yield up to the highest rate (600 g a.i./ha). A significant interaction between application rate and timing is reported in Table 3. In this interaction, the earliest application gave the highest yield responses to all rates. Although the highest rate yielded the most, the greatest incremental responses occurred at the lowest rates applied early (100 and 200 g a.i./ha). As application dates progressed to later growth stages, the higher rates decreased in seed yield response to the point where the lower rates were yielding more (see the last application date) Though the later application timings gave less yield response, the lower rates (100 and 200 g a.i./ha) were well above the untreated yield while the higher rates were comparable to no treatment. Increases in seed yield appear to come from increased seed number potential (data not included here) and from improved seed set and filling by prevention of lodging.

Rate x date interactions with seed yield and crop lodging at harvest are presented in Table 3. Seed yield was previously discussed. Crop lodging response was sensitive to both timing and rate of PGR applications, with the early treatments all losing the ability to prevent lodging until harvest except at the highest rate (600 g a.i./ha). Lodging was effectively controlled compared to the untreated crop. A lodging score of four or higher indicated the heads and plant structures are in contact with the ground. At harvest the treated plots were still off the ground, which allowed for easier windrowing. In the higher rate PGR treated plots the windrows were smaller and had less crop residue to combine. At the second application date, which is the time for the most rapid internode expansion, all but the lowest rate controlled lodging until crop harvest. The lowest PGR rates at the last date were a little more effective at keeping the seed heads up than the earlier dates but did not translate into any seed yield increase. Control and timing of lodging can be manipulated by using rates and times to keep the stand upright for pollination and seed fill and allow some lodging prior to harvest as with the low rates at the middle timings. Thousand seed weight was increased some by the latest application date (Table 2) but also was lower yielding.

Fertile tiller densities and total biomass were not affected by any treatments. Cleanout was not impacted by PGR treatments in this trial. Harvest index (a ratio of seed yield to total biomass) tended to increase with applications of Palisade. This is to be expected as the seed yield improved with no changes in total biomass. Culm length was reduced an average of 13% with progressively shorter stems as the rate increased. The greatest height reduction (inhibition of growth) across all treatments occurred at the 2 node application timing with an average 23% height reduction. The evidence here, and in the previous trials, indicate the best timing for yield responses would be during early internode expansion and prior to flag and head emergence. Early application was especially important if using the higher rates, but at the lower rates (100 and 200 g a.i./ha) yield was less impacted by later application dates.

Table 3. Perennial ryegrass rate x date interactions for seed yield and lodging when treated with Palisade PGR, 2001.

Rate	Date of application			
(g a.i./ha)	4/17	4/26	5/3	5/16
	SEED YIELD (LB/A)			
100 (0.7)[1]	1705	1539	1517	1449
200 (1.4)	1658	1743	1696	1693
400 (2.9)	1854	1659	1640	1366
600 (4.3)	1927	1960	2103	1365
LSD 0.05	296			
	LODGING SCORE (1-5)			
100 (0.7)	4.0	4.0	4.3	3.3
200 (1.4)	4.0	3.3	4.3	3.0
400 (2.9)	4.0	2.3	3.3	3.3
600 (4.3)	2.2	2.0	2.3	2.7
LSD 0.05	0.8			

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

Tall fescue

Similar to 2000, tall fescue was very responsive to PGR applications this year. Comparison of all treated plots with the untreated was significant (Table 4). Overall the seed yield was increased by 629 pounds. Harvest index increased by 3% with no statistical change in total biomass, which follows with the perennial ryegrass as previously discussed. Height of treated plots was 29% less than the untreated and lodging was very effectively controlled by the PGR applications. The only plots to significantly lodge were the untreated checks. Seed size was decreased slightly ($P<0.10$) and fertile tiller populations were not affected by PGR applications. There were no differences in seed yield due to rate or date of PGR treatment. Opposite of last year, there was a tendency for the higher rate to have a little lower seed yield, but this was not statically significant. All treatments increased seed yield over the untreated check and all application dates were equally effective (as contrasted with the perennial ryegrass). This was the second crop for this stand.

Creeping red fescue

Silverlawn creeping red fescue showed very good seed yield responses to applications of Palisade. Seed yield averaged a 68% increase (~600 lb/a) over the check (Table 5). Seed yield response peaked at about the 400 g a.i./ha rate. The 400 g a.i./ha rate and 600 g a.i./ha rate were about the same, but yielded significantly more than the 200 g a.i./ha rate. Timing of the applications at the growth stages observed had an equal effect on seed yield. Last year (2000), much later treatments (at full heading) decreased yield (see 2000 Seed Production Research report). Above ground biomass, fertile tiller density, and 1000 seed weight were not affected by the increased rates of Palisade. Harvest index was improved by 7% as is reflected by the increased seed yield. Plant height was reduced an average of 8% with the highest treatment rate (600 g a.i./ha) reducing plant height by 12%. Lodging was well controlled with all treatments keeping the crop from laying flat on the ground as fine fescue is prone to do. Even the lowest rate helped reduce lodging. The results from this third year of trials continue to indicate that creeping red fescues are very responsive to PGR applications.

Chewings fescue

Seed yield results for the Chewings type fescue in this study were also very good. Palisade treated plots averaged 46% greater seed yield than the untreated check (~630 lb/a) as shown in Table 6. In this trial there was significant response with seed yield to increased rates of Palisade up to the 400 g a.i./ha rate but no differences in timing. All timings from early node expansion to early heading averaged a 46% increase over the untreated plots. The use of the lowest rate (100 g a.i./ha) in this trial gave the largest incremental increase in seed yield as was the case last year. Using a rate higher than 200 g a.i./ha did not increase seed yield which is in contrast to the creeping red fescue which was more responsive to the 400 g a.i./ha rate. Total biomass, fertile tiller density, and 1000 seed weight were not affected by Palisade applications at this site. Harvest index increased 7% using a contrast comparison between the treated and the check plots. Treated plant height averaged 18% less than the untreated. Lodging was well controlled and even at harvest the crop was easy to swath in the treated plots.

Lodging control was effective at all application timings and was rate responsive with the highest rate giving the greatest control.

Summary

All four species treated this year were responsive to Palisade applications. Creeping red fescue, Chewings fescue, and tall fescue were the most responsive in seed yield. Seed yield in perennial ryegrass was little less responsive to PGR applications and affected more by different rates and timings. This compound was effective at controlling lodging and increasing yield. The cause of the yield increase seems to come from a combination of several factors including (from other data collected this season, but not presented here): improved seed set, reduced lodging and improvements in yield components. The use of these types of PGRs allow the crop to increase the reproductive efficiency without any additional resource inputs except the application of the compound.

The most important part of using this compound will be knowing the optimum stage of crop development to apply Palisade for maximum effect. The timing appears to have different windows in the different crop species, some are more sensitive to timing than others. Perennial ryegrass does not respond as well to later applications (following flag leaf emergence). The fine fescues and tall fescue have a wider range of response and do well with the range of timings tested here, but very late applications (after 25% head emergence) are much less effective. The best timing and rate for tall fescue is yet to be identified, but it seems to respond similar to the fine fescues. Fine fescues and tall fescue were responsive merely to PGR applications (though the creeping fescue showed some rate response with higher rates). The lowest rate (100 g a.i./ha) was effective but often less than the higher rates. Each year is unique, but the responses observed in all these species were very similar to those reported last year. In these four trials, every PGR treatment yielded higher than the untreated check. This product appears to be a useful and effective tool in helping improve and realize the yield potential of these grass seed crops.

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

Table 1. Calendar dates for PGR application, swathing, and combining, 2001.

Species	Onset of elongation	1-2 nodes elongation	Flag leaf emergence	Early heading	Swath	Combine
Per. rye.	4/17	4/26	5/3	5/16	7/9	7/26
Tall fescue		4/26	5/3	5/13	7/6	7/20
Cr. red fescue	---------- 4/25 ---------		5/4	5/12	7/14	7/24
Ch. fescue	---------- 4/25 ---------		5/4	5/12	7/7	7/16

Table 2. Main factor effects of foliar applied Palisade (trinexapac-ethyl) on seed yield, harvest components, and tiller length in Cutter perennial ryegrass, 2001.

Main factor treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Culm reduction	Lodging score
	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	-------- (%)	--------	(1-5)[1]
Check vs Treated								
Check	1349 b[3]	100	5.9	257	1.99	11.6	0	3.7
Treated (all)	1680 a	125	6.3	275	1.93	13.8	13 a	3.3
Rate of application g a.i./ha (pt/a)[2]								
100 (0.7)	1552[4]	115	6.5	289	1.98	12.5	-3	3.9[4]
200 (1.4)	1697	126	6.7	280	1.90	13.0	12	3.7
400 (2.9)	1630	121	6.1	274	1.93	14.0	15	3.3
600 (4.3)	1839	136	5.9	259	1.91	15.9	27	2.3
Date of application								
Apr. 17	1786 [4]	132	6.6	262	1.90 b	13.9	10	3.5[4]
Apr. 26	1725	128	5.9	258	1.91 b	15.0	23	2.9
May 3	1739	129	6.0	272	1.92 b	14.7	10	3.6
May 16	1468	109	6.6	310	2.00 a	11.8	8	3.1

[1] Lodging score at harvest 1-5: 1 = vertical; 5 = horizontal
[2] The pint/acre rate is for the 1 lb a.i./gal EC formulation
[3] Within each main factor, means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05. No letters = no significant differences
[4] Rate x Date interaction significant P≤0.05

Table 4. Main factor effects of foliar applied Palisade (trinexapac-ethyl) on seed yield, harvest components, and tiller length in Velocity tall fescue, 2001.

Main factor treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Culm reduction	Florets per spklt
	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	-------- (%) --------		(no.)
Check vs Treated								
Check	1359 b[2]	100	11.3	103	2.59	6 b	0 b	4.6
Treated (all)	1988 a	146	10.9	111	2.47	9 a	29 a	5.2
Rate of application								
g a.i./ha (pt/a)[1]								
100 (0.7)	2113	156	11.9	110	2.44	9	15 c	5.4
200 (1.4)	2052	151	10.4	104	2.52	11	24 c	5.4
400 (2.9)	1910	141	11.0	107	2.48	9	34 b	5.0
600 (4.3)	1879	138	10.4	125	2.42	9	42 a	5.0
Date of application								
Apr. 26	1881	138	9.1	97	2.42	10	31 a	5.5
May 3	2043	150	11.4	118	2.45	9	33 a	5.3
May 13	2041	150	12.1	119	2.52	9	22 b	4.8

[1]The pint/acre rate is for the 1 lb a.i./gal EC formulation
[2]Within each main factor, means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05. No letters = no significant differences

Table 5. Main factor effects of foliar applied Palisade (trinexapac-ethyl) on seed yield, harvest components, and tiller length in Silverlawn creeping red fescue, 2001.

Main factor Treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Culm reduction	Lodging score
	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	-------- (%)	--------	(1-5)[1]
<u>Check vs Treated</u>								
Check	896 b[3]	100	4.8	389	1.08	9 b	0	4.7 b
Treated (all)	1509 a	168	4.9	398	1.07	16 a	8	3.1 a
<u>Rate of application</u>								
g a.i./ha (pt/a)[2]								
100 (0.7)	1206 c	135	5.0	399	1.08	12 b	0 b	4.1 a
200 (1.4)	1477 b	165	4.7	374	1.05	16 a	8 a	3.6 b
400 (2.9)	1707 a	190	4.8	410	1.08	19 a	13 a	2.7 c
600 (4.3)	1645 a	184	5.2	410	1.06	16 a	12 a	1.8 d
<u>Date of application</u>								
Apr. 25	1572	175	4.9	399	1.07	17	9	3.0 ab
May 4	1509	168	5.0	413	1.06	15	11	3.3 a
May 12	1446	161	4.9	383	1.08	16	5	2.8 b

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

Table 6. Main factor effects of foliar applied Palisade (trinexapac-ethyl) on seed yield, harvest components, and tiller length in Britanny Chewings fescue, 2001.

Main factor Treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Culm reduction	Lodging score
	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	-------- (%)	--------	(1-5)[1]
<u>Check vs Treated</u>								
Check	1368 b[3]	100	6.2	431	1.11	10 b	0 b	4.0 b
Treated (all)	1999 a	146	5.2	426	1.09	17 a	18 a	2.4 a
<u>Rate of application</u>								
g a.i./ha (pt/a)[2]								
100 (0.7)	1832 b	134	5.3	397	1.07	15 b	8 c	3.6 a
200 (1.4)	1956 ab	143	5.8	466	1.09	15 b	8 c	3.2 b
400 (2.9)	2173 a	159	4.7	395	1.10	19 a	23 b	1.7 c
600 (4.3)	2033 ab	149	5.0	445	1.10	17 ab	31 a	1.1 d
<u>Date of application</u>								
Apr. 25	1988	145	4.9	407	1.08	17	15	2.5
May 4	2041	149	5.5	435	1.09	17	18	2.3
May 12	1966	144	5.3	436	1.10	16	19	2.4

[1] Lodging score at harvest 1-5: 1 = vertical; 5 = horizontal
[2]The pint/acre rate is for the 1 lb a.i./gal EC formulation
[3]Within each main factor, means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05. No letters = no significant differences

PALISADE AND STAND AGE EFFECTS ON SEED YIELD IN PERENNIAL RYEGRASS

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

Introduction

Palisade retards plant growth by inhibiting the 3β-hydroxylation of the growth inactive form of gibberellic acid to the active form. Application of Palisade can reduce or delay lodging in perennial ryegrass. Lodging during flowering is generally thought to restrict pollination, reduce the rate of fertilization, and can later inhibit seed filling due to self-shading of the lodged crop. Our objectives were to determine how Palisade improves seed yield in perennial ryegrass and to measure the long-term impact of annual applications of Palisade on stand life and seed yield.

Procedure

Trials were conducted in an experimental field of Cutter perennial ryegrass planted in autumn 1998. This trial was designed to determine the long-term impacts of annual and alternate year applications of Palisade on crop yield and yield components (spike number, spikelets per spike, florets per spike) of perennial ryegrass. Eight treatments were identified to provide all possible combinations of single applications over a three-year period (Table 1). Palisade was applied in single applications each year at 2.9 pt/acre in early May 1999, 2000, and 2001.

Seed yield components were determined on samples taken in each plot prior to harvest. These included spike, spikelet, and floret number. Spike length was also measured. Seed yield was determined by harvest with our small plot swather and combine. Root biomass density was determined at depths up to one foot in the soil profile in winter.

Results

Seed yield declined as the stand aged from Year 1 to Year 3 regardless of treatment, but Palisade application greatly lessened this loss in yield (Table 1). Yield was increased by Palisade application in all of the treatment combinations over the untreated plots in all of the three years. Prior treatment of Palisade in one year typically had no effect in the yield of the seed crop in a subsequent year. In other words, there was generally no carry over effect of Palisade from one year to the next with one exception. When the crop was treated in each of the three years, seed yield in Year 3 was increased but not to the same extent that was observed for other plots that were treated in Year 3.

Cumulative seed yield over the three-year stand life was 4745 lb/acre when the crop was not treated with Palisade. A single application of Palisade in any one of the three years (5372 cumulative yield) would have resulted in 627 lb/acre increase over the untreated crop. Single applications of Palisade in two of the three years (5848 cumulative yield) produced an increase of 1103 when compared to the untreated crop. When the crop was treated in each of the three years (6142 cumulative yield), seed yield was improved by 1397 lb/acre compared to the untreated crop. The magnitude of the seed yield increase resulting from annual single applications of Palisade in all three of the years was essentially equivalent to the seed yield that might be normally harvested from a 3rd year crop of untreated perennial ryegrass (Table 1).

Palisade did not affect final above ground dry weight or spike number, although there was a trend for fewer spikes to be formed in treated plants in Year 2 and Year 3 (Table 2). There were no differences in the number of spikelets per spike. Palisade reduced spike length, especially in Year 1 and Year 3, which may have contributed to increased seed yield. Increased numbers of florets per spikelet likely accounted for a portion of

Table 1. Effect of stand age and Palisade application on perennial ryegrass seed yield.

Palisade treatment			Seed yield		
Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
			(lb/a)		
Untreated	Untreated	Untreated	2144 a	1325 a	1276 a
Treated	Treated	Treated	2719 b	1922 b	1501 b
Treated	Untreated	Untreated	2785 b	1336 a	1327 a
Treated	Treated	Untreated	2789 b	1926 b	1311 a
Untreated	Treated	Untreated	2179 a	1922 b	1300 a
Untreated	Treated	Treated	2209 a	1876 b	1655 c
Untreated	Untreated	Treated	2262 a	1354 a	1652 c
Treated	Untreated	Treated	2773 b	1399 a	1605 bc
Average treatment effect (yield increase)			25%	41%	23%

Table 2. Palisade treatment and stand age effects on yield components and seed yield of Cutter perennial ryegrass.

Yield component	Year 1		Year 2		Year 3	
	Untreated	Treated	Untreated	Treated	Untreated	Treated
Spikes/ft^2	276	277	338	308	363	320
Spikelets/spike	21	21	24	23	24	23
Spike length (cm)	22.6	19.9	21.4	20.1	20.8	16.5
Florets/Spikelet - Top	8.4	9.7	7.1	7.3	5.3	6.2
Florets/Spikelet - Middle	10.8	12.3	7.5	7.8	6.5	7.5
Florets/Spikelet - Bottom	9.1	11.0	7.2	7.5	5.0	6.4
Seed set (%)	21.3	22.7	12.2	19.3	14.0	17.0
Seed yield (lb/a)	2215	2772	1354	1912	1304	1603

the seed yield increase noted in Palisade treated plots. Significant increases in floret number were noted in spikelets located in the top, middle, and bottom portions of the spike in the Year 1 and Year 3, but only in the middle portion in the Year 2. Seed set (conversion of florets to seeds) was increased by Palisade in Year 2 and Year 3, but not in Year 1. Seed yield increases by Palisade ranged from 23% in Year 3 to 41% in Year 2.

Seed yields were increased by Palisade in each of the three years, but this increase was manifested via a different mechanism in each year. Seed yield increases in Year 1 by Palisade application were based on greater numbers of florets per spikelet without an increase in seed set. Seed yield in Year 2 was increased through Palisade-induced improvements in seed set with little or no improvement in florets per spikelet. Year 3 yield increases resulted from both increased numbers of florets per spikelet and seed set. The ability of Palisade to increase yield by more than one mechanism contributes to the consistency of results observed with this product. Increased seed yield likely results from a combination of lodging control (improvement of seed set) provided by Palisade and by improvement of flowering as evident by the greater numbers of florets per spikelet in treated plants.

Root samples taken during the winter indicate that Palisade application had no effect on root biomass density and distribution at moderate and deep portions of the soil profile (Figure 1). Inconsistent, minor reductions in root biomass were attributable to Palisade in the shallowest portion of the soil profile. Since Palisade is effective in reducing shoot biomass, some effect on root systems might also be expected. These effects were small and only statistically significant in Year 2.

Plant growth regulators such as Palisade and Apogee are beneficial management tools that provide seed producers with the opportunity to improve the reproductive efficiency of grass seed crops and to improve production cost efficiencies.

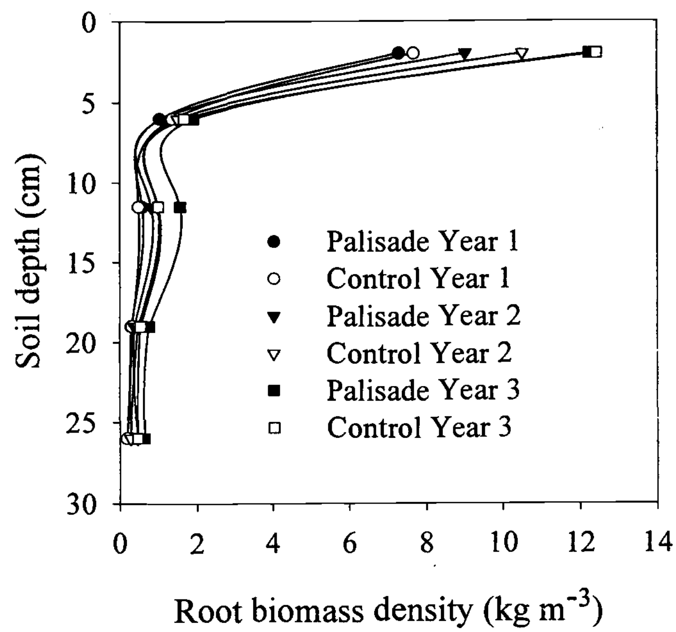

Figure 1. Palisade application and stand age effects on root system distribution in Cutter perennial ryegrass.

EFFECT OF SPRING NITROGEN RATES AND PALISADE APPLICATIONS ON SEED YIELDS IN RED FESCUE

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

Introduction

For the past several years research has been conducted to determine optimum spring nitrogen rates on the major grass species in western Oregon. Two fine fescue fields have been included in this research since 1999. Nitrogen was applied at seven rates ranging from 0 to 140 lb N/a on a creeping red fescue and a Chewings fescue field. Results of these trials have been reported in previous OSU Seed Production Research reports.

The trials were established on new fields prior to the first seed harvest. Results have shown optimum seed yields are produced at rates 30 and 70 lb spring applied N/acre. These rates are considerably lower than current OSU recommendations and also lower than many growers routinely apply. Growers have speculated the lack of response to higher N rates may be due to the trials being conducted on new and relatively young fields and that older fields might need higher rates for optimum seed production. To address this issue an additional trial was established in the spring of 2001 on an older Pennlawn creeping red fescue field.

In addition to evaluating different N rates these trials provided an opportunity to study the interaction of a plant growth regulator (PGR) application across the range of N treatments. Individual plot sizes were sufficiently large to allow using half of each for a PGR application.

Method

Two large scale, on-farm trials were conducted on creeping red fescue fields east of Silverton. One site was in the Shademark field that had been a part of the nitrogen study the past three years. The second site was established on an eight-year-old field of Pennlawn creeping red fescue. Treatments at each site were replicated three times in a randomized complete block design. Individual plots were 23 ft wide by 600 to 1000 ft long depending on field size and configuration. Spring nitrogen was applied in a single application. At the Shademark site treatments were 0, 30, 50, 70, 90, 110 and 140 lb N/a and 0, 30, 60, 90 and 120 lb N/a on the Pennlawn field.

At the early heading stage of growth (May 5, 2001), Palisade EC® at 2.0 pt/a was applied to half of each plot. The grower made the Palisade applications at the same time the remainder of the fields were treated. Grower equipment was used for swathing and harvest of the plots. A weigh wagon was used to determine seed yields. Sub-samples collected at harvest were used to determine clean-out, 1000 seed weight and calculate clean seed yields.

Results

Shademark creeping red fescue: Seed yield responded to spring applied nitrogen (Table 1). When only spring N is evaluated the optimum rate was between 30-50 lb N/a. Nitrogen rates above 50 lb/a did not result in additional seed yield. When Palisade was applied over the nitrogen rates the optimum N rate occurred at 50 lb N/a. At higher rates there was no additional benefit to seed yields. At the 90 lb N/a rate the incremental benefit of the Palisade treatment was significantly greater than at other nitrogen rates, however, it was due to an unusually low yield of the untreated portion of the plot.

Table 1. Effect of spring nitrogen by Palisade interaction on seed yield of Shademark creeping red fescue, 2001.

Spring	Clean seed yield		
N rate	Untreated	Palisade[1]	Treated – untreated
(lb/a)	---------- (lb/a) ----------		(lb/a)
0	1111	1095	-16
30	1433	1516	84
50	1377	1776	398
70	1324	1723	399
90	1220	1761	542
110	1331	1726	395
140	1266	1585	319
LSD 0.05	125	125	

[1]2.0 pt/a Palisade EC® applied at early heading (May 5, 2001).

Pennlawn creeping red fescue: Where spring nitrogen applications alone are compared there was no significant seed yield response from any of the treatments (Table 2). Seed yield was slightly higher at the 30 lb N/a rate but not at any of the higher N rates. Preliminary results indicate that older stands may not be more responsive to spring applied nitrogen than younger ones. This is, however, the first year on an older stand and additional research is likely needed. The addition of Palisade increased seed yields across all N rates but maximum benefit occurred at a somewhat higher N rate (60 to 90 lb N/a), than on the Shademark field. There was no decline in seed yield at the highest N rate, with or without Palisade, as was seen at the 140 lb N/a rate on the Shademark.

Table 2. Effect of spring nitrogen by Palisade interaction on seed yield of Pennlawn creeping red fescue, 2001.

Spring N rate	Clean seed yield Untreated	Palisade[1]	Treated – untreated
(lb/a)	--------- (lb/a) ----------		(lb/a)
0	791	939	148
30	832	1035	203
60	772	1048	276
90	726	1022	296
120	774	1072	298
LSD 0.05	NS	NS	

[1]2.0 pt/a Palisade EC® applied at early heading (May 5, 2001).

Summary

Fine fescue seed fields tend to respond to both nitrogen fertilization and to applications of plant growth regulators. However this trial has shown that older stands are no more responsive to spring nitrogen than what has been observed in the new stands used in the earlier N rate trials. On commercial fine fescue fields, managed with customary fertility programs, applications of PGRs have consistently provided significantly higher seed yields. In both trials of this study the Palisade treatment did not increase seed yields as much at the 0 and 30 lb N/a treatments as at higher nitrogen rates. There was no seed yield advantage from nitrogen rates over 50 to 70 lb/a. The yield advantage from Palisade applications also leveled off at about the same point as did seed yields at optimum nitrogen rates alone.

Appreciation is expressed to the growers who allowed us to conduct these trials on their fields and assisted with the PGR applications and harvest of the plots.

RESPONSE OF COOL SEASON GRASSES TO FOLIAR APPLICATIONS OF APOGEE® (PROHEXADIONE-CALCIUM) PLANT GROWTH REGULATOR, 2001

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

Introduction

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

Recent development of foliar applied PGR type chemicals that readily breakdown in the environment and are effective at controlling rapid stem elongation are being studied to assess their potential for use in grass seed production systems. Initial trials using Apogee (prohexadione-calcium), a foliar applied PGR manufactured by BASF Corporation, on perennial ryegrass grown for seed production were conducted on an older perennial ryegrass stand in 1998. The trial resulted in substantial yield improvement (see 1998 Seed Production Research report). How well this compound works on different age stands of perennial ryegrass as well as other cool season grasses (primarily tall fescue and fine fescue) grown for seed in the Willamette Valley was not known. The trials summarized in this report are for the third crop year in perennial ryegrass, creeping red fescue, and chewings fescue and a second crop year in tall fescue. Previous years data are reported in the annual Seed Production Research report (1999 and 2000).

Procedure

Established stands of Cutter perennial ryegrass (Hyslop Research Farm), Brittany Chewings fescue (Joe Schumacher Farm) and Silverlawn creeping red fescue (Ioka Farms) entering the third seed crop year were used for this experiment. In addition, a spring 1999 planted stand of Velocity tall fescue (Hyslop Research Farm) in the second year of seed production was included. A randomized complete block design with rates and date as factors was used. PGR treatments were applied at walking speed using a bicycle-type 10-foot wide boom sprayer with nozzles at 18 inch spacing. The sprayer operated at 20 psi with XR TEEJET 8003VS nozzles (approx. 20 gal/a water). Treatments at all sites were applied as single or split treatments of prohexadione-calcium (1/8 or 1/4 lb a.i./a, using 0.275 or 0.75 a.i. formulations). Treatment dates were selected to coincide with defined plant growth stages. Application dates generally coincided with rapid node expansion with some flag leaves emerging (1st date) and early heading (2nd date). Plot size ranged from 10 ft x 30 to 50 ft depending on location. Stem elongation and nodal development was assessed using a weighted average of tiller size and node development from random plant samples to determine treatment dates.

Plots were sampled at early bloom for fertile tiller counts, length measurements, and above ground biomass dry weights. Inflorescences were also randomly sampled for yield component analysis and inflorescence length measurements. Harvesting was done using a 6 ft wide swather for windrowing and a Hege 180 small plot combine for harvest (see Table 1 for harvest dates). Combine harvested seed samples were cleaned using an M2-B clipper cleaner for final cleanout; sub-samples from combine run were taken for 1000 seed weights.

Table 1. Calendar dates for PGR application, swathing, and combining, 2001.

Crop species	2 nodes	Flag leaf	Early heading	Swath	Combine
Per. rye.	4/26	5/3	---	7/9	7/26
Tall. fescue	---	5/3	5/13	7/6	7/20
Cr. red fescue	---	5/4	5/12	7/14	7/25
Chewings. fescue	---	5/4	5/12	7/7	7/16

Results

Perennial Ryegrass

Apogee applications to perennial ryegrass increased seed yield over the untreated check by an average 300 lb/a (24%) as shown in Table 2. Generally, yield was increased as application rate was increased. Splitting the application did not improve yield responses. Above ground biomass, fertile tiller density were not affected by PGR applications. Seed size (1000 seed weight) was reduced by the early application compared to both the check and later application. Plant height was reduced an average of 30% and lodging was controlled more by the earlier than the later application. This trial also included the use of a higher a.i. (0.75 a.i.) formulation and results were similar to the commercially available form (0.275 a.i.). Also the use of AMS (used Class Act @ 2%) added to the spray mixture did not change the effectiveness of Apogee. Improved seed yield without increased biomass resulted in an increase in the harvest index, a good measure of increased plant efficiency.

Tall fescue

Tall fescue was very responsive to applications of Apogee in 2001. The seed yield increase averaged over 700 lb/a with the application of Apogee (Table 3) compared to the untreated check. There was no significant treatment effect from different rates or dates. There was no effect form splitting the applications. Fertile tiller density was not affected by the PGR applications, nor were above ground biomass and seed size (1000 seed weight). Harvest index increased by 5%, and plant height was reduced an average of 27% (with the greatest reduction from the first applications). Lodging was effectively managed at all rates and dates. Very little lodging occurred in any of the treatments except the untreated check.

Creeping red fescue

The Silverlawn creeping red fescue site was similar in seed yield response to the tall fescue previously discussed. Treatment with Apogee increased yields an average of 570 lb/a (64%) over the untreated check (Table 4). Above ground biomass, fertile tiller density and 1000 seed weight were not affected by PGR treatments. Harvest index was increased 5%. Lodging was reduced more by the second application timing but both were effective at reducing the amount and severity of lodging. The use of AMS or the higher a.i. formulation were similar in response to the other treaments.

Chewings fescue

Seed yield in Brittany Chewings fescue was greatly improved by the applications of Apogee PGR. The seed yield increase averaged ~550 lb/a (42%) as recorded in Table 5. Above ground biomass and 1000 seed weight were not affected by the PGR applications, and the increase in seed yield subsequently increased harvest index. Fertile tiller density remained constant. Crop lodging was decreased most by the higher rates and the second timing application.

Summary

All four species treated this year were responsive to Apogee applications. The creeping red, Chewings fescue, and tall fescue species were the most responsive in seed yield. Perennial ryegrass was a little less responsive. This compound was effective at controlling lodging and increasing yield. The cause of the yield increase has not been fully accounted for, but from other data collected this season (not presented here), improved seed set, reduced lodging and improvements in yield components are all adding to the increased yield. It should be noted also that no treatment by the PGR was less than the untreated check. Each year is unique, but the responses observed in all these species were very similar to those reported last year. In these four trials, every PGR treatment yielded higher than the untreated check. This product appears to be a useful and effective tool in helping improve and realize the yield potential of these grass seed crops.

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

Table 2. Main factor effects of foliar applied Apogee (prohexadione-calcium) on seed yield, harvest components, and tiller length in Cutter perennial ryegrass, 2001.

Main factor treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Culm reduction	Lodging score
(lb a.i./a)	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	--------- (%)	--------	(1-5)[1]
Untreated check	1295 c*	100	7.3	304	1.96 bc	9 d	0 f	4.3 a
2 node stage								
1/8	1452 bc	112	5.0	251	1.90 cd	15 abc	45 a	2.7 b
1/4	1784 a	138	5.1	246	1.82 de	18 ab	31 bcd	3.3 b
1/4 + AMS	1680 ab	130	6.5	326	1.82 de	14 bcd	33 bcd	2.7 b
1/4 (0.75 ai) + AMS	1707 ab	132	7.5	320	1.84 de	11 cd	37 abc	2.7 b
Flag leaf emergence								
1/8	1447 bc	112	6.6	330	2.00 ab	11 dc	25 de	3.3 b
1/4	1604 ab	124	6.9	225	2.00 bc	12 bcd	20 e	3.3 b
1/4 + AMS	1438 bc	111	6.9	252	2.01 ab	10 cd	27 cde	2.8 b
1/4 (0.75 ai) + AMS	1466 bc	113	6.7	293	2.05 a	11 cd	17 e	3.3 b
Split application								
1/8+1/8	1571 abc	121	6.2	322	1.88 cd	13 bcd	35 abcd	3.0 b
1/8+1/8 (0.75 ai)+AMS	1865 a	144	4.9	226	1.80 e	20 a	39 ab	3.0 b

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

Table 3. Main factor effects of foliar applied Apogee (prohexadione-calcium) on seed yield, harvest components, and tiller length in Velocity tall fescue, 2001.

Main factor treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Culm reduction
(lb a.i./a)	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	--------(%)	-------
Untreated check	1387 b*	100	11.3	96	2.66	6	0
Flag leaf emergence							
1/8	2080 a	150	10.3	120	2.47	11	28
1/4	1902 a	137	9.8	95	2.56	10	36
1/4 + AMS	2071 a	149	8.7	106	2.51	12	30
1/4 (0.75 ai) + AMS	2202 a	159	7.9	89	2.52	14	40
Early heading							
1/8	2125 a	153	10.4	95	2.57	10	9
1/4	2202 a	159	9.0	106	2.54	13	19
1/4 + AMS	2248 a	162	11.0	96	2.53	10	21
1/4 (0.75 ai) + AMS	2102 a	152	11.7	102	2.56	9	18
Split application							
1/8+1/8	2182 a	157	10.7	108	2.54	10	29
1/8+1/8 (0.75 ai)+AMS	2057 a	148	10.0	91	2.37	11	36

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

Table 4. Main factor effects of foliar applied Apogee (prohexadione-calcium) on seed yield, harvest components, and tiller length in Silverlawn creeping red fescue, 2001.

Main factor treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Culm reduction	Lodging score
(lb a.i./a)	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	--------- (%)	--------	(1-5)[1]
Untreated check	896 c*	100	4.8	389	1.08	9 d	0	4.7
Flag leaf emergence								
1/8	1360 ab	152	5.0	447	1.06	14 bc	6	4.2
1/4	1601 a	179	4.7	390	1.06	18 a	4	3.2
1/4 + AMS	1469 a	164	5.2	476	1.04	14 abc	-3	3.8
1/4 (0.75 ai) + AMS	1614 a	180	5.3	431	1.04	15 ab	5	3.7
Early heading								
1/8	1170 b	131	5.2	320	1.06	11 cd	0	3.7
1/4	1597 a	178	6.2	522	1.06	13 bcd	5	3.7
1/4 + AMS	1480 a	165	4.6	360	1.08	16 ab	2	3.5
1/4 (0.75 ai) + AMS	1436 ab	160	5.8	431	1.09	13 bcd	-2	3.2

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

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

Table 5. Main factor effects of foliar applied Apogee (prohexadione-calcium) on seed yield, harvest components, and tiller length in Brittany Chewings fescue, 2001.

Main factor treatments	Seed yield		Above ground biomass	Fertile tillers	1000 seed weight	Harvest index	Culm reduction	Lodging score
(lb a.i./a)	(lb/a)	(% of check)	(ton/a)	(no./sq. ft.)	(g)	-------- (%)	--------	(1-5)[1]
Untreated check	1368 b*	100	6.2	431	1.11	10.1	0 c	4.0 a
Flag leaf emergence								
1/8	1986 a	145	5.6	396	1.06	15.5	6 abc	3.8 ab
1/4	1922 a	140	5.2	389	1.08	16.2	15 a	3.2 cd
1/4 + AMS	1935 a	141	5.4	449	1.04	15.3	14 ab	2.8 cde
1/4 (0.75 ai) + AMS	1853 a	135	4.6	419	1.06	17.2	13 ab	3.0 cde
Early heading								
1/8	1908 a	139	5.2	425	1.08	15.6	5 bc	3.3 bc
1/4	1962 a	143	4.4	363	1.10	18.2	13 ab	2.7 def
1/4 + AMS	2005 a	147	5.1	358	1.11	16.5	15 a	2.2 f
1/4 (0.75 ai) + AMS	1960 a	143	5.7	426	1.08	15.2	12 ab	2.5 ef

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

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

EFFECT OF PLANT GROWTH REGULATORS ON SEED YIELDS OF TALL FESCUE AND ORCHARDGRASS

G.A. Gingrich and M.E. Mellbye

Introduction
The commercial use of synthetic plant growth regulators has become an accepted crop production practice for many Oregon seed producers. Two products are currently registered for use on grass seed crops and are applied to fields to reduce crop lodging, facilitate swathing and harvest and to increase seed yields. During the past several years OSU and private researchers have conducted many experimental trials with PGRs. They have studied various aspects of PGR effects on most species of grass seed crops grown in Oregon. Results of a number of these research trials have been reported in previous issues of this publication as well as many other papers, grower meetings and field tours.

This is the third consecutive year that we have conducted large scale, on-farm trials looking at the effect of Palisade and Apogee applications on seed yields. In 1999 Palisade EC (trinexapac-ethyl), manufactured by Syngenta Crop Protection was granted a label for use on perennial ryegrass grown for seed. The following year that label was expanded to include additional grass seed crops and another PGR called Apogee DF (prohexadione-calcium), produced by BASF Corp., received a label for use on certain grass seed crops.

Methods
Large scale, on-farm seed yield trials were established on four commercial grass seed fields in the Willamette Valley. Trials were conducted on two orchardgrass and two tall fescue fields; one field of each species was located in Marion and in Linn counties. Each trial was arranged in a randomized complete block design with three replications. Individual plots were 23 ft wide by 300 to 380 ft long. Grower equipment was used for swathing and harvest; and the area harvested for seed yields was determined by swather width and length of the individual plot. A weigh wagon was used to determine seed yields. Subsamples of the harvested seed were collected to determine 1000 seed weight, percent cleanout and calculate total clean seed yield.

All PGR applications were made using an ATV mounted with a 20 ft boom sprayer equipped with TeeJet 11002 VS nozzles at 30 psi to apply a total spray volume of 14 gpa. All Apogee treatments included the surfactant Hasten at 0.25% and the liquid nitrogen Cayuse Plus at 0.5% by spray volume. No surfactant or liquid N was applied with the Palisade treatments. Application dates and crop growth stage at treatment are listed below each seed yield data table. All treatments were applied on the same day at each location except for the second application of the split treatment of Apogee at the two Marion county sites. The grower applied fertilizers and fungicides on the plot area at the same time and at the same rates as was done on the remainder of the field. Total nitrogen applied on the tall fescue fields was approximately 160 lb/a. The orchardgrass fields received from 100 to 140 lb N/acre. The tall fescue field in Marion County was the only one of the four sites that was irrigated.

Both tall fescue fields were planted to the variety 'Bravo.' The Marion county field was a new stand with the 2001 harvest being its first. The Linn county field was in its third seed crop. Both fields of orchardgrass were planted to the variety 'Potomac' and have been in production for at least five years.

Results
Tall fescue. Both fields responded positively to PGR applications with the least responsive being only a 57 lb/a increase at the Linn site and the greatest response at the Marion site of 510 lb/a additional seed when compared to the untreated check. Seed yield responses from PGR treatments were statistically significantly greater only at the Marion county site (Table 1). Plots at the Linn site may have been swathed too early to optimize seed yields on the PGR-treated plots. However the trial produced seed yields comparable to the remainder of the field. All treated plots at the Marion site provided statistically higher seed yields than the untreated check. However there were no statistical differences in yields among the various products or application rates.

Table 1. Effect of PGR applications on seed yields of Bravo tall fescue, 2001.

Treatment	Rate	Clean seed yield: Marion County	Linn County	2-site avg.
	(product/a)	------------ (lb/a)		-------------
Check	0	2322	1230	1776
Apogee DF	9 oz.	2727	1390	2059
Apogee DF	14 oz.	2736	1448	2092
Apogee DF	7 oz. + 7 oz.	2779	----	----
Apogee DF	22 oz.	2722	1415	2069
Palisade EC	1.0 pt	----	1287	----
Palisade EC	1.5 pt	2635	1360	1998
Palisade EC	2.0 pt	2832	1335	2084
Palisade EC	2.5 pt	2661	----	----
LSD 0.05		230	NS	----

Application dates and stage of growth at treatment.
Marion County site

May 8	all treatments	2-3 nodes, 30-40% of heads emerging
May 17	2nd Apogee only	40% of heads emerged, some completely

Linn County site

May 3	all treatments	2 -3 nodes, boot to early heading

Results from the cleanout and 1000 seed weight determinations done on the sub-samples collected at harvest varied at the different locations. There was no difference in the cleanout percentage for the harvested seed at the Marion site. There was significantly greater cleanout on most of the treated plots at the Linn county location and results are presented in Table 2. There was some variability in 1000 seed weights but no particular trend was observed between the seed harvested from the treated and untreated plots.

Orchardgrass. At each location most PGR treatments resulted in significantly greater seed yields than the untreated check (Table 3). Although not statistically different, there seems to be a trend for the lowest rates of each product to also be the lowest yielding treatment at each location. The yield benefits of higher application rates were minimal at both sites.

Table 2. Effect of PGR applications on cleanout in tall fescue and orchardgrass. 2001.

Treatment	Rate	Tall fescue Linn County	Orchardgrass Marion County
	(product/a)	---- (% cleanout) ------	
Check	0	7	17
Apogee DF	9 oz.	11	--
Apogee DF	14 oz.	11	19
Apogee DF	7 oz. + 7 oz.	--	21
Apogee DF	22 oz.	10	19
Palisade EC	1.0 pt	10	--
Palisade EC	1.5 pt	10	18
Palisade EC	2.0 pt	14	19
Palisade EC	2.5 pt	--	20
LSD 0.05		3	1.6

At the Marion county site there were significant differences observed for both percent cleanout and 1000 seed weight. There was a significantly higher cleanout percentage for all PGR treated plots, except the split Apogee treatment, when compared to the untreated check. This is an important factor that helps determine seed yields and may explain the relatively small yield increases obtained at this location. Percent cleanout data for the Marion county orchardgrass is shown in Table 3. There was also significant variability seen in 1000 seed weights but no consistent pattern between treated and untreated plots. There has been relatively few PGR trials conducted on orchardgrass and additional work is needed.

Table 3. Effect of PGR applications on seed yields of Orchardgrass, var. Potomac. 2001.

Treatment	Rate	Clean seed yield Marion County	Linn County	2-site avg.
	(product/a)	----------- (lb/a) -------------		
Check	0	991	785	888
Apogee DF	7 oz.	----	942	---
Apogee DF	14 oz.	1024	957	991
Apogee DF	7 oz. + 7 oz.	996	---	---
Apogee DF	22 oz.	1034	905	970
Palisade EC	1.5 pt	1022	894	958
Palisade EC	2.0 pt	1047	933	988
Palisade EC	2.5 pt	1043	---	---
LSD 0.05		40	129	---

Application dates and stage of growth at treatment.

Marion County site		
April 27	all treatments	2-3 nodes, 25 –30% of heads emerging
May 4	2nd Apogee only	40% of heads emerged, some completely
Linn County site		
April 26	all treatments	2 -3 nodes, early heading

Summary

Applications of either Apogee or Palisade to commercial grass seed fields in Oregon can result in significant increases in seed yields. There are, however, fairly wide variations in the amount of yield increases that have been obtained from PGR applications. In the majority of the trials conducted the past several years the benefits from an application is greater than the cost of application. This is a production practice that may be worth consideration by grass seed growers. These results indicate that the lower rates may be more cost-effective than the high rates. At a time when there is a surplus of most seed crops the decision to make a PGR application is complex and not an easy one.

Acknowledgements: Appreciation is extended to BASF Corp. and Syngenta Crop Protection, Inc. for their financial support of these trials. We also express appreciation to the growers who allowed us to conduct this research on their farms and for the assistance with working around the trial area and harvesting the many plots.

EVALUATION OF PALISADE ON KENTUCKY BLUEGRASS AND ROUGH BLUEGRASS IN CENTRAL OREGON, 2001

M.D. Butler and C.K. Campbell

Research to evaluate Palisade on Kentucky bluegrass was initiated during 1999. This was followed by a second year of evaluation during 2000 when Palisade was applied at 11 oz/a, 22 oz/a and 33 oz/a at each of the following growth stages: when one to two nodes were detectable (Feekes 7), when the heads were just emerging (Feekes 10.1) and when heads extended just above the flag leaf (Feekes 10.4). Yields were increased by 36 percent by Palisade applied at 22 oz/a from detection of the first and second node (Feekes 7) to when the head just becomes visible (Feekes 10.1) compared to untreated plots. Increasing the rate of Palisade increasingly reduced plant height and lodging. Late application when the heads extended just above the flag leaf (Feekes 10.4) produced the greatest reduction in plant size, while plants tended to out grow the effect of earlier Palisade applications. There were no differences between treatments in weight per 1000 seed. Percent germination for Palisade treated plots was equal to or better than the untreated plots.

Plots 10 ft x 25 ft were replicated four times in a randomized complete block design in commercial fields of 'Merit' Kentucky bluegrass and 'Laser' rough bluegrass near Madras, Oregon. Palisade was applied at 1.5 pt/a, 2.0 pt/a and 2.5 pt/a on the first two application dates, with the addition of a 1.0 pt/a treatment for the third application. Treatments were applied to rough bluegrass on May 9 (2nd node detectable), May 18 (very few heads visible) and May 29 (heads beginning to open), and to Kentucky bluegrass on May 18 (very few heads visible), May 25 (heads out but not open) and June 1 (pre-anthesis). The Kentucky bluegrass was quite short in the plots and, unfortunately, the first node went undetected near the bottom up the stem. This delayed the first application beyond the targeted developmental stage.

Treatments were applied with a CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal/a water using TeeJet 8002 nozzles. Both Kentucky bluegrass and rough bluegrass plots were evaluated for plant height June 6, June 13, June 20 and June 29. Percent lodging was evaluated June 20 and June 29.

Prior to harvest, a Jari mower was used to cut 3-foot alleyways across the front and back of each row of plots. A research-sized swather was use to harvest a 42 inch by 22-foot portion of Kentucky bluegrass plots July 3 and of rough bluegrass plots July 6. Samples were placed in large bags and hung in an equipment shed to dry, and then transported to Corvallis for combining with a Hege 180 and were subsequently cleaned at the Hyslop Farm. Thousand seed counts were conducted using the seed-conditioning lab at the National Forage Seed Production Research Center, and germination testing was done at the Central Oregon Agricultural Research Center.

There were no statistically significant differences between treatments on seed yield for Kentucky bluegrass. However, the trend was for Palisade to increase yields 7 to 10 percent, at rates of 1.0 to 2.5 pt/a when applied pre-anthesis on June 1 (Table 1). Rough bluegrass yields were significantly increased at 2.0 pt/a applied May 9, compared to untreated plots or most application rates made May 29 when heads were beginning to open (Table 2). There is no indication that rates above 2.0 pt/a increases efficacy.

Reduction in plant height for Kentucky bluegrass was the greatest with Palisade applied at 2.5 pt/a applied May 25. All treatments of Palisade greater than 1.0 pt/a significantly reduced plant height on the final evaluation date compared to untreated plots. Plants tended to out grow early applications of Palisade.

With rough bluegrass the best treatment to control plant height appeared to be with Palisade applied at 2.5 pt/a on May 9 or May 18, though not statistically significant. It doesn't appear that rough bluegrass out grew earlier applications of Palisade. There was good correlation between plant height and percent lodging; however, the amount of biomass doesn't appear to be correlated with either.

There were no differences between treatments for percent germination or 1000 seed weight as a measure of seed size for either Kentucky bluegrass or rough bluegrass. The only difference between biomass harvested per plot appears to be an anomaly between Palisade applied at 2.0 pt/a on May 18 and on June 1 for Kentucky bluegrass.

Table 1. Effect of Palisade growth regulator on yield, thousand seed weight, and percent germination of Kentucky bluegrass, Madras, Oregon, 2001.

Treatment	Application timing May 18	May 25	June 1	Seed yield		1000 seed weight	Germination
	---------------(product/a)-------------			(lb/a)	(% check)	(g)	(%)
Palisade	1.5 pt	----	----	1446	92	0.413	89
Palisade	2.0 pt	----	----	1547	98	0.401	90
Palisade	2.5 pt	----	----	1537	97	0.398	86
Palisade	----	1.5 pt	----	1605	102	0.405	78
Palisade	----	2.0 pt	----	1534	98	0.396	89
Palisade	----	2.5 pt	----	1549	98	0.400	91
Palisade	----	----	1.0 pt	1692	107	0.411	87
Palisade	----	----	1.5 pt	1702	108	0.402	83
Palisade	----	----	2.0 pt	1713	109	0.410	90
Palisade	----	----	2.5 pt	1727	110	0.400	85
Untreated	----	----	----	1584	100	0.420	88
				NS[1]	NS	NS	NS

[1]Mean separation with Student-Newman-Kuels (SNK) Test at P≤0.05.

Table 2. Effect of Palisade growth regulator on yield, thousand seed weight, and percent germination of rough bluegrass, Madras, Oregon, 2001.

Treatment	Application timing May 9	May 18	May 29	Seed yield		1000 seed weight	Germination
	---------------(product/a)-------------			(lb/a)	(% check)	(g)	(%)
Palisade	1.5 pt			1263 ab[1]	104 ab	0.297	85
Palisade	2.0 pt			1560 a	129 a	0.275	89
Palisade	2.5 pt			1490 ab	123 ab	0.279	92
Palisade		1.5 pt		1333 ab	110 ab	0.278	91
Palisade		2.0 pt		1306 ab	108 ab	0.284	84
Palisade		2.5 pt		1294 ab	107 ab	0.296	87
Palisade			1.0 pt	1150 b	95 b	0.281	85
Palisade			1.5 pt	1200 b	100 b	0.281	89
Palisade			2.0 pt	1313 ab	109 ab	0.286	93
Palisade			2.5 pt	1212 b	100 b	0.286	88
Untreated	----	----	----	1211 b	100 b	0.264	88
						NS	NS

[1]Mean separation with Student-Newman-Kuels (SNK) Test at P≤0.05.

Table 3. Effect of Palisade growth regulator on biomass, height, and lodging of Kentucky bluegrass, Madras, Oregon, 2001.

Treatment	Application timing May 18	Application timing May 25	Application timing June 1	Biomass	Height June 6	Height June 13	Height June 20	Height June 29	Lodging June 20	Lodging June 29
	(product/a)			(t/a)	(in)				(%)	
Palisade	1.5 pt	----	----	5.4 ab[1]	13.2 cde	18.0 bcd	19.9 cd	25.1 bc	0	8
Palisade	2.0 pt	----	----	5.0 b	11.8 e	15.0 d	19.0 d	23.3 bc	0	0
Palisade	2.5 pt	----	----	5.9 ab	10.8 e	14.7 d	19.4 d	23.5 bc	0	0
Palisade	----	1.5 pt	----	5.7 ab	15.7 bcd	17.3 cd	21.0 bcd	23.7 bc	0	5
Palisade	----	2.0 pt	----	5.5 ab	14.3 cde	15.7 d	18.0 d	21.4 c	0	0
Palisade	----	2.5 pt	----	5.4 ab	12.3 de	13.7 d	14.6 e	17.8 d	0	0
Palisade	----	----	1.0 pt	5.6 ab	19.0 ab	21.8 ab	23.8 bc	27.3 ab	0	0
Palisade	----	----	1.5 pt	6.0 ab	20.1 a	20.8 abc	24.4 b	26.3 b	0	8
Palisade	----	----	2.0 pt	6.2 a	16.7 abc	17.9 bcd	18.8 d	22.1 c	0	0
Palisade	----	----	2.5 pt	6.0 ab	16.6 abc	17.8 bcd	20.6 bcd	21.5 c	0	0
Untreated	----	----	----	5.5 ab	19.0 ab	23.6 a	28.0 a	30.0 a	0	8
									NS	NS

[1]Mean separation with Student-Newman-Kuels (SNK) Test at P≤0.05.

Table 4. Effect of Palisade growth regulator on biomass, height, and lodging of rough bluegrass, Madras, Oregon, 2001.

Treatment	Application timing May 18	Application timing May 25	Application timing June 1	Biomass	Height June 6	Height June 13	Height June 20	Height June 29	Lodging June 20	Lodging June 29
	(product/a)			(t/a)	(in)				(%)	
Palisade	1.5 pt	----	----	6.2	22.8 ab	27.7 ab	31.5 ab	32.3	30	69 b
Palisade	2.0 pt	----	----	6.9	21.7 ab	26.2 ab	28.7 ab	31.8	30	56 b
Palisade	2.5 pt	----	----	6.4	18.6 b	23.8 b	28.2 b	30.3	30	50 b
Palisade	----	1.5 pt	----	5.7	22.3 ab	26.1 ab	29.7 ab	31.1	30	69 b
Palisade	----	2.0 pt	----	6.0	23.8 a	26.1 ab	29.0 ab	32.5	30	50 b
Palisade	----	2.5 pt	----	5.2	22.3 ab	25.7 ab	29.5 ab	30.5	30	50 b
Palisade	----	----	1.0 pt	5.1	25.3 a	28.9 a	32.8 a	33.6	30	75 b
Palisade	----	----	1.5 pt	5.7	25.3 a	26.4 ab	31.3 ab	32.8	30	50 b
Palisade	----	----	2.0 pt	6.2	22.6 ab	25.3 ab	29.0 ab	31.5	30	50 b
Palisade	----	----	2.5 pt	5.9	22.3 ab	27.1 ab	28.9 ab	31.7	30	63 b
Untreated	----	----	----	5.9	24.7 a	27.3 ab	32.6 ab	35.5	30	94 a
				NS[1]				NS	NS	

[1]Mean separation with Student-Newman-Kuels (SNK) Test at P≤0.05.

EVALUATION OF APOGEE ON KENTUCKY BLUEGRASS AND ROUGH BLUEGRASS IN CENTRAL OREGON, 2001

M.D. Butler and C.K. Campbell

Research to evaluate Apogee on Kentucky bluegrass was first conducted during 1999. Three rates were applied early and late, or as a split application. The greatest reduction in plant height was from split applications at 11 oz/a or 14.5 oz/a. Lodging was best controlled with a late application at 22 oz/a or 29 oz/a. Yields showed the greatest increase with an early application at 29 oz/a.

In 2001, plots 10 ft x 25 ft were replicated four times in a randomized complete block design in commercial fields of 'Merit' Kentucky bluegrass and 'Laser' rough bluegrass near Madras, Oregon. Apogee plots were placed adjacent to an existing rough bluegrass trial after the first treatment of Palisade had been applied. To fit existing plot configuration, treatments were replicated only three times. Apogee was applied to the Kentucky bluegrass at 14.5 oz/a on May 18 (very few heads visible), May 25 (heads out but not open), or as a split application at 7.3 oz/a across both dates. The same treatments were applied to rough bluegrass on May 18 (very few heads visible) and May 29 (heads beginning to open). Treatments were applied both with and without 2 percent ammonium sulfate (AMS). A non-ionic surfactant was added to all treatments at 0.25 percent.

Treatments were applied with a CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal/a water using TeeJet 8002 nozzles. Both Kentucky bluegrass and rough bluegrass plots were evaluated for plant height June 6, June 13, June 20 and June 29. Percent lodging was evaluated June 20 and June 29.

Prior to harvest, a Jari mower was used to cut 3-foot alleyways across the front and back of each row of plots. A research-sized swather was used to harvest a 42 inch by 22-foot portion of Kentucky bluegrass plots July 3 and of rough bluegrass plots July 6. Samples were placed in large bags and hung in an equipment shed to dry, and then transported to Corvallis for combining with a Hege 180 and were subsequently cleaned. Tom Silberstein cleaned the seed at the Hyslop Farm. Thousand seed counts were conducted using the seed-conditioning lab at the National Forage Seed Production Research Center, and germination testing was done at the Central Oregon Agricultural Research Center.

There was no statistical difference between treatments on seed yield for either Kentucky or rough bluegrass. However, the trend was for Apogee at 14.5 oz/a applied May 18, either with or without AMS, to increase yield on Kentucky bluegrass eight to ten percent. On rough bluegrass the split application of Apogee, either with or without AMS, tended to increase yields by seven to ten percent. Plant height on the final evaluation date was significantly reduced on Kentucky bluegrass by a split application of Apogee with AMS. On rough bluegrass the split application, either with or without AMS, significantly reduced lodging on the final evaluation date. This, while generating the highest seed yields.

There were no differences between treatments for biomass harvested, percent germination or 1,000 seed weight as a measure of seed size for either Kentucky bluegrass or rough bluegrass.

Table 1. Effect of Apogee growth regulator on yield, thousand seed weight, and percent germination of Kentucky bluegrass, Madras, Oregon, 2001.

Treatment	Application timing May 18	May 25	Seed yield		1000 seed weight	Germination
	---------(product/a)-----------		(lb/a)	(% check)	(g)	(%)
Apogee	14.5 oz	----	1718	108	0.408	83
Apogee+AMS[1]	14.5 oz +2%	----	1578	100	0.398	89
Apogee	7.3 oz	7.3 oz	1491	95	0.413	95
Apogee+AMS	7.3 oz +2%	7.3 oz +2%	1521	96	0.413	90
Untreated	----	----	1584	100	0.420	88
			NS[2]	NS	NS	NS

[1]AMS=ammonium sulfate
[2]Mean separation with Student-Newman-Kuels (SNK) Test at $P \leq 0.05$.

Table 2. Effect of Apogee growth regulator on yield, thousand seed weight, and percent germination of rough bluegrass, Madras, Oregon, 2001.

Treatment	Application timing May 18	Application timing May 29	Seed yield	Seed yield	1000 seed weight	Germination
	(product/a)	(product/a)	(lb/a)	(% check)	(g)	(%)
Apogee	14.5 oz	----	1160	96	0.271	86
Apogee+AMS[1]	14.5 oz +2%	----	1184	98	0.289	85
Apogee	7.3 oz	7.3 oz	1327	110	0.269	87
Apogee+AMS	7.3 oz +2%	7.3 oz +2%	1294	107	0.286	87
Untreated	----	----	1211	100	0.264	88
			NS[2]	NS	NS	NS

[1]AMS=ammonium sulfate
[2]Mean separation with Student-Newman-Kuels (SNK) Test at $P \leq 0.05$.

Table 3. Effect of Apogee growth regulator on biomass, height, and lodging of Kentucky bluegrass, Madras, Oregon, 2001.

Treatment	Application timing May 18	Application timing May 25	Biomass	Plant height June 6	Plant height June 13	Plant height June 20	Plant height June 29	Lodging June 20	Lodging June 29
	(product/a)	(product/a)	(t/a)	(in)	(in)	(in)	(in)	(%)	(%)
Apogee	14.5 oz	----	6.2	14.9 b	20.9 ab	24.4 b	28.5 ab	0	15
Apogee+AMS[1]	14.5 oz +2%	----	5.6	14.3 b	19.4 bc	25.0 b	28.4 ab	0	5
Apogee	7.3 oz	7.3 oz	5.8	12.8 b	17.6 bc	22.5 c	27.0 ab	0	10
Apogee+AMS	7.3 oz +2%	7.3 oz +2%	5.2	12.0 b	17.0 c	19.4 d	25.8 b	0	13
Untreated	----	----	5.5	19.0 a	23.6 a	28.0 a	30.0 a	0	8
			NS[2]					NS	NS

[1]AMS=ammonium sulfate
[2]Mean separation with Student-Newman-Kuels (SNK) Test at $P \leq 0.05$.

Table 4. Effect of Apogee growth regulator on biomass, height, and lodging of rough bluegrass, Madras, Oregon, 2001.

Treatment	Application timing May 18	Application timing May 25	Biomass	Plant height June 6	Plant height June 13	Plant height June 20	Plant height June 29	Lodging June 20	Lodging June 29
	(product/a)	(product/a)	(t/a)	(in)	(in)	(in)	(in)	(%)	(%)
Apogee	14.5 oz	----	5.9	20.4	26.7	30.0	33.2	30	67 ab
Apogee+AMS[1]	14.5 oz +2%	----	5.5	23.0	28.6	30.8	34.4	30	67 ab
Apogee	7.3 oz	7.3 oz	6.2	22.2	25.7	28.6	32.0	30	58 b
Apogee+AMS	7.3 oz +2%	7.3 oz +2%	5.8	22.5	25.2	27.2	31.7	30	50 b
Untreated	----	----	5.9	24.7	27.3	32.6	35.5	30	94 a
			NS[2]	NS	NS	NS	NS	NS	

[1]AMS=ammonium sulfate
[2]Mean separation with Student-Newman-Kuels (SNK) Test at $P \leq 0.05$.

ANNUAL BLUEGRASS RESPONSE TO GROWTH REGULATORS

B.D. Brewster, C.A. Mallory-Smith and C.M. Cole

Introduction

Annual bluegrass (*Poa annua*) infests many grass seed fields in the Willamette Valley. In research conducted with plant growth regulators to increase grass seed yields, it was noted that annual bluegrass growth was affected by the growth regulator treatments. Research was conducted to evaluate the effect of two plant growth regulators, trinexapac-ethyl (Palisade) and prohexadione-calcium (Apogee), applied at various stages of growth on annual bluegrass. Also, seed was collected for analysis from a prohexadione-calcium application on perennial ryegrass that was infested with annual bluegrass.

Methods

A plant growth regulator trial on perennial ryegrass that was conducted on the K&K Koos Farm near Tangent in 1999 was infested with annual bluegrass. Seed samples were collected during harvest of the trial from one treatment and the untreated check for analysis of annual bluegrass seed content. The treated plots received applications of prohexadione-calcium at 0.25 lb a.i./a on the two-node stage (April 23) and again on the three-node stage (May 5). There were four replications of each treatment, and individual plots were 8 ft by 25 ft.

Trials were conducted in the 1999-2000 and 2000-2001 crop years at the Hyslop research farm near Corvallis on stands of annual bluegrass in the absence of a crop. In the 1999-2000 crop year, prohexadione-calcium was applied on four dates from November 15 through March 30. Trinexapac-ethyl and the herbicide glufosinate (Rely) were included for comparison. The treatments that were applied through December 20, 1999, were prior to annual bluegrass heading. Treatments in the 2000-2001 crop year were applied on four dates from February 28 through April 16. Trinexapac-ethyl and prohexadione-calcium were applied on each date, and glufosinate was included on one date for comparison. Percent cover of the soil surface by bluegrass panicles was measured by recording the number of hits in 100 points in each plot. The experimental design was a randomized complete block with four replications in both years. Plot size was 8 ft by 35 ft in 1999-2000, and 8 ft by 20 ft in 2000-2001. A non-ionic surfactant, R-11, was included in all treatments at a rate of 0.25% v/v.

Results

Annual bluegrass seed that was harvested along with the perennial ryegrass seed at the K&K Koos Farm trial in 1999 averaged 130 lb/a in the prohexadione-calcium treated plots and 328 lb/a in the untreated check plots. The *p*-value for the analysis of variance of the means was 0.0283. Prohexadione-calcium applied prior to flowering in 1999-2000 at Hyslop had essentially no effect on annual bluegrass. Trinexapac-ethyl and prohexadione-calcium applied during late flowering hastened the senescence of the annual bluegrass (Table 1), but did not affect annual bluegrass seed production. Glufosinate ratings earlier in the year ranged from 80% to 95% control, but without crop competition the annual bluegrass almost completely recovered.

All growth regulator applications in 2001 provided at least some control of annual bluegrass (Table 2). Ground cover measurements of annual bluegrass panicles showed a dramatic reduction 2 months following application in February, but control ratings in May revealed considerable recovery. The dry conditions during 2001 caused the annual bluegrass to senesce earlier than in 2000, so later evaluations could not be made. These preliminary findings indicate that growth regulators can cause a dramatic hastening of senescence if applied during flowering and contamination of the crop seed may be reduced, but annual bluegrass seed production may not be affected. More in-depth research is currently underway to study the effect of growth regulators on annual bluegrass seed production in grass seed crops.

Table 1. Annual bluegrass control following applications of growth regulators and herbicide, 2000, Hyslop Farm.

Treatment	Rate	Application date	Growth stage	Annual bluegrass control[a]
	(lb a.i./a)			(%)
Prohexadione	0.125	11/15/99	1-2 leaf	0
Glufosinate	0.38	11/15/99		0
Prohexadione	0.125	12/20/99	3-6 leaf, 0-2 tillers	0
Glufosinate	0.38	12/20/99		18
Glufosinate	0.38	3/30/00	3-4 inches tall, flowering	8
Prohexadione	0.25	4/18/00	6-8 inches tall	95
Trinexapac	0.36	4/18/00	Flowering to soft dough	94
Check	0	---		0
LSD 0.05				

[a]Evaluated June 6, 2001.

Table 2. Panicle ground cover and control of annual bluegrass following applications of growth regulators and herbicide, 2001, Hyslop Farm.

Treatment	Rate	Application date	Growth stage	Panicle ground cover[a]	Annual bluegrass control[b]
	(lb a.i./a)				(%)
Trinexapac	0.36	2/28/01	Early heading	4	63
Prohexadione	0.25	2/28/01		10	53
Glufosinate	0.38	2/28/01		1	35
Trinexapac	0.36	3/14/01	10% flowering	5	76
Prohexadione	0.25	3/14/01		10	53
Trinexapac	0.36	4/3/01	Anthesis to milk stage	---	86
Prohexadione	0.25	4/3/01		---	86
Trinexapac	0.36	4/16/01	Anthesis to soft dough	---	80
Prohexadione	0.25	4/16/01		---	78
Check	0	---		55	0
LSD 0.05				6	8

[a]Measured April 4, 2001.
[b]Evaluated May 1, 2001.

WILD CARROT CONTROL IN ESTABLISHED PERENNIAL RYEGRASS

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

Introduction

Wild carrot (*Daucus carota*) has become a ubiquitous weed in western Oregon grass seed fields because it is tolerant of the herbicides that are commonly used in grass seed production. Also, germination of wild carrot seeds occurs over a long period which makes the optimum timing of herbicide applications difficult to determine. Tribenuron (Express) is registered for use in grasses grown for seed and can be effective on wild carrot, but some perennial ryegrass cultivars are particularly sensitive. We found prosulfuron (Peak) to be an effective herbicide for wild carrot control in the 1999-2000 crop year. The objectives for wild carrot research in the 2000-2001 crop year were to confirm the efficacy of prosulfuron, test other herbicides, and evaluate the safety of prosulfuron relative to tribenuron on perennial ryegrass cultivars.

Methods

Two trials were conducted in perennial ryegrass fields that were infested with wild carrot. The Venell field was seeded to 'Laredo' perennial ryegrass in 1998, while the Crossan field was seeded to 'Barlennium' perennial ryegrass in 1999. Herbicides were applied in water at 20 gallons per acre at 20 psi. Individual plots were 8 ft by 25 ft arranged in a randomized complete block design with four replications. Soil at the Venell site was a Dayton silt loam with an organic matter content of 3.2% and a pH of 6.5; soil at the Crossan site was a Holcomb silt loam with an organic matter content of 5.2% and a pH of 5.4. The first herbicide timing was September 11, 2000, in the Venell trial and October 23, 2000, in the Crossan trials; the second timing was March 7, 2001, at both sites. Wild carrots at the Venell site were 6 to 12 inches tall and flowering in September and cotyledon to 4 inches in diameter in March, and at the Crossan site were cotyledon to 2 ft tall and blooming in October and cotyledon to 8 inches in diameter in March.

In a trial at the OSU Hyslop Research Farm, three rows each of 12 cultivars of perennial ryegrass were seeded across each plot. The objectives of the trial were to compare the crop tolerance to tribenuron and prosulfuron and evaluate the safening effect of adding 2,4-D (Envy), MCPA (Rhomene), dicamba (Banvel), or triclopyr (Garlon) to tribenuron or prosulfuron. Herbicide applications, in pounds active ingredient per acre, were as follows: tribenuron 0.008 and 0.016, prosulfuron 0.024 and 0.048, 2,4-D, MCPA, and triclopyr at 0.5, and dicamba at 0.25. A nonionic surfactant, R-11, was added to each treatment at 0.25% v/v. The trial design was a randomized complete block with three replications. Individual plots were 8 ft by 40 ft. The herbicide treatments were applied on October 16, 2000; the ryegrass had 4 to 5 leaves with 1 to 2 tillers and was 2 to 4 inches tall. Soil was a Woodburn silt loam with an organic matter content of 2.4% and a pH of 6.0.

Herbicides in all three trials were applied in water at 20 gallons per acre at 20 psi. Visual evaluations were conducted periodically to assess wild carrot control and perennial ryegrass injury.

Results

Prosulfuron provided the best control of wild carrot at both locations, regardless of application date (Tables 1 & 2). Wild carrot control from treatments in the first timing was declining by May 1, but the prosulfuron treatment in the March timing provided excellent carrot control at both sites on May 1. Tribenuron was nearly equal in effectiveness to prosulfuron in the October timing at the Crossan site, a possible result of the later application. However, crop injury from prosulfuron and tribenuron was greater at the Crossan site than at Venell's. Injury symptoms from the fall applications began to fade in the spring, but were still evident in May (Table 3.) Quinclorac (Paramount) was ineffective on wild carrot while triclopyr provided partial control. Neither of these herbicides injured the ryegrass.

Some cultivars such as 'Pronto II' and 'Aquarius II' were more susceptible to prosulfuron and tribenuron in the Hyslop trial, while others such as 'Top Gun' or 'Black Hawk' were more tolerant. There was little difference between the two herbicides in crop safety and the addition of other herbicides did not improve crop safety. Tribenuron, quinclorac, 2,4-D, MCPA, and dicamba are currently registered for use on perennial ryegrass grown for seed; prosulfuron and triclopyr are not.

Table 1. Percent control of wild carrot in established perennial ryegrass, Venell Farm, Corvallis, OR.

Treatment	Rate	Appl. date	Wild carrot control evaluation date 11/16	3/28	5/1
	(lb a.i./a)		----------(%)----------		
Prosulfuron	0.024	9/11/00	100	91	53
Prosulfuron + dicamba	0.024 + 0.25	9/11/00	95	83	63
Tribenuron	0.016	9/11/00	80	43	20
Tribenuron + dicamba	0.016 + 0.25	9/11/00	81	50	28
Quinclorac	0.38	9/11/00	55	15	40
Triclopyr	0.5	3/7/01	---	20	45
Triclopyr+ dicamba	0.5 + 0.25	3/7/01	---	58	69
Prosulfuron + dicamba	0.024 + 0.25	3/7/01	---	78	99
Tribenuron + dicamba	0.016 + 0.25	3/7/01	---	65	58
Check	0	---	0	0	0
LSD 0.05			21	25	27

Table 2. Percent control of wild carrot in established perennial ryegrass, Crossan Farm, Lebanon, OR.

Treatment	Rate	Appl. date	Wild carrot control evaluation date 11/3	3/27	5/1
	(lb a.i./a)		----------(%)----------		
Prosulfuron	0.024	10/23/00	63	94	83
Prosulfuron + dicamba	0.024 + 0.25	10/23/00	59	94	84
Tribenuron	0.016	10/23/00	53	98	73
Tribenuron + dicamba	0.016 + 0.25	10/23/00	55	90	75
Quinclorac	0.38	10/23/00	58	30	33
Triclopyr	0.5	3/7/01	---	45	73
Triclopyr+ dicamba	0.5 + 0.25	3/7/01	---	53	83
Prosulfuron + dicamba	0.024 + 0.25	3/7/01	---	73	96
Tribenuron + dicamba	0.016 + 0.25	3/7/01	---	48	43
Check	0	---	0	0	0
LSD 0.05			26	18	23

Table 3. Percent injury of perennial ryegrass on May 1, 2001, at two sites following application of herbicides for wild carrot control.

Treatment	Rate	Perennial ryegrass injury Venell	Crossan
	(lb a.i./a)	----------(%)------------	
Prosufluron	0.024	0	21
Prosulfuron + dicamba	0.024 + 0.25	0	10
Tribenuron	0.016	0	20
Tribenuron + dicamba	0.016 + 0.25	0	9
Quinclorac	0.38	0	0
Triclopyr	0.5	0	0
Triclopyr + dicamba	0.5 + 0.25	0	0
Prosulfuron + dicamba	0.024 + 0.25	20	43
Tribenuron + dicamba	0.016 + 0.25	0	4
Check	0	0	0
LSD 0.05		0	12

CONTROL OF WESTERN MANNAGRASS IN ANNUAL RYEGRASS

B.D. Brewster, C.M. Cole and C.A. Mallory-Smith

Introduction

The mannagrasses (*Glyceria* spp.) are commonly found infesting grass fields that are poorly drained in western Oregon. Ethofumesate (Nortron) has long been the primary herbicide for controlling mannagrass in grass seed fields, but has become ineffective in some fields in recent years. Two trials were conducted in an annual ryegrass field near Lebanon, OR, that was heavily infested with western mannagrass (*Glyceria occidentalis*) in order to identify potential herbicide treatments.

Methods

A randomized complete block with four replications was the experimental design used in both trials; individual plots were 8 ft by 25 ft. Herbicides were applied with a single-wheel plot sprayer that delivered 20 gallons per acre at 20 psi. The soil was a Holcomb silt loam with a pH of 5.1 and an organic matter content of 4.8%. A non-ionic surfactant was added to all treatments at a rate of 0.25% of the spray volume. The soil was muddy when the herbicides were applied in both trials. Trial 1 was initiated on January 4, 2001. The air temperature was 43 F, the mannagrass had 3 to 4 leaves and 0 to 1 tiller, and the annual ryegrass had 2 to 3 tillers. Trial 2 was initiated on February 6, 2001. The air temperature was 46 F, the mannagrass mostly had 4 leaves with 0 to 3 tillers and was up to 5 inches tall, and the annual ryegrass was 4 to 12 inches tall. Visual evaluations were conducted to assess crop injury and mannagrass control.

Results

Pyrithiobac (Staple) and difenzoquat (Avenge) were the most promising herbicides in Trial 1, and the final ratings for those treatments are presented in Table 1. At the rates tested, pyrithiobac provided complete control of western mannagrass but stunted the annual ryegrass. No attempt was made to assess the effect of pyrithiobac on annual ryegrass seed yield. Difenzoquat initially provided 70% control of mannagrass but control was less than 50% in the final evaluation. Difenzoquat had no visible effect on annual ryegrass. The reduced rates of pyrithiobac in Trial 2 (Table 2) caused less crop injury than the higher rates in Trial 1 and still provided excellent control of western mannagrass. The addition of difenzoquat to pyrithiobac did not increase injury on annual ryegrass. Additional research is underway to assess the efficacy of pyrithiobac on mannagrass and it safety on various grass species.

Table 1. Control of western mannagrass and injury to Italian ryegrass with pyrithiobac and difenzoquat, near Lebanon, OR (Trial 1).

Treatment	Rate	Italian ryegrass injury	Western mannagrass control
	(lb a.i./a)	-------------(%)-------------	
Pyrithiobac	0.11	21	100
Pyrithiobac	0.16	34	100
Difenzoquat	2.0	0	43
Check	0	0	0
LSD 0.05	---	9	6

Table 2. Control of western mannagrass and injury to Italian ryegrass with pyrithiobac and difenzoquat, near Lebanon, OR (Trial 2).

Treatment	Rate	Italian ryegrass injury	Western mannagrass control
	(lb a.i./a)	-------------(%)-------------	
Pyrithiobac	0.027	10	97
Pyrithiobac	0.053	19	100
Difenzoquat + pyrithiobac	0.5 + 0.027	13	96
Difenzoquat + pyrithiobac	0.5 + 0.053	13	99
Check	0	0	0
LSD 0.05	---	7	4

TOLERANCE OF SEEDLING GRASSES AND CONTROL OF BROADLEAF WEEDS WITH CARFENTRAZONE

B.D. Brewster, C.M. Cole and C.A. Mallory-Smith

Introduction

Carfentrazone (Aim) was recently registered in Oregon for the control of broadleaf weeds in grasses grown for seed, but little is known about the tolerance of seedling grasses when carfentrazone is tank-mixed with other herbicides. Carfentrazone has been particularly effective on ivyleaf speedwell (*Veronica hederifolia*) and catchweed bedstraw (*Galium aparine*) in western Oregon, but is less effective on certain other species such as mayweed chamomile (*Anthemis cotula*) and sharppoint fluvellin (*Kickxia elatine*). Oxyfluorfen (Goal) was included for comparison. Oxyfluorfen is registered for use in seedling annual ryegrass, perennial ryegrass, and tall fescue after the grasses have at least one tiller.

Methods

A trial was conducted at the OSU Hyslop research farm near Corvallis to evaluate carfentrazone applied alone and in combination with other herbicides on five seedling grass species. Six rows each of 'Highland' bentgrass, 'Pennlate' orchardgrass, 'Gator II' perennial ryegrass, 'Shademaster' creeping red fescue, and 'Velocity' tall fescue were seeded on 12 inch row spacings across each plot with Planet Jr. seeders on April 16, 2001. The trial site was irrigated. A randomized complete block experimental design with four replications and 8 ft by 35 ft plots was used in this study. The soil was a Woodburn silt loam with an organic matter content of 2.6% and a pH of 5.7. Herbicide treatments were applied on May 16 with a single-wheel compressed-air plot sprayer which delivered 20 gallons per acre at 20 psi. The perennial ryegrass had 4 to 5 leaves and 1 to 2 tillers when treated, while the other grasses had 3 leaves. Shepherdspurse and mayweed chamomile had 4 to 6 leaves, common lambsquarters 2 to 4 leaves, and sharppoint fluvellin 2 leaves.

Results

Orchardgrass was injured more by carfentrazone than were the other grasses 1 week after application (Table 1), but the injury was nearly gone 2 weeks later. The addition of some herbicides to carfentrazone tended to increase injury to some grasses. Clopyralid plus 2,4-D (Curtail) and 2,4-D amine (Envy) significantly increased injury to orchardgrass when tank-mixed with carfentrazone, and perennial ryegrass was quite sensitive to the addition of tribenuron (Express). Most of the injury ratings for treatments that contained carfentrazone were relatively minor with less than 20% injury 3 weeks after application. Oxyfluorfen is not registered for use on seedling bentgrass, orchardgrass, or creeping red fescue. These species were initially injured to a greater extent than was tall fescue or perennial ryegrass, but the creeping red fescue recovered quickly.

Oxyfluorfen was applied to the tall fescue at an earlier stage of growth than the label allows, but it also recovered quickly from the initial injury.

All of the carfentrazone treatments provided excellent control of shepherdspurse and common lambsquarters (Table 2). Carfentrazone alone was not effective on sharppoint fluvellin or mayweed chamomile, but the addition of other herbicides improved control. The treatments that contained tribenuron were especially effective on these two species. Oxyfluorfen controlled common lambsquarters and sharppoint fluvellin, but failed to control shepherdspurse or mayweed chamomile.

Table 1. Crop injury ratings 1 and 3 weeks after herbicide application to seedling grasses on May 16, 2001, Hyslop Farm, Corvallis, OR.

		Crop injury									
		Bentgrass		Orchard grass		Red fescue		Tall fescue		Perennial ryegrass	
Treatment	Rate	1 wk	3wk	1 wk	3 wk	1 wk	3 wk	1 wk	3 wk	1 wk	3 wk
	(lb a.i./a)	(%)									
Carfentrazone	0.017	3	0	15	5	0	5	0	3	0	3
Carfentrazone	0.025	3	3	13	5	8	3	3	3	0	3
Oxyfluorfen	0.038	70	28	38	18	30	8	20	8	10	5
Carfentrazone + 2,4-D	0.017 + 0.25	8	9	15	20	3	9	0	6	0	3
Carfentrazone + 2,4-D	0.025 + 0.25	8	6	23	23	15	9	13	9	0	3
Carfentrazone + MCPA	0.017 + 0.38	5	8	8	10	3	10	0	4	0	5
Carfentrazone + MCPA	0.25 + 0.38	3	4	15	8	5	3	5	5	0	0
Carfentrazone + dicamba	0.017 + 0.25	0	4	13	10	10	9	3	9	0	11
Carfentrazone + dicamba	0.025 + 0.25	0	3	28	13	5	6	5	3	0	3
Carfentrazone + clopyralid & 2,4-D	0.017 + 0.3	3	9	25	23	13	15	13	15	0	8
Carfentrazone + clopyralid & 2,4-D	0.025 + 0.3	5	9	23	38	10	18	3	15	0	9
Carfentrazone + tribenuron	0.017 + 0.016	3	3	18	13	3	5	5	11	8	24
Carfentrazone + tribenuron	0.025 + 0.016	0	10	25	18	5	10	8	18	3	35
Check	0	0	0	0	0	0	0	0	0	0	0
LSD 0.05	---	7	10	16	14	12	NS	8	NS	4	10

Table 2. Broadleaf weed control 3 weeks following herbicide application to seedling grasses on May 16, 2001, Hyslop Farm, Corvallis, OR.

		Weed control			
Treatment	Rate	Shepherdspurse	Common lambsquarters	Sharppoint fluvellin	Mayweed chamomile
	(lb a.i./a)	(%)			
Carfentrazone	0.017	95	99	0	5
Carfentrazone	0.025	99	99	28	25
Oxyfluorfen	0.038	60	90	99	25
Carfentrazone + 2,4-D	0.017 + 0.25	95	99	76	48
Carfentrazone + 2,4-D	0.025 + 0.25	98	99	78	65
Carfentrazone + MCPA	0.017 + 0.38	99	100	73	48
Carfentrazone + MCPA	0.25 + 0.38	100	100	74	18
Carfentrazone + dicamba	0.017 + 0.25	93	100	81	33
Carfentrazone + dicamba	0.025 + 0.25	98	99	73	63
Carfentrazone + clopyralid & 2,4-D	0.017 + 0.3	96	100	82	49
Carfentrazone + clopyralid & 2,4-D	0.025 + 0.3	100	99	85	95
Carfentrazone + tribenuron	0.017 + 0.016	99	99	99	99
Carfentrazone + tribenuron	0.025 + 0.016	100	99	99	98
Check	0	0	0	0	0
LSD 0.05	---	4	4	21	29

TOLERANCE OF THREE GRASS SPECIES TO PREPLANT APPLICATION OF QUINCLORAC

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

Introduction
Quinclorac (Paramount) was recently registered for the control of field bindweed in some grass species grown for seed. This herbicide is quite persistent in the soil so care must be taken to avoid injury to sensitive rotation crops. Since field bindweed potentially could be treated with quinclorac prior to seeding the grass, a trial was conducted to evaluate preplant application of quinclorac on grass seed production.

Methods
A seedbed was prepared one month prior to seeding the grasses at the Hyslop research farm near Corvallis; three trials – one for each grass species – were established at the site. The soil was a Woodburn silt loam with a pH of 6.0 and an organic matter content of 2.4%. The experimental design was a randomized complete block with four replications. Individual plots were 8 ft by 30 ft. Quinclorac was applied with a single-wheel plot sprayer on three dates prior to seeding. The first application date was August 30, 2000, the second on September 13, and the third on September 27. Quinclorac was applied at two rates – the maximum labelled rate and a rate twice as high. The soil was lightly harrowed prior to seeding. 'Shademaster' creeping red fescue, 'Pennlate' orchardgrass, and 'Buccaneer' perennial ryegrass were carbon-seeded in 12-in-wide rows on September 27. The perennial ryegrass and orchardgrass were seeded at 8 lb/a while the fescue was seeded at 5 lb/a. Diuron was applied at 1.6 lb a.i./a on September 28 to aid in weed control. Bromoxynil, MCPA, and dicamba were also employed along with hand-weeding to minimize weed competition. Sprinkler irrigation was applied after seeding to establish the crops.

The grasses were swathed prior to threshing with a small-plot combine in July. The seed was cleaned prior to weighing.

Results
No injury symptoms were observed prior to seed harvest, and perennial ryegrass and orchardgrass seed yields were not affected by the quinclorac treatments (Table 1). Seed yield of creeping red fescue was reduced by quinclorac at the higher rate on all application dates, and the lower rate reduced seed yield when applied on the day of planting. If quinclorac is to be labelled for use in close proximity to seeding creeping red fescue, a lower rate will need to be applied.

Table 1. Grass seed yields following preplant applications of quinclorac at Hyslop Farm.

		Seed yield		
Quinclorac rate	Application date	Perennial ryegrass	Orchard-grass	Red fescue
(lb a.i./a)		----------------	(lb/a)	----------------
0.38	8/30/00	1343	698	672
0.75	8/30/00	1308	648	621
0.38	9/13/00	1331	675	814
0.75	9/13/00	1328	605	678
0.38	9/27/00	1216	614	654
0.75	9/27/00	1324	573	540
0	---	1354	578	809
LSD 0.05	---	NS	NS	151

CARBON SEEDING AND HERBICIDE BANDING IN PERENNIAL RYEGRASS

B.D. Brewster, C.M. Cole and C.A. Mallory-Smith

Introduction
The application of activated charcoal (carbon) over the seed row to safen a crop to preemergence herbicides has been a common practice in grass seed production in Oregon for over three decades. During that time annual bluegrass (*Poa annua*) developed resistance to diuron (Karmex, Direx) in some fields so an alternative to diuron is needed for stand establishment. Some growers have expressed interest for seeding without carbon to reduce cost of stand establishment. A trial was conducted at the OSU Hyslop Research Farm to assess the merits of applying norflurazon (Solicam) and flufenacet-metribuzin (Axiom) as banded treatments between rows during seeding versus applying them over activated charcoal after planting.

Methods
Two banding methods were evaluated. One method involved the use of rake tines mounted on the drill behind the spray boom to incorporate the herbicide immediately after spraying while seeding. The second banding method simply involved applying the herbicides in 8-inch-wide bands between the 12-inch-wide rows with a spray boom that was mounted on the drill. The carbon-seeding herbicide treatments were applied with a small-plot sprayer immediately after planting on October 6, 2000. A randomized complete block experimental design with four replications was used in the trial. Individual plots were 8 ft by 50 ft and the soil was a Woodburn silt loam with an organic matter content of 2.5% and a pH of 5.9. Powdery dry soil was present at seeding, but a significant rain occurred on October 9 and 10. 'Buccaneer' perennial ryegrass

was seeded at 8 lb per acre. The trial site was infested with annual bluegrass and ivyleaf speedwell (*Veronica hederifolia*); the annual bluegrass population was not resistant to diuron. Visual evaluations were conducted periodically to assess crop tolerance and weed control.

Results

Perennial ryegrass injury with banding treatments was about the same with or without tillage (Table 1). Symptoms from the norflurazon treatments appeared before those of the flufenacet-metribuzin treatments, but by spring the injury was about the same. Injury was not excessive with the banding treatments, although it was somewhat greater than the standard diuron carbon-seeding treatment. Activated charcoal improved crop safety over the banding applications. There was a trend for the flufenacet-metribuzin treatment to be better on annual bluegrass in the carbon-seeding application, but norflurazon was about equally effective in all applications (Table 2). Norflurazon was the only treatment that controlled ivyleaf speedwell. Diuron is registered for use in grass seed stand establishment in Oregon. Flufenacet metribuzin is legal for use on established stands only, while norflurazon is not labeled for any application in grass seed production.

Table 1. Perennial ryegrass injury in a new planting with three herbicide application methods.

Treatment	Rate	Application	Perennial ryegrass injury 11/6/00	Perennial ryegrass injury 3/12/01
	(lb a.i./a)		--------------- (%) ---------------	
Norflurazon	2.0	Banding w/ tillage	21	21
Flufenacet-metribuzin	0.2	Banding w/ tillage	0	21
Flufenacet-metribuzin + diuron	0.2 + 1.2	Banding w/ tillage	0	23
Norflurazon	2.0	Banding w/o tillage	25	25
Flufenacet-metribuzin	0.2	Banding w/o tillage	1	20
Flufenacet-metribuzin + diuron	0.2 + 1.2	Banding w/o tillage	3	25
Norflurazon	2.0	Carbon seeding	8	5
Flufenacet-metribuzin	0.2	Carbon seeding	0	3
Flufenacet-metribuzin + diuron	0.2 + 1.2	Carbon seeding	0	3
Diuron	2.4	Carbon seeding	3	15
Check	0	---	0	0
LSD 0.05			5	6

Table 2. Annual bluegrass and ivyleaf speedwell control in a new planting of perennial ryegrass with three herbicide application methods.

Treatment	Rate	Application	Weed control: Annual bluegrass, Evaluation date 11/6/00	Annual bluegrass 11/12/00	Ivyleaf speedwell 11/6/00	Ivyleaf speedwell 1/18/01
	(lb a.i./a)		(%)			
Norflurazon	2.0	Banding w/ tillage	99	96	99	95
Flufenacet-metribuzin	0.2	Banding w/ tillage	99	85	38	0
Flufenacet-metribuzin + diuron	0.2+ 1.2	Banding w/ tillage	99	88	43	28
Norflurazon	2.0	Banding w/o tillage	99	99	99	95
Flufenacet-metribuzin	0.2	Banding w/o tillage	99	88	63	40
Flufenacet-metribuzin + diuron	0.2+ 1.2	Banding w/o tillage	99	94	70	58
Norflurazon	2.0	Carbon seeding	99	97	97	91
Flufenacet-metribuzin	0.2	Carbon seeding	99	94	60	0
Flufenacet-metribuzin + diuron	0.2+ 1.2	Carbon seeding	99	96	70	13
Diuron	2.4	Carbon seeding	99	90	13	0
Check	0	---	0	0	0	0
LSD 0.05			0	5	25	21

REPLACING HORIZON FOR ROUGHSTALK BLUEGRASS CONTROL

G.W. Mueller-Warrant

Horizon 1EC, a mixed-isomer emulsifiable concentrate formulation of fenoxaprop, was first registered in 1987 for control of roughstalk bluegrass, wild oats, and warm-season annual grasses in Italian (annual) ryegrass, perennial ryegrass, tall fescue, and fine fescue grown for seed (Mueller-Warrant and Brewster, 1987; Mueller-Warrant, 1990). Declining sales of this formulation of fenoxaprop in other crops led to the manufacturer's recent decision to stop producing Horizon. Several other formulations of fenoxaprop are also being phased out, and the manufacturer's current plan is to eventually produce, and support for registration, only a few single-isomer formulations. Early in 2001 representatives of Aventis Corp. believed that Whip 360 and Silverado were the most likely candidates for long-term support. However, they now indicate that Puma, a single-isomer formulation containing a chemical safener, has the best chance of long-term support by their company. Tests conducted in 1989, 1990, and 1991 discovered that two single-isomer formulations of fenoxaprop (ones later named Whip 360 and Silverado) possessed unexpectedly enhanced activity on cool-season grass, providing better weed control but also causing greater crop damage than standard rates of Horizon (Mueller-Warrant, 1991). Instead of being merely the expected 2.0-times as active as Horizon, the Silverado formulation was 3.0-times as active, and the Whip 360 formulation 3.75-times as active.

Tests were initiated in the 2000-2001 growing season in a perennial ryegrass stand heavily infested with roughstalk bluegrass to evaluate the efficacy and safety of Whip 360 and Silverado formulations of fenoxaprop as potential replacements for Horizon. Rely was included as a new standard treatment for roughstalk bluegrass control in perennial ryegrass. The test was conducted in an area that had received a variety of herbicide treatments in previous growing seasons, thereby generating a wide range of roughstalk bluegrass infestations. This range in weed densities was used as a treatment blocking factor, allowing us to test the effects of seven herbicide treatments plus an untreated check under conditions of high, medium, low, and no roughstalk bluegrass. We also were able to test full straw load chop versus bale/flail chop/rake residue management. All plots were treated with Prowl + Axiom at 2.0 + 0.38 lb a.i./a on October 13, 2000, followed by Goal + metribuzin (Sencor/Lexone) at 0.12 + 0.38 lb a.i./a on November 20, 2000. When fenoxaprop formulations and Rely were applied for roughstalk bluegrass control on March 19, 2001, perennial ryegrass plants averaged 5 inches tall, with growing points 0.1 inches above the ground. Ground cover of roughstalk bluegrass was measured before and after treatment, and clean seed yields of perennial ryegrass and roughstalk bluegrass were determined.

Blocking and treatment assignment procedures succeeded in providing uniform conditions for testing the effects of fenoxaprop formulations and Rely on crop tolerance and weed control efficacy under high, medium, low, and no roughstalk bluegrass pressure. Roughstalk bluegrass ground cover in spring 2000, 10 months before control treatments were applied, averaged 28% over all plots (Table 1). Roughstalk bluegrass density averaged 50, 28, 19, and 0% ground cover in plots classified as possessing high, medium, low, and no infestation. Roughstalk bluegrass was highly competitive. When averaged over all herbicide and residue management treatments, plots with initially high levels of infestation yielded 216 lb/a less perennial ryegrass seed than plots without any roughstalk bluegrass. Without herbicide treatment on March 19, 2001, roughstalk bluegrass density in late spring increased to nearly double that present the previous year, going from 27 to 52% ground cover (Table 2). Whip 360, Silverado, and Rely were all highly effective in controlling roughstalk bluegrass, reducing ground cover by this weed an average of 22% between years. Horizon was slightly less effective, reducing ground between years by 13 and 18% at 0.2 and 0.25 lbs/a.

When averaged over all infestation levels and residue management treatments, the untreated check yielded 402 and 375 lbs/a less perennial ryegrass seed than the best two treatments, Whip 360 at 0.067 lb/a and Rely at 0.3 lb/a, respectively (Table 2). The value of controlling roughstalk bluegrass was also quite evident in a graph of seed yield versus roughstalk bluegrass ground cover for all treatments (Figure 1). The regression equation for this graph predicted a yield of 1260 lb/a in the absence of roughstalk bluegrass, and a yield loss of 8.4 lbs/a of seed for each 1% increase in roughstalk bluegrass ground cover. When this yield loss coefficient was multiplied by the difference in roughstalk bluegrass ground cover between the high rate of Whip 360 and the untreated check, an expected yield difference of 413 lb/a was obtained, nearly identical to the measured yield difference of 402 lb/a. The similarity of these values strongly implies that there were no negative effects of Whip 360 treatment on seed yield. Given that there was a pronounced and lasting reduction in crop height from Whip 360 treatment, the absence of any detectable negative effects on seed yield combined with the presence of large benefits from controlling roughstalk is encouraging. Similar comparisons using the other potential replacements for Horizon also provided good evidence for their safety when applied in March. There were also no instances where applying herbicides to plots with low or no roughstalk bluegrass reduced seed yield, and indeed any trends present were toward increasing seed yield with all replacements for Horizon even in the absence of roughstalk bluegrass (interaction level data not shown in tables). Bale/flail chop/rake plots were generally higher yielding than full straw load plots, especially in cases with some degree of roughstalk bluegrass infestation. While slightly more volunteer perennial ryegrass and annual bluegrass was present with full straw load than bale/flail chop/rake management, seedling weeds were generally well controlled by the fall treatment program, and seedling densities were far too low to have caused serious yield losses in full straw load plots. Roughstalk bluegrass control was slightly better in bale/flail chop/rake than in full straw load management, and differences in roughstalk bluegrass survival following March 19 herbicide treatment, and hence competition, probably caused much of the yield differential between residue management treatments.

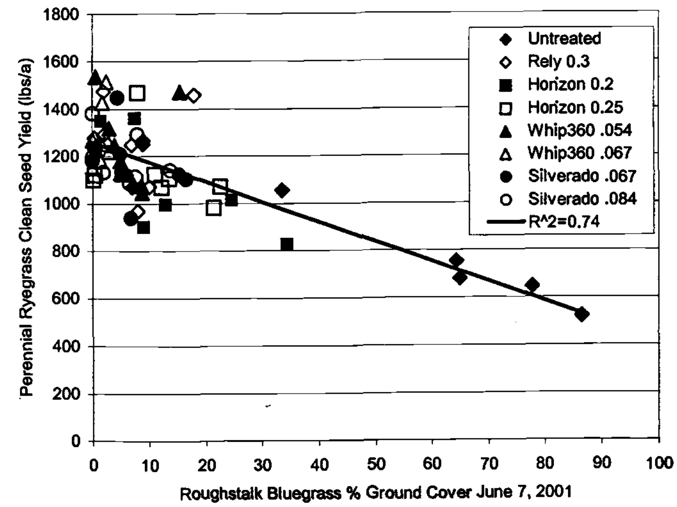

Figure 1. Perennial ryegrass seed yield versus roughstalk bluegrass ground cover for all treatments. Regression equation: Seed yield = 1260 – 8.432* Roughstalk bluegrass ground cover.

Given known differences in tolerance to herbicides such as Horizon and Rely among the crops (and among varieties within some crops) that were listed on the Horizon label (perennial ryegrass, annual ryegrass, tall fescue, fine fescue), it is likely that replacing Horizon will ultimately involve use of a number of different herbicides. Some of these may be useful against many weeds in many crops, while others may only control a few weeds in a few crops. Tests being conducted during the 2001-2002 growing season will evaluate a wider range of treatments across a wider array of weeds and crops. While it is possible that none of the herbicides will replace all of Horizon's uses on all crops, it is also possible that some of the alternatives will actually be better, controlling weeds that Horizon didn't or possessing better crop safely while controlling weeds.

Mueller-Warrant, G.W., and B.D. Brewster. 1987. Control of roughstalk bluegrass (*Poa trivialis*) in perennial ryegrass (*Lolium perenne*) grown for seed. J. Applied Seed Prod. 4:44-51.

Mueller-Warrant, G.W. 1990. Control of roughstalk bluegrass (*Poa trivialis*) with fenoxaprop in perennial ryegrass (*Lolium perenne*) grown for seed. Weed Tech. 4:250-257.

Mueller-Warrant, G.W. 1991. Enhanced activity of single-isomer fenoxaprop on cool season grasses. Weed Technol. 5:826-833.

Table 1. Main effects of residue management and roughstalk bluegrass pre-treatment infestation level on roughstalk bluegrass ground cover and perennial ryegrass seed yield.

Roughstalk bluegrass infestation class	Residue management	Roughstalk bluegrass ground cover 23-May-00	7-Jun-01	Change†	Perennial ryegrass clean seed yield
		----------(%)----------			(lb/a)
High	Bale/flail/rake	60	23	-37	1106
Medium	Bale/flail/rake	28	9	-19	1218
Low	Bale/flail/rake	18	5	-14	1350
None	Bale/flail/rake	0	2	2	1280
High	Full straw load	47	23	-24	996
Medium	Full straw load	28	15	-12	1060
Low	Full straw load	20	15	-5	1071
None	Full straw load	0	2	2	1212
---	Bale/flail/rake	27	10	-17	1238
---	Full straw load	29	16	-13	1066
High	---	50	23	-26	1018
Medium	---	28	14	-14	1099
Low	---	19	10	-9	1211
None	---	0	2	2	1234

†Difference between roughstalk bluegrass ground cover on June 7, 2001, and on May 23, 2000.

Table 2. Main effects of fenoxaprop formulations and Rely on roughstalk bluegrass ground cover and perennial ryegrass seed yield.

Herbicides applied on 19-Mar-01 (lb a.i./a)	Roughstalk bluegrass ground cover 23-May-00	7-Jun-01	Change†	Perennial ryegrass clean seed yield (lbs/a)
	(%)			(lb/a)
Horizon at 0.2	29	16	-13	1037
Horizon at 0.25	31	13	-18	1090
Whip 360 at 0.054	28	7	-22	1190
Whip 360 at 0.067	27	3	-24	1242
Silverado at 0.067	28	8	-20	1133
Silverado at 0.084	29	7	-22	1175
Rely at 0.3	29	7	-22	1215
Untreated check	27	52	24	840

†Difference between roughstalk bluegrass ground cover on June 7, 2001, and on May 23, 2000.

RESPONSE OF SPACE-PLANTED BENTGRASS TO GRASS-CONTROL HERBICIDES

G.W. Mueller-Warrant

Efforts to develop turfgrass varieties with herbicide resistance and other traits of agronomic interest are currently underway in various breeding programs. Approaches being used include insertion of genes conveying herbicide resistance, and selection through conventional breeding methods for moderate increases in tolerance to Roundup in a number of crops. Because of the outcrossing nature of most cool-season grasses, there is risk of herbicide-resistance traits spreading to other crops or related weed species through pollen, seed, and vegetative propagules. Specific details of transgenic or conventional breeding methods used to develop herbicide-resistant varieties will influence the likelihood of gene escape and the severity of potential weed problems. However, there are common features of approaches to contain these problems. One critical concern is the method used to remove the herbicide-resistant crop after its productive stand life. If tillage is used to "plow out" the herbicide-resistant crop, large quantities of herbicide-resistant seed will remain in the soil, and likely be viable for years. In such a case, management practices for different crops that might be grown in rotation during the next decade would need to consider the presence of herbicide-resistant weed seeds. Failing to take that into consideration might permit resistance to multiply and spread. An obvious alternative is to destroy the stand without tillage. The difficulty in doing so will be the fact that the plants would be resistant to at least one commonly used broad-spectrum herbicide. As a consequence, there is critical need for up-to-date information on how hard it is to kill these plants with a variety of herbicides that might be used non-selectively in fallow or selectively in possible rotational crops.

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

Three cycles of tests are being conducted. The first test cycle commenced after transplanting five bentgrass species (dryland, redtop, Colonial, creeping, and velvet) in late winter 2000 into an old orchardgrass stand, followed by initiation of herbicide treatments in two timing sequences in October and November 2000. The first application in the early timing sequence was made soon after the initiation of vigorous fall regrowth, and treatments were reapplied in early spring and again in early summer after plants had recovered from herbicide damage and initiated new tiller growth. Treatments in the later timing sequence were applied approximately one month after those in the early sequence. The eight herbicide treatments were Roundup 1.5 lb a.i./a, Rely 1.0 lb a.i./a, Gramoxone Extra 0.625 lb a.i./a, Fusilade DX 0.375 lb a.i./a, Kerb 0.375 lb a.i./a, Select 0.125 lb a.i./a, Raptor 0.039 lb a.i./a, and a tank-mix of Roundup 1.5 lb a.i./a plus Fusilade DX 0.375 lb a.i./a. The early sequence consisted of applications on October 26, 2000, and March 20, June 12, and November 6, 2001. The later sequence consisted of applications on November 17, 2000, and April 19, July 10, and December 21, 2001. Treatments were initially applied to all plots, and subsequently reapplied only to those plots in which living bentgrass plants remained. All herbicides achieved fair to good initial "burndown" of bentgrass except for 0.375 lb a.i./a Kerb. Kerb rate was increased to 1.0 lb a.i./a after failure of the lower rate to kill any bentgrass plants in the first application of either sequence. The second test cycle commenced after transplanting seven bentgrass species or varieties (Seaside creeping, Penncross 'F1' creeping, SRX7100 Colonial, dryland, velvet, redtop, and a not-yet-identified weedy species collected from a perennial ryegrass field on OR Hwy. 34) in late winter 2001 into an old orchardgrass stand, followed by initiation of herbicide treatments in two timing sequences in November and December 2001. The ten herbicide treatments were Roundup 1.5 lb a.i./a, Rely 1.0 lb a.i./a, Gramoxone Extra 0.625 lb a.i./a, Fusilade DX 0.375 lb a.i./a, Kerb 1.0 lb a.i./a, Select 0.125 lb a.i./a, Raptor 0.039 lb a.i./a, a tank-mix of Roundup 1.5 lb a.i./a plus Fusilade DX 0.375 lb a.i./a, Assure II 0.0825 lb a.i./a, and a tank-mix of Roundup 1.5 lb a.i./a plus Assure II 0.0825 lb a.i./a. The early sequence began with applications on November 6, 2001, and will include subsequent applications in March, June, and October/November 2002. The later sequence began with applications on December 21, 2001, and will include subsequent applications in April, July, and November/December 2002. The third test cycle commenced after transplanting seven bentgrass species or varieties (repeating those used in the second test cycle) in late fall 2001 into an old perennial ryegrass stand, to be followed by initiation of herbicide treatments in October/November and November/December 2002. Herbicide treatments used in the second cycle will be repeated in the third.

Data being collected includes monthly observations of whether regrowth has occurred by each individual plant. Regrowth status is rated into one of four categories: *Dead* = no signs of any new growth or survival of treated shoots; *Unclear* = any regrowth present is too small to identify, or some treated shoots injured but tissue not quite dead; *Alive* = one or more healthy tillers present, but tillers smaller in size and fewer in number than before treatment; *Robust* = many tillers present, plant nearing pre-treatment size. Repeat herbicide applications are generally not made until none of the plants fall into the *unclear* response category. Individual plots are being retreated until all bentgrass plants present in them have been killed. Primary result of the research will be information on the number of times each of the herbicide treatments in the early and later timing sequence (16 treatments in cycle one, 20 in cycles two and three) must be applied in order to kill the bentgrasses (Table 1).

None of the treatments in the first cycle of testing were successful in destroying space-planted, well-established bentgrass plants in a single application. Indeed, some bentgrass plants have survived four applications of the least successful treatments. The most effective treatment was a tank-mix of 1.5 lb a.i./a Roundup plus 0.375 lb a.i./a Fusilade, requiring an average of 1.95 applications to kill all bentgrass for the early timing sequence and 1.55 applications for the later timing sequence. Herbicides requiring between 2 to 3 applications to eliminate bentgrass included 1.5 lb a.i./a Roundup, 0.375 lb a.i./a Fusilade, 0.125 lb a.i./a Select, and 1.0 lb a.i./a Rely. For the remaining herbicides, some individual bentgrass plants have required treatment at all four application dates. The average total number of applications needed to kill bentgrass with these herbicides is therefore not yet finalized, but will apparently exceed 3.0 applications for 0.625 lb a.i./a Gramoxone Extra and 0.039 lb a.i./a Raptor, and 4.0 applications for 1.0 lb a.i./a Kerb. For the most effective treatments, regrowth was often limited to only a few tillers per plant and was delayed for as long as 6 months after application. For treatments with only limited effectiveness, regrowth often commenced within 4 weeks after application and involved large numbers of tillers. Differences among bentgrass species were small, but dryland, redtop, and velvet were slightly harder to kill than Colonial, creeping, and the unidentified species (avg. 2.66 vs. 2.43 applications to date for all herbicides). The later timing sequence was more effective than the earlier sequence for Roundup, Rely, Gramoxone Extra, and Roundup plus Fusilade, mainly due to differences in effectiveness of the October 26 vs. November 17, 2000, applications. The October 26 application was made only 17 days after the first substantial autumn rainfall, and although considerable new shoot growth had occurred during that period, apparently not all tillers had appeared. Poor performance by Kerb may be a result of the rate being too low in applications the first fall, and the weather being too warm and dry during the spring and summer applications. However, many bentgrass plants survived treatment with 1.0 lb a.i./a Kerb in fall 2001, and an alternative explanation for poor control by Kerb could be enhanced microbial degradation brought on through long-term (7 years) prior use of Kerb in this orchardgrass stand.

Table 1. First-year results from bentgrass control study, winter 2002.

Sequence start date[†]	Herbicide Trade name	Rate	Bentgrass status before 2nd application (Mar/Apr 2001) Robust	Alive	Dead	Bentgrass status before 4th application (Nov/Dec 2001) Robust	Alive	Dead	Total number of times each plant treated to present date
		(lb a.i./a)	------------(% of plants in each category)					------------	(applications)
Oct 2000	Roundup	1.5	0	90	10	0	0	100	2.5
Nov 2000	Roundup	1.5	0	60	40	5	0	95	1.75
Oct 2000	Rely	1.0	65	30	5	20	15	65	3
Nov 2000	Rely	1.0	35	65	0	10	0	90	2.25
Oct 2000	Gramoxone Extra	0.625	45	50	5	40	5	55	3.1
Nov 2000	Gramoxone Extra	0.625	10	80	10	40	5	55	2.8
Oct 2000	Fusilade DX	0.375	0	95	5	0	10	90	2.2
Nov 2000	Fusilade DX	0.375	0	65	35	10	15	75	2.2
Oct 2000	Kerb	0.375* ->1*	95	5	0	50	25	25	3.6
Nov 2000	Kerb	0.375* ->1*	80	15	5	40	45	15	3.65
Oct 2000	Select	0.125	0	95	5	5	10	85	2.55
Nov 2000	Select	0.125	0	80	20	20	15	65	2.45
Oct 2000	Raptor	0.039	50	45	5	30	20	50	3.05
Nov 2000	Raptor	0.039	45	45	10	25	25	50	2.95
Oct 2000	Roundup + Fusilade	1.5 + 0.375	0	95	5	0	0	100	1.95
Nov 2000	Roundup + Fusilade	1.5 + 0.375	0	45	55	0	5	95	1.55

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

[†]Early sequence: Oct. 26, 2000; Mar. 20, 2001; June 12, 2001; Nov. 6, 2001. Late sequence: Nov. 17, 2000; Apr. 19, 2001; July 10; Dec. 21, 2001. Treatments only reapplied to plots with live bentgrass present. Bentgrass species included dryland, redtop, colonial, creeping, velvet and unidentified.

WEED SPECIES TRENDS IN OSU SEED CERTIFICATION INSPECTIONS, 1994-2001

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OSU Seed Certification field inspection reports and Seed Laboratory test results represent a largely untapped source of information on the demography of weeds in Oregon's grass seed crops. Access to these databases was granted under the provision that individual grower production data not be identifiable in any public data releases, maps, or summaries. The OSU Seed Certification pre-harvest inspection database was queried to determine the abundance and geographic distribution of grasses, broadleaves, rushes, and sedges. Data for weeds with synonymous names (red fescue and creeping red fescue, jointed goatgrass and goatgrass) or for closely related and potentially identical species (vernalgrass and sweet vernalgrass, foxtail and green foxtail) were pooled. Data from all certified grass seed crops grown in Oregon were included in this summary, while data from all other crops (e.g., clovers and cereals) were excluded.

A total of 59 grassy weeds and 126 broadleaves and other nongrass weeds were found in certified grass seed fields in Oregon during the period from 1994 through 2001 (Table 1). The 47 most common grasses occurred in an average of 0.1% or more of all fields or changed in abundance at a rate of more than 0.01% of fields per year (Table 2). The 47 most common broadleaves and rushes occurred in an average of 0.3% or more of all fields or changed in abundance at a rate of more than 0.03% of fields per year (Table 3). Many weed species were found in only a few fields, and infrequently occurring species omitted from the detailed summaries of Tables 2 and 3 are identified in footnotes to Table 1. Weeds present in more than 1% of all certified grass seed fields included 23 grassy weeds, 15 broadleaves, and one rush. Weeds present in more than 5% of all certified grass seed fields included annual (Italian) ryegrass, wild oats, tall fescue, unspecified bromes, roughstalk bluegrass, cheatgrass (downy brome), annual bluegrass, Canada thistle, and wild cucumber. Most species exhibited large year-to-year fluctuations in prevalence: an average of 5.3 times as many fields were infested in the weediest than the cleanest year for each weed species. Almost half of the grasses (27 out of 59) increased in prevalence over this 8-year period, with roughstalk bluegrass, rattail fescue, canarygrass, cereal rye, and annual bluegrass increasing most rapidly. Over two-thirds of the broadleaves and other species (86 out of 126) increased over the same time period, with Canada thistle and field bindweed increasing most rapidly. Between 85 and 90% of all infestations each year were rated as *trace*, and the frequency of infestations rated as either *many* or *excessive* declined by one-fifth during the 8-year period. Grassy weed infestations were an average of 1.8 times more likely to be rated as *many* and 7.9 times more likely to be rated as *excessive* than broadleaf infestations.

Weeds can be usefully grouped into several categories based on frequency of occurrence in grass seed fields and rate of change of occurrence over the past eight years. The most troublesome group consists of weeds that were already present at moderate to high frequencies (>1% of fields infested) and were also increasing in abundance at moderate to high rates (>0.05% per year). Grasses in this category included roughstalk bluegrass, rattail fescue, canarygrass, annual bluegrass, Kentucky bluegrass, and quackgrass. Broadleaves in this category included Canada thistle, field bindweed, smartweed, sowthistle, wild carrot, prickly lettuce, horsetail rush, mustard, mallow, henbit, and groundsel. Most members of this group of weeds are already well known to the seed industry as serious threats to production.

A second group of interest consists of weeds present at moderate to high, but relatively stable, frequencies. Grasses in this category included wild barley, perennial ryegrass, unspecified bluegrass, velvetgrass, cheatgrass, and bentgrass. Broadleaves in this category included curly dock and wild radish. A third group of interest consists of weeds present at moderate to high, but apparently declining, frequencies. Grasses in this category include meadow foxtail, witchgrass, barnyardgrass, fine fescue, orchardgrass, wheat, wild oats, unspecified bromes, annual ryegrass, German velvetgrass, and tall fescue. Broadleaves in this category include dogfennel, dock, and wild cucumber. Weeds in the second and third categories may have already reached their ecological potential, although the idea that annual ryegrass can't get much worse is probably of little comfort to growers who have fought this weed for decades. If weeds in the third group were to continue declining in frequency of occurrence long enough, they might eventually disappear as major problems in grass seed production. Alternately, their current decline in abundance could be a transitory response to some recent change in land use patterns or weather. In any case, these weeds would require a continuation of current trends for next 10 to 50 years before potentially disappearing from Oregon's grass seed industry.

A fourth group of special interest consists of weeds present at low, but increasing, frequencies. The only grass in this category was cereal rye. Broadleaves in this category included kochia, bracken fern, blackberry, sharppoint fluvellin, ox-eye daisy, shepherdspurse, common lamb's-quarters, prostrate pigweed, bedstraw, and bull thistle. Because of their rapid rates of increase, these weeds may cause serious problems in grass seed production in the near future. Indeed, the one grass and seven of the ten broadleaves in this group were found in 1.2% of all grass seed fields in 2001, in sharp contrast to their average of only 0.4% of fields in 1994. A final group of concern includes weeds that have only recently appeared in Oregon grass seed fields. For these weeds, the 8-year period for trends in frequency of occurrence may understate the risk if the weeds were not introduced until late in that period. One notable species in this category of weeds is *Viola*, first detected in 2000 in a Kentucky bluegrass field in Union County.

A useful next step in analyzing information in the OSU Seed Certification and Seed Testing Laboratory databases will be to examine the spatial and temporal distribution of weed species, and correlate those distributions with factors such as soil type, weather patterns, stand age, planting date, and crop species. Such correlations should lead to the identification of two major types of fields: (1) those whose weed populations closely follow the dominant trends for year, stand age, weather patterns, soil type, crop species, etc., and (2) those whose weeds populations sharply diverge from the dominant trends. Follow-up surveys with growers whose individual fields are significantly weedier or cleaner than average should be useful in identifying the management practices most important in controlling weed populations in grass seed crops. Agronomic practices that are probably important include factors such as herbicide treatment, crop rotation scheme, planting method, harvest technique, and residue management system. Other factors influencing weed populations will likely be identified over time as survey data is accumulated and other sources of information are accessed. Knowledge gained will be useful at many levels, including helping individual growers better manage their own fields and farming systems, helping researchers identify topics deserving added attention, helping the entire industry stay abreast of newly invading species and newly resistant biotypes, and providing public policy decision makers with better information on the benefits to agriculture of many specific practices, including individual herbicide treatments, tillage practices, residue management systems, and crop rotations.

Table 1. OSU Seed Certification database overall summary from 1994 through 2001.

	1994	1995	1996	1997	1998	1999	2000	2001	8-yr trend[c]
# certified grass fields each year	3594	5132	5288	5679	6297	6850	6731	6647	412.7
# weed infestations found	6477	10488	11476	12062	12775	12429	13633	13065	778.7
# grass infestations found	4272	7310	7796	7914	8607	7995	7955	7315	307.3
# other species infestations found	2205	3178	3680	4148	4168	4434	5678	5750	471.4
# all weed species found	131	141	128	139	133	144	160	150	3.214
# grass species found[a]	49	50	47	53	50	53	55	52	0.726
# other species found[b]	81	91	81	86	83	91	102	98	2.393
% of grass infestations rated *excessive*	0.75	0.71	0.45	0.57	0.81	0.85	0.65	0.51	-0.006
% of grass infestations rated *many*	16.03	14.21	13.88	15.54	15.06	15.88	14.20	11.78	-0.289
% of grass infestations rated *trace*	83.22	85.08	85.67	83.89	84.13	83.26	85.14	87.71	0.295
% of other infestations rated *excessive*	0.09	0.03	0.05	0.24	0.07	0.09	0.04	0.05	-0.004
% of other infestations rated *many*	10.16	8.37	7.39	8.39	7.89	8.73	7.93	7.25	-0.227
% of other infestations rated *trace*	89.75	91.60	92.55	91.37	92.03	91.18	92.04	92.70	0.231
% of all infestations rated *excessive*	0.52	0.51	0.32	0.46	0.57	0.58	0.40	0.31	-0.014
% of all infestations rated *many*	14.03	12.44	11.80	13.08	12.72	13.33	11.59	9.79	-0.354
% of all infestations rated *trace*	85.44	87.05	87.88	86.46	86.71	86.09	88.01	89.90	0.368

[a]Uncommon grasses (present in less than 0.1% of fields averaged over years and changing in abundance at a rate of less than 0.01% of fields per year) included in overall summary (Table 1) but omitted from detailed listing (Table 2) included: *Elymus*, Johnsongrass, bulbous bluegrass, *Ventenata*, *Triticale*, rabbitfoot grass, fowl bluegrass, intermediate ryegrass, jointed goatgrass, sloughgrass, bristly dogtail, and silver hairgrass.

[b]Uncommon broadleaves and non-grass monocots (present in less than 0.3% of fields averaged over years and changing in abundance at a rate of less than 0.03% of fields per year) included in overall summary (Table 1) but omitted from detailed listing (Table 3) included: flixweed, wild garlic, speedwell, *Brassica* spp., yellow nutsedge, crimson clover, cocklebur, tumble mustard, wild berry, wild buckwheat, sugar beet, alfalfa, potato, fireweed, common cowparsnip, smooth hawksbeard, black medic, spurry, red deadnettle, tarweed, sweetclover, cutleaf cranesbill, meadowfoam, dogbane, cutleaf geranium, lupine, scotch thistle, milkweed, purple lythrum, marshelder, garlic, nipplewort, willowherb, corn spurry, subterranean clover, peppermint, yellow starthistle, lesser snapdragon, puncturevine, little bittercress, teasel, waterhemlock, common vetch, black mustard, sprenger asparagus, St. Johns chamomile, *Viola*, wild pea, small scorpiongrass, Italian thistle, bachelor button, yellowrocket, hairy nightshade, dodder, alsike clover, annual polemonium, cutleaf nightshade, perennial pepperweed, red clover, Russian knapweed, Virginia groundcherry, chicory, yarrow, marestail, field pepperweed, hedge mustard, whitetop, buttercup, perennial sowthistle, blue mustard, buckhorn plantain, black nightshade, common purslane, bur beakchervil, toad rush, mouse-ear chickweed, rush, field pennycress, and tansy ragwort.

[c]Trend is the slope of linear regression versus time in years from 1994 through 2001.

Table 2. OSU Seed Certification database selected grass weeds from 1994 through 2001.

Common grassy weeds	1994	1995	1996	1997	1998	1999	2000	2001	8-yr mean	8-yr trend
	-----(% of all certified grass seed fields infested at any level with specific weeds) ----									
Rough bluegrass	4.98	5.71	7.94	6.06	6.70	8.80	7.03	5.25	6.56	0.1393
Rattail fescue	3.20	3.25	3.61	4.56	3.45	3.52	4.31	3.97	3.73	0.1105
Canarygrass	1.42	1.52	1.53	2.73	2.37	2.44	2.12	1.91	2.00	0.1050
Cereal rye	0.45	0.70	0.66	0.99	0.92	0.79	1.40	1.07	0.87	0.0970
Annual bluegrass	3.37	5.11	7.11	5.62	6.19	6.58	5.32	4.36	5.46	0.0838
Kentucky bluegrass	0.67	1.83	1.80	1.46	1.10	1.97	1.89	1.47	1.52	0.0724
Colonial bentgrass	0.14	0.14	0.28	0.32	0.71	0.28	0.48	0.44	0.35	0.0495
Quackgrass	3.09	4.23	3.76	3.89	3.54	3.17	3.86	4.24	3.72	0.0490
Wild barley	1.42	1.99	1.76	1.04	1.11	0.96	1.72	2.23	1.53	0.0240
Perennial ryegrass	0.83	1.31	1.38	1.58	1.10	0.99	1.25	1.40	1.23	0.0239
Wheatgrass	0.00	0.10	0.09	0.07	0.06	0.03	0.21	0.12	0.09	0.0142
Soft chess	0.03	0.02	0.06	0.19	0.03	0.12	0.01	0.20	0.08	0.0139
Red fescue	0.08	0.12	0.85	0.05	0.16	0.34	0.22	0.32	0.27	0.0085
Large crabgrass	0.03	0.29	0.06	0.44	0.16	0.34	0.07	0.20	0.20	0.0076
Slender foxtail	0.00	0.00	0.00	0.30	0.52	0.13	0.00	0.00	0.12	0.0074
Alkaligrass	0.03	0.16	0.17	0.21	0.14	0.19	0.12	0.08	0.14	0.0016
Redtop	0.14	0.10	0.00	0.18	0.16	0.10	0.07	0.12	0.11	0.0005
Hairgrass	0.06	0.06	0.23	0.35	0.11	0.04	0.16	0.09	0.14	-0.0003
Tall oatgrass	0.11	0.10	0.19	0.07	0.03	0.07	0.13	0.12	0.10	-0.0017
Bluegrass	1.11	0.99	1.66	1.92	3.06	1.14	1.20	0.99	1.51	-0.0027
Squirreltail	0.11	0.10	0.04	0.35	0.05	0.09	0.10	0.08	0.11	-0.0045
Velvetgrass	2.23	2.86	1.95	5.53	3.75	2.16	2.44	2.62	2.94	-0.0064
Cheatgrass (downy brome)	4.67	6.88	7.36	6.16	5.96	5.47	6.02	6.05	6.07	-0.0065
Canada bluegrass	0.17	0.21	0.09	0.04	0.16	0.15	0.13	0.09	0.13	-0.0079
Vernalgrass	0.11	0.08	0.06	0.04	0.03	0.03	0.03	0.02	0.05	-0.0119
Barley	0.19	0.21	0.26	0.16	0.08	0.04	0.33	0.06	0.17	-0.0134
Medusahead rye	0.17	0.78	0.47	0.55	0.25	0.41	0.52	0.23	0.42	-0.0163
Mannagrass	0.11	0.43	0.15	0.05	0.08	0.07	0.22	0.08	0.15	-0.0177
Oat	0.53	0.66	0.30	0.41	0.75	0.34	0.36	0.47	0.48	-0.0182
Foxtail	0.19	0.39	0.40	0.14	0.17	0.07	0.27	0.14	0.22	-0.0234
Timothy	0.33	0.14	0.64	0.28	0.21	0.16	0.24	0.09	0.26	-0.0324
Spike bentgrass	0.14	0.55	0.32	0.46	0.24	0.07	0.12	0.12	0.25	-0.0385
Water foxtail	0.64	0.99	1.00	0.72	1.02	0.60	0.89	0.36	0.78	-0.0402
Bentgrass	0.89	3.78	6.11	4.47	4.32	3.77	2.91	2.03	3.54	-0.0421
Saltgrass	0.53	0.29	0.00	0.04	0.00	0.01	0.19	0.00	0.13	-0.0499
Meadow foxtail	1.17	1.33	2.17	1.64	1.18	1.23	0.79	1.02	1.31	-0.0835
Witchgrass	2.00	1.09	0.62	1.41	0.78	0.83	1.07	1.01	1.10	-0.0843
Windgrass	0.70	1.54	1.30	1.06	0.65	0.74	0.68	0.44	0.89	-0.0974
Barnyardgrass	0.95	1.73	1.46	3.28	1.43	0.76	0.85	0.89	1.42	-0.1046
Fine fescue	1.03	1.91	1.59	2.69	1.24	0.93	0.94	0.84	1.40	-0.1142
Orchardgrass	5.98	5.34	2.72	4.09	4.29	2.69	3.95	4.95	4.25	-0.1675
Wheat	4.98	3.88	3.46	3.19	3.11	3.28	3.21	3.13	3.53	-0.2012
Wild oat	13.11	11.46	11.80	11.22	11.02	7.07	10.62	11.24	10.94	-0.3767
Brome	6.43	9.63	9.68	9.05	7.77	6.44	5.08	6.05	7.51	-0.4333
Annual ryegrass	32.55	39.42	41.74	37.00	41.83	37.27	34.87	30.48	36.89	-0.5457
German velvetgrass	4.95	4.58	7.72	4.72	4.11	3.64	2.32	1.52	4.19	-0.5737
Tall fescue	12.72	14.26	10.53	8.31	10.42	6.13	7.04	7.21	9.58	-1.0211

Table 3. OSU Seed Certification database selected broadleaves and other non-grasses from 1994 through 2001.

Common grassy weeds	1994	1995	1996	1997	1998	1999	2000	2001	8-yr mean	8-yr trend
	-----(% of all certified grass seed fields infested at any level with specific weeds) ----									
Canada thistle	8.18	8.55	9.08	9.17	9.66	7.93	12.24	13.69	9.81	0.6433
Field bindweed	2.98	3.14	3.65	4.16	3.06	4.20	6.28	7.45	4.37	0.5666
Smartweed	1.98	1.23	2.52	3.93	3.60	2.60	4.37	2.63	2.86	0.2408
Sowthistle	1.36	0.86	1.46	1.62	2.29	1.08	2.90	2.57	1.77	0.2167
Kochia	0.28	0.53	0.26	0.42	0.14	1.27	1.41	1.52	0.73	0.1887
Wild carrot	2.39	1.71	2.16	2.10	3.78	1.49	3.73	2.93	2.54	0.1612
Prickly lettuce	2.20	2.71	3.08	2.24	2.70	2.42	3.54	3.75	2.83	0.1602
Bracken fern	0.00	0.00	0.00	0.00	0.81	0.61	0.74	0.71	0.36	0.1347
Horsetail rush	0.64	0.41	0.51	1.22	1.83	1.07	1.28	1.29	1.03	0.1333
Blackberry	0.00	0.00	0.00	0.00	0.00	0.00	0.49	1.05	0.19	0.1169
Mustard	1.73	2.01	2.48	2.48	1.91	2.74	3.00	2.35	2.34	0.1137
Sharppoint fluvellin	0.14	0.06	0.13	0.25	0.16	0.26	0.51	1.04	0.32	0.1051
Ox-eye daisy	0.06	0.02	0.02	1.99	0.14	0.67	0.76	0.74	0.55	0.1021
Mallow	1.03	1.38	1.34	0.92	1.08	0.93	2.01	1.81	1.31	0.0891
Shepherdspurse	0.53	0.47	1.55	0.85	0.57	1.46	1.10	1.22	0.97	0.0886
Henbit	0.86	1.44	1.55	1.14	0.84	1.82	1.26	1.84	1.35	0.0766
Common lamb's-quarters	0.53	0.74	0.74	0.97	0.30	0.64	0.80	1.50	0.78	0.0737
Prostrate pigweed	0.00	0.16	0.04	0.44	0.40	0.77	0.46	0.30	0.32	0.0690
Bedstraw	0.72	0.70	0.98	0.77	1.24	0.92	1.20	1.13	0.96	0.0669
Groundsel	5.43	4.15	5.52	3.31	2.73	3.27	4.44	7.03	4.48	0.0634
Bull thistle	0.61	0.64	0.96	0.92	1.29	0.61	1.03	1.16	0.90	0.0601
Nightshade	0.33	0.21	0.13	0.60	0.46	0.50	0.49	0.56	0.41	0.0463
Prostrate knotweed	0.36	0.45	0.53	0.72	0.35	0.80	0.92	0.51	0.58	0.0460
Hairy hawksbeard	0.25	0.16	0.19	0.28	0.35	0.45	0.45	0.41	0.32	0.0404
Western yellowcress	0.08	0.99	0.72	0.76	0.35	1.45	0.59	0.57	0.69	0.0380
Broadleaf plantain	0.08	0.18	0.19	0.26	0.17	0.19	0.49	0.32	0.24	0.0371
Curly dock	1.22	0.70	0.78	1.07	1.86	0.82	1.26	1.13	1.11	0.0363
Russian thistle	0.39	0.49	0.64	0.51	0.30	0.73	0.55	0.71	0.54	0.0308
Redstem filaree	0.06	0.37	0.30	0.35	0.30	0.35	0.53	0.29	0.32	0.0301
Vetch	0.50	0.74	0.76	0.88	0.92	0.61	0.77	0.74	0.74	0.0170
Wild radish	1.45	1.56	1.89	2.11	1.86	1.30	1.63	1.85	1.71	0.0139
Redroot pigweed	1.00	1.01	0.66	1.69	0.73	0.53	0.71	1.46	0.97	0.0040
Salsify	0.28	0.43	0.30	0.11	0.24	0.35	0.40	0.30	0.30	0.0035
Pineappleweed	0.64	0.60	1.53	0.99	0.48	0.99	0.73	0.77	0.84	-0.0073
St. Johnswort	0.89	0.66	0.74	0.72	0.68	0.53	0.76	0.83	0.73	-0.0076
Dandelion	0.70	0.90	1.17	0.88	0.70	0.92	0.58	0.93	0.85	-0.0103
Lowland cudweed	0.75	0.41	0.95	0.90	0.24	0.41	1.08	0.47	0.65	-0.0106
Common mullein	1.14	0.74	1.21	0.76	0.73	0.73	0.98	1.02	0.91	-0.0130
Fiddleneck	0.45	0.35	0.17	0.23	0.30	0.44	0.28	0.21	0.30	-0.0132
Common chickweed	0.58	0.27	0.59	0.23	0.21	0.28	0.48	0.36	0.37	-0.0178
Spotted cat's-ear	0.92	0.51	0.49	0.95	0.41	0.19	0.58	0.66	0.59	-0.0342
Sheep sorrel	0.56	0.49	0.34	0.32	0.22	0.22	0.49	0.14	0.35	-0.0404
White clover	0.50	0.82	0.25	0.42	0.41	0.12	0.43	0.11	0.38	-0.0608
Dogfennel	3.62	3.74	5.39	4.00	3.35	4.45	3.70	2.95	3.90	-0.0994
Dock	1.81	2.03	2.25	3.05	2.18	1.09	1.46	1.04	1.86	-0.1498
Marguerite	0.95	1.11	0.38	0.30	0.06	0.07	0.01	0.05	0.37	-0.1540
Wild cucumber	6.34	6.49	4.71	6.69	5.94	5.34	4.92	4.47	5.61	-0.2361

CLOVER BROOMRAPE MANAGEMENT WITH FUMIGATION AND HERBICIDES

J.B. Colquhoun and C.A. Mallory-Smith

Introduction

Clover broomrape (*Orobanche minor*) is a parasitic plant that attaches to and draws water and nutrients from several plant species, including red clover. Clover broomrape is a federally listed noxious weed that has quarantine significance to many of Oregon's trading partners. Since 1923, there have been six reports of clover broomrape in Oregon. In 1998, clover broomrape was identified in a single field. In 2000 and 2001, clover broomrape was found in 15 and 22 fields, respectively.

Clover broomrape is an obligate parasite (the presence of a host plant species is required – clover broomrape will not survive on its own) that lacks chlorophyll. It reproduces and spreads only by seed. One broomrape plant produces up to 500,000 dust-like seeds that may be dispersed by wind, machinery, contaminated seed crops, animals, or clothing. Flowering plants that are hand-pulled may still mature and produce viable seed. Seed can remain dormant in the soil for 10 years or more. After germination, clover broomrape attaches to and penetrates the root of the host plant, disrupting nutrient and water transport in the host root system. Parasitism by clover broomrape can reduce host crop yield, and, in heavy infestations, may kill the host plant.

While host parasitism in Oregon is currently limited to red clover, greenhouse studies have identified several other weed and crop species that are clover broomrape hosts. Clover broomrape germinated and attached to nasturtium, red clover, arrowleaf clover, subterranean clover, white clover, alfalfa, sweet pea, lettuce, snap bean, sunflower, celery, and carrot. Weedy host species included spotted catsear (also known as false dandelion, *Hypochaeris radicata*), wild carrot (*Daucus carota*), and prickly lettuce (*Lactuca serriola*).

Methods

Fumigation and herbicide trials were chemical fallowed to remove volunteer red clover and heavy infestations of dog fennel, then plowed, disced, and harrowed. The fumigation trial was arranged in a randomized complete block with 6 replications of plots that measured 8 by 100 ft. Metam sodium (Vapam) was applied, rotovated, and rolled for thorough incorporation and sealing of the soil surface. Red clover was planted four weeks after metam sodium application. Fumigated plots were evaluated for control of clover broomrape and red clover crop vigor.

Herbicide trial plots measured 8 by 50 ft and were arranged in a randomized complete block with 4 replications. Herbicides were applied with a CO_2 backpack sprayer delivering 20 gallons of water per acre. Treatments were evaluated for red clover injury and clover broomrape control. Clover broomrape control was quantified by counting the number of emerged clover broomrape plants prior to herbicide treatment and 2 and 4 weeks after treatment. Clover broomrape control was calculated as the number of clover broomrape plants present 4 weeks after herbicide application divided by the number of clover broomrape plants present prior to herbicide application. Therefore, evaluations less than 1.0 indicated that there were fewer emerged clover broomrape plants present after herbicide application. Additionally, broomrape control was calculated as the number of emerged plants 4 weeks after treatment in herbicide treatments divided by the number of emerged plants in the untreated check.

Results

Red clover injury from metam sodium was significantly greater than the untreated check in all spring fumigation treatments (Table 1). The use of metam sodium presents a production constraint for red clover; by the time that the fumigant has sufficiently dissipated from the soil to prevent red clover injury, there is little soil moisture available to establish a red clover crop. Fall fumigation may alleviate this constraint. However, clover broomrape attached to red clover and produced seed in the 75 gallon per acre treatment, thus preliminary results indicated that metam sodium is not effective for control of clover broomrape. Additionally, product costs were high and prohibitive to profitable red clover seed production.

Imazamox (Raptor) reduced the number of emerged broomrape plants by about 50% (Table 2). The number of emerged broomrape plants after herbicide application was similar to the untreated check in all other treatments. When compared to the untreated check, imazamox reduced the number of emerged broomrape plants by 96%. Red clover injury was greater than the untreated check where glyphosate was applied at the highest rate. Injury from all other herbicide treatments was minimal and similar to the untreated check.

Table 1. Visual estimation of red clover vigor, presence of emerged clover broomrape, and product cost per acre in response to metam sodium fumigation.

Treatment	Red clover vigor	Clover broomrape emergence	Metam sodium cost
(gal/a)	(%)		($/acre)
0	87.5 a[1]	Yes	0
50	56.7 b	No	190.00
75	55.9 b	Yes	285.00
100	46.7 b	No	380.00
LSD 0.05	22.5		

[1]Means followed by the same letter are not significantly different ($p = 0.05$).

Table 2. Visual evaluation of red clover injury, fraction of broomrape emergence after treatment as compared to before treatment, and fraction of untreated check as evaluated 4 weeks after herbicide application.

Treatment	Rate	Red clover injury	Broomrape emergence[2]	Fraction of un-treated check[3]
	(lb a.i./a)	(%)		
Pendimethalin	2.48	0.0 b[1]	2.7 ab	0.27 bc
Imazethapyr	0.09	20.0 b	2.6 ab	0.26 bc
Pyridate	0.94	0.0 b	5.5 ab	0.31 bc
Bentazon	1.0	0.0 b	7.0 a	0.56 ab
Imazamox	0.04	16.7 b	0.5 b	0.04 c
Glyphosate	0.05	8.3 b	1.3 ab	0.16 bc
Glyphosate	0.09	15.0 b	1.5 ab	0.13 bc
Glyphosate	0.18	51.7 a	0.8 ab	0.17 bc
Check	--	0.0 b	3.3 ab	1.0 a
LSD 0.05		23	6.4	0.5

[1]Means followed by the same letter are not significantly different (p = 0.05).
[2]The number of broomrape emerged 4 weeks after treatment divided by the number of broomrape emerged prior to herbicide treatment.
[3]The number of emerged broomrape plants in herbicide treatment divided by the number of emerged broomrape plants in the untreated check 4 weeks after treatment.

EVALUATION OF HERBICIDES FOR CONTROL OF CHEATGRASS, VOLUNTEER PERENNIAL RYEGRASS AND ESTABLISHED ROUGH BLUEGRASS IN CENTRAL OREGON, 2000-2001

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

Cheatgrass (downy brome) control in Kentucky bluegrass is a major concern to the grass seed industry in central Oregon. Contaminated seed lots must either be re-cleaned at a significant cost to the grower or remain largely unmarketable. The objective of this project was to evaluate herbicide treatments on a commercial Kentucky bluegrass field, a perennial ryegrass field and two rough bluegrass fields. The new product, Axiom, was of particular interest in combination with current products in use.

Plots were replicated four times in a randomized complete block design in a commercial Kentucky bluegrass (cultivar 'Geronimo') seed field north of Madras, in a commercial perennial ryegrass (cultivar 'SH-2') field between Metolius and Culver, and two commercial rough bluegrass (cultivars 'Laser' and 'Saber II') fields west and north of Madras. Each plot received two herbicide applications. Treatments were applied to Kentucky bluegrass plots on September 25 and November 16, to the perennial 'SH-2' ryegrass and 'Saber II' rough bluegrass on September 26 and November 16, and to the 'Laser' rough bluegrass on October 18 and November 16, 2000. A non-ionic surfactant was applied in combination with all treatments at 1 qt/100 gal. Treatments were made to 10 ft x 20 ft plots with a CO_2 pressurized, hand-held boom sprayer at 40 psi and 20 gal/acre water. Plots were evaluated March 9, 2001 for control of cheatgrass, volunteer perennial ryegrass and established rough bluegrass, as appropriate for each location. Kentucky bluegrass plots were evaluated for crop injury, perennial ryegrass plots were evaluated for injury to established plants and control of seedling volunteers, and rough bluegrass was evaluated for control of established plants ('Laser') and cheatgrass control ('Saber II').

There was no observable injury to either established Kentucky bluegrass or established perennial ryegrass. However, treatments that included Axiom provided 100 percent control of volunteer rough bluegrass (*Poa trivialis*), between 90 and 100 percent control of established rough bluegrass and 97 to 98 percent control of volunteer perennial ryegrass. The follow up treatments applied November 16 that included Goal plus Sinbar generally provided better control than Goal plus Diuron. Treatments that included Axiom in the first application did not gain efficacy by adding Prowl to the follow up application.

Table 1. Control of cheatgrass in 'Saber II' rough bluegrass and control of volunteer perennial ryegrass seedlings in established perennial ryegrass near Madras, Oregon 2000-2001.

Treatment		Product/acre		Percent control	
Sept 26	Nov 16	Sept 26	Nov 16	Cheatgrass	Vol. Ryegrass
Axiom + Goal	Goal + Diuron	11 oz 8 oz	1.0 pt 1.0 lb	70 ab[1]	98 a
Axiom + Goal	Goal + Sinbar	11 oz 8 oz	1.0 pt 0.3 lb	70 ab	97 a
Axiom + Goal	Goal + Diuron + Sinbar	11 oz 8 oz	1.0 pt 1.0 lb 0.3 lb	70 ab	98 a
Axiom + Goal + Prowl	Goal + Diuron	11 oz 8 oz 5 pt	1.0 pt 1.0 lb	60 ab	98 a
Axiom + Goal + Prowl	Goal + Sinbar	11 oz 8 oz 5 pt	1.0 pt 0.3 lb	76 a	98 a
Axiom + Goal + Prowl	Goal + Diuron + Sinbar	11 oz 8 oz 5 pt	1.0 pt 1.0 lb 0.3 lb	70 ab	97 a
Goal + Prowl	Goal + Diuron	8 oz 5 pt	1.0 pt 1.0 lb	40 c	73 c
Goal + Prowl	Goal + Sinbar	8 oz 5 pt	1.0 pt 0.3 lb	53 b	85 b
Goal + Prowl	Goal + Diuron + Sinbar	8 oz 5 pt	1.0 pt 1.0 lb 0.3 lb	56 b	88 ab
Beacon	Goal + Diuron	0.75 oz	1.0 pt 1.0 lb	60 ab	53 d
Beacon	Goal + Sinbar	0.75 oz	1.0 pt 0.3 lb	66 ab	53 d
Beacon	Goal + Diuron + Sinbar	0.75 oz	1.0 pt 1.0 lb 0.3 lb	66 ab	78 c
Untreated	----	----	----	0 d	0 e

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

Table 2. Control of established 'Laser' rough bluegrass near Madras, Oregon 2000-2001.

Treatment		Product/acre		Percent control
Oct 18	Nov 16	Oct 18	Nov 16	Rough Bluegrass
Axiom + Goal	Goal + Diuron	11.0 oz 4.0 oz	1.0 pt 2.0 lb	90 a[1]
Axiom + Goal	Goal + Sinbar	11.0 oz 4.0 oz	1.0 pt 0.75 lb	97 a
Axiom + Goal	Goal + Diuron + Sinbar	11.0 oz 4.0 oz	1.0 pt 2.0 lb 0.75 lb	99 a
Axiom + Goal + Prowl	Goal + Diuron	11.0 oz 4.0 oz 5.0 pt	1.0 pt 2.0 lb	93 a
Axiom + Goal + Prowl	Goal + Sinbar	11.0 oz 4.0 oz 5.0 pt	1.0 pt 0.75 lb	100 a
Axiom + Goal + Prowl	Goal + Diuron + Sinbar	11.0 oz 4.0 oz 5.0 pt	1.0 pt 2.0 lb 0.75 lb	98 a
Goal + Prowl	Goal + Diuron	4.0 oz 5.0 pt	1.0 pt 2.0 lb	60 b
Goal + Prowl	Goal + Sinbar	4.0 oz 5.0 pt	1.0 pt 0.75 lb	86 a
Goal + Prowl	Goal + Diuron + Sinbar	4.0 oz 5.0 pt	1.0 pt 2.0 lb 0.75 lb	96 a
Beacon	Goal + Diuron	0.75 oz	1.0 pt 2.0 lb	91 a
Beacon	Goal + Sinbar	0.75 oz	1.0 pt 0.75 lb	93 a
Beacon	Goal + Diuron + Sinbar	0.75 oz	1.0 pt 2.0 lb 0.75 lb	91 a
Untreated	---	---	---	0 c

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

EVALUATION OF MILESTONE FOR CROP TOLERANCE ON KENTUCKY BLUEGRASS AND ROUGH BLUEGRASS IN CENTRAL OREGON, 2000-2001

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

Grass seed growers in central Oregon are using banded spraying between rows to control weeds and seedlings. However, this leaves in-row seedlings and weeds that remain untreated. The objective of this trial was to evaluate Milestone as a banded spray between planted rows of Kentucky bluegrass and rough bluegrass in combination with low rates broadcast over the top to provide potential control of in-row seedlings and weeds.

Plots were placed in a commercial Kentucky bluegrass ('Merit') field and two commercial rough bluegrass ('Laser' and 'Saber') fields near Madras, Oregon. Plots were replicated three times in a split-block design, with the broadcast application as the main plots. Broadcast rates of Milestone were 1 oz/a, 2 oz/a, and 4 oz/a. Sub-plots were banded with Milestone at 4 oz/a, 8 oz/a and banded at 5.25 oz/a and 10.5 oz/a on the rough bluegrass locations.

Broadcast treatments were applied to 10 ft x 30 ft plots with a CO_2 pressurized, hand-held boom sprayer at 40 psi and 20 gal/acre water. Banded applications were applied with an experimental push-type shielded sprayer to 10 ft x 10 ft plots. Treatments were applied to the Kentucky bluegrass plots October 6 and to the rough bluegrass plots October 13, 2000. Plots were evaluated for percent between row seedling control and percent stand reduction on April 3 for the Kentucky bluegrass, April 5 for the 'Laser' rough bluegrass and April 6 for the 'Saber' rough bluegrass.

Milestone applied broadcast alone significantly reduced stand for all treatments compared to untreated plots (Table 1), except Kentucky bluegrass at 1 oz/a. Kentucky bluegrass ('Merit') shows greater tolerance to Milestone applied broadcast than rough bluegrass ('Laser' and 'Saber'), with 3 percent rather than 30 percent stand reduction at 1 oz/a, 33 percent compared to 67 or 73 percent at 2 oz/a, and 72 percent rather than 97 or 98 at 4 oz/a.

Seedling control was greater for rough bluegrass than Kentucky bluegrass. Milestone broadcast at 1 oz/a reduced Kentucky bluegrass seedlings by 17 percent, without a banded application. All other treatments were unacceptable, with stands of either Kentucky or rough bluegrass reduced between 50 and 100 percent. No seedlings were present in the 'Saber' rough bluegrass plots.

There appeared to be an effect on crop stands by banded application of Milestone alone, as indicated by the reduced stands observed in plots without a broadcast application. The crop stands in these plots were consistently reduced as banded application rates increased. This may have been the result of the product movement into the root zone, or increased Milestone concentrated at the base of the shields near the seed line.

The potential use of Milestone for row spraying appears greater for Kentucky bluegrass than rough bluegrass. However, lower rates will need to be evaluated to determine if adequate crop safety can be achieved.

Table 1 Evaluation of Milestone for crop tolerance on Kentucky bluegrass ('Merit') and Rough bluegrass ('Laser' and 'Saber') in three commercial fields near Madras, OR, 2001.

Treatment		Stand reduction			Seedling control	
Broadcast	Banded	'Merit'	'Laser'	'Saber'	'Merit'	'Laser'
----- (Product/acre) -----		----- (%) -----			----- (%) -----	
4 oz	8 or 10.5 oz	91 a[1]	100 a	100 a	98 a	100 a
4 oz	4 or 5.25 oz	75 ab	100 a	100 a	95 a	100 a
4 oz	Untreated	2 ab	97 a	98 a	78 a	92 a
2 oz	8 or 10.5 oz	70 ab	99 a	100 a	90 a	100 a
2 oz	4 or 5.25 oz	40 c	94 a	100 a	85 a	99 a
2 oz	Untreated	33 cd	67 b	73 a	50 b	70 b
1 oz	8 or 10.5 oz	47 bc	97 a	100 a	88 a	100 a
1 oz	4 or 5.25 oz	7 d	85 ab	8 a	77 a	98 a
1 oz	Untreated	3 d	30 c	30 b	17 c	53 c
Untreated	8 or 10.5 oz	33 cd	80 ab	100 a	80 a	100 a
Untreated	4 or 5.25 oz	0 d	37 c	88 a	73 a	98 a
Untreated	Untreated	0 d	0 d	0 c	0 c	0 d

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

EVALUATION OF POSTEMERGENCE HERBICIDES ON EIGHT NATIVE GRASS SPECIES GROWN FOR SEED IN CENTRAL OREGON, 2000-2001

M.D. Butler, P.J. Sexton, C.K. Campbell and R.R. Bafus

The demand for seed of native grasses used to reseed burned or otherwise disturbed rangelands continues to increase. Because agricultural production of native grasses is relatively new, management practices are still in the process of being determined. One of the major factors for successful production is adequate weed control. The objective of this project is to evaluate the crop safety of potential herbicides that may be used in native grass seed production.

On April 20, 2000 big bluegrass, bluebunch wheatgrass, squirreltail, great basin wildrye, streambank wheatgrass, and Idaho fescue were planted at a rate of 45 seeds per foot. Indian ricegrass was planted at a rate of 90 seeds per foot and prairie junegrass was planted at 135 seeds per foot. A four-row small-plot cone planter (Almaco Inc.) was used with a planting depth of 0.25 inches. Plots were single rows 80 feet long with 2-foot row spacing. Plots were irrigated as needed to keep the seed zone moist for two weeks following planting. Weeds were controlled by hoeing and cultivation, with no herbicides applied prior to plot treatment.

Most herbicides were applied at both 1x and 2x rates. Application timing included fall-applied herbicides on October 18 and herbicides applied during dormancy on November 3, 2000. Treatments were applied with a CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal/a water in 9-foot bands perpendicular to the grass rows. A non-ionic surfactant was added at 0.5 percent v/v to the November 3 application of Maverick only.

Evaluations were conducted using a rating scale from 0 (no negative effect) to 5 (maximum negative effect). Plots were evaluated for stunting, chlorosis, and mortality on March 27 and 28, 2001. Reduced heading was evaluated June 16-19, and stand reduction was evaluated November 2, 2001. Data were analyzed as a randomized complete block design, and no comparisons were made between grasses.

Table 1 is a summary of the results for herbicide treatments across the eight native grass species for both stand reduction and reduced heading. Less than 10 percent damage is indicated with a "+", over 50 percent damage is shown with a "-", while 10 to 50 percent damage received a 0. Separate numerical ratings for the effect of herbicide treatments on reducing heading and stand reduction are provided in Table 2 and Table 3.

Treatments that caused the most damage across grass species were Roundup at 1.5 pt/a applied during dormancy, and 2x fall-applied treatments of Sinbar at 1.5 lb/a and Kerb at 0.8 lb/a. The safest herbicides at the 2x rate across grass species were Frontier at 64 fl oz/a, Goal at 20 oz/a and Surflan at 6 qt/a. Other 2x herbicide treatments that were relatively safe include Axiom at 22 oz/a, Beacon at 1.52 oz/a, Maverick at 1.34 oz/a and Milestone at 4 oz/a.

Stand reduction following herbicide treatments was the greatest for Indian ricegrass and great basin wildrye, followed by squirreltail, prairie junegrass and Idaho fescue. Stands were least affected by herbicide treatments for streambank wheatgrass and big bluegrass.

Grass species where heading was least effected following herbicide treatments were bluebunch wheatgrass, great basin wildrye and streambank wheatgrass. Grass species where there was the greatest reduction on heading following herbicide treatments were Idaho fescue, prairie junegrass and squirreltail. It is interesting to note that herbicide treatments on these three species generally had little effect on stand reduction but then caused a strong reduction in heading.

An expanded report in the Central Oregon Agricultural Research Center 2001 Annual Report includes additional Tables 4 to 11 that provide results by grass species for stunting, chlorosis, mortality, stand reduction and reduced heading following each of the herbicide treatments.

Table 1. Summary of herbicide effect on reduced heading (RH) evaluated June 16-19 and stand reduction (SR) evaluated November 2 across native grass species, 2001.

			Great basin wildrye		Bluebunch wheatgrass		Streambank wheatgrass		Big bluegrass		Idaho fescue		Indian ricegrass		Squirreltail		Prairie junegrass	
Treatment	Product Rate/acre	Timing	SR	RH	SR	RH	SR	RH	SR	RH	SR	RH	SR	RH	SR	RH	SR	RH
Axiom	11 oz	fall	0[1]	0	+	+	+	0	+	–	+	0	0	0	+	+	+	–
Axiom	22 oz	fall	+	+	+	0	+	0	+	–	+	–	+	0	0	+	0	–
Beacon	0.76 oz	fall	0	+	+	+	0	0	+	+	+	0	+	0	+	0	+	0
Beacon	1.52 oz	fall	+	0	0	+	+	0	+	+	+	0	+	0	+	–	0	–
Clarity	4 pt	fall	0	0	+	0	0	0	+	0	0	–	0	0	0	–	0	–
Clarity	8 pt	fall	0	–	0	–	+	–	+	0	0	–	0	–	0	–	+	–
Diuron	1.8 lb	fall	+	+	0	+	+	+	+	0	+	0	0	0	+	0	0	–
Diuron	3.6 lb	fall	0	0	0	–	0	0	+	–	0	–	0	0	–	–	0	–
Frontier	32 fl oz	fall	0	0	+	+	+	+	+	0	0	0	–	0	+	+	+	0
Frontier	64 fl oz	fall	+	+	+	+	+	+	+	+	+	–	+	+	+	+	+	0
Goal	10 fl oz	fall	+	+	+	+	+	+	+	+	+	0	0	+	+	0	0	+
Goal	20 fl oz	fall	0	+	+	+	+	+	+	+	+	0	0	0	+	–	+	0
Kerb	0.4 lb	fall	0	–	0	–	+	0	0	–	0	–	0	0	–	–	+	–
Kerb	0.8 lb	fall	–	–	–	–	+	–	–	–	–	–	0	0	–	–	–	–
Maverick	0.67 oz	fall	0	+	+	+	+	+	+	+	0	–	0	0	0	0	+	0
Maverick	1.34 oz	fall	0	0	+	+	+	0	+	0	0	–	0	0	+	+	+	–
Maverick	0.67 oz	dormant	0	0	+	+	+	0	+	0	0	–	0	0	+	–	0	–
Milestone	2 oz	dormant	+	+	0	+	+	+	+	+	+	0	0	0	+	–	+	+
Milestone	4 oz	dormant	0	+	+	+	+	+	+	0	0	0	0	0	+	+	0	0
Rely	3 pt	dormant	+	+	0	0	+	+	+	0	+	0	0	0	+	–	+	0
Roundup	1.5 pt	dormant	0	–	–	–	–	–	–	–	–	–	0	–	–	–	–	–
Sencor	0.4 lb	fall	0	0	+	+	+	+	+	0	+	0	+	0	0	0	0	+
Sencor	0.8 lb	fall	0	+	+	+	0	0	–	–	0	–	0	0	0	0	0	–
Sinbar	0.75 lb	fall	+	0	+	0	+	0	0	0	+	0	+	0	–	–	0	0
Sinbar	1.5 lb	fall	–	–	–	–	–	–	–	–	–	–	+	0	–	–	–	–
Surflan	3 qt	fall	0	+	+	+	+	+	+	+	+	0	0	0	+	+	+	0
Surflan	6 qt	fall	+	+	0	+	+	+	+	+	0	0	0	+	0	+	+	0
Control	---	----	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

[1] Symbol key: "+" = damage < 10% damage , "0" = damage 10-50%, "–" = > 50% damage

Table 2. Effect of herbicide treatments on reduced heading of native grass species evaluated June 16-19, 2001.

Treatment	Product rate/acre	Timing	Great basin wildrye	Bluebunch wheatgrass	Streambank wheatgrass	Big bluegrass	Idaho fescue	Indian ricegrass	Squirreltail	Prairie junegrass
Axiom	11 oz	fall	0.5[1] a[2]	0.3 a	0.6 ab	2.7 c	1.7 cdef	1.1	0.0	2.5 bcd
Axiom	22 oz	fall	0.0 a	0.7 a	1.1 ab	4.0 d	2.7 fgh	1.3	0.3	4.0 de
Beacon	0.76 oz	fall	0.0 a	0.2 a	1.0 ab	0.2 a	1.2 bcde	0.8	0.9	1.7 abc
Beacon	1.52 oz	fall	0.8 ab	0.3 a	1.7 bc	0.2 a	2.0 def	1.7	5.0	4.0 de
Clarity	4 pt	fall	1.5 ab	2.0 b	2.4 cd	1.0 a	3.5 ghi	2.2	5.0	2.7 cde
Clarity	8 pt	fall	2.6 ab	3.0 c	2.6 cd	0.7 a	3.5 ghi	2.8	4.1	3.0 cde
Diuron	1.8 lb	fall	0.0 a	0.2 a	0.3 ab	0.5 a	1.0 abcd	0.6	1.9	4.3 e
Diuron	3.6 lb	fall	1.5 ab	3.0 c	1.0 ab	2.5 bc	2.5 efg	2.4	5.0	5.0 e
Frontier	32 fl oz	fall	0.8 ab	0.0 a	0.3 ab	0.5 a	1.7 cdef	1.9	0.0	2.0 abc
Frontier	64 fl oz	fall	0.3 a	0.3 a	0.2 a	0.2 a	3.5 ghi	0.2	0.0	2.0 abc
Goal	10 fl oz	fall	0.0 a	0.2 a	0.0 a	0.0 a	0.7 abcd	0.0	1.9	0.0 a
Goal	20 fl oz	fall	0.4 a	0.0 a	0.4 ab	0.0 a	1.0 abcd	0.6	3.4	0.5 ab
Kerb	0.4 lb	fall	2.7 ab	3.4 c	2.3 cd	4.5 d	3.7 hij	1.1	4.1	4.0 de
Kerb	0.8 lb	fall	4.1 b	4.6 de	3.0 d	5.0 d	5.0 k	1.7	4.1	5.0 e
Maverick	0.67 oz	fall	0.3 a	0.2 a	0.3 ab	0.2 a	2.7 fgh	1.3	0.9	1.0 abc
Maverick	1.34 oz	fall	0.8 ab	0.3 a	0.6 ab	1.0 a	4.2 ijk	2.4	0.3	2.5 bcd
Maverick	0.67 oz	dormant	1.2 ab	0.3 a	0.9 ab	1.5 ab	4.0 ijk	2.2	3.4	3.0 cde
Milestone	2 oz	dormant	0.0 a	0.2 a	0.3 ab	0.2 a	0.5 abc	1.1	2.8	0.0 a
Milestone	4 oz	dormant	0.0 a	0.2 a	0.0 a	0.5 a	2.0 def	1.1	0.0	2.0 abc
Rely	3 pt	dormant	0.3 a	1.3 ab	0.0 a	0.5 a	1.5 bcdef	0.8	3.4	1.3 abc
Roundup	1.5 pt	dormant	4.1 b	5.0 e	4.7 e	5.0 d	4.7 jk	2.8	4.1	5.0 e
Sencor	0.4 lb	fall	0.5 ab	0.4 a	0.0 a	0.5 a	1.0 abcd	1.1	1.3	0.3 abc
Sencor	0.8 lb	fall	0.0 a	0.0 a	0.7 ab	4.5 d	2.5 efg	0.6	0.9	3.0 cde
Sinbar	0.75 lb	fall	1.2 ab	1.3 ab	0.9 ab	2.2 bc	1.5 bcdef	0.6	5.0	1.3 abc
Sinbar	1.5 lb	fall	2.8 ab	4.1 d	5.0 e	5.0 d	4.5 ijk	1.9	3.4	5.0 e
Surflan	3 qt	fall	0.0 a	0.0 a	0.0 a	0.0 a	0.7 abcd	0.6	0.0	1.0 abc
Surflan	6 qt	fall	0.0 a	0.4 a	0.3 ab	0.2 a	0.7 abcd	0.2	0.3	1.3 abc
Control	---	----	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0	0.0	0.0 a

[1] Rating scale from 0 (no negative effect) to 5 (maximum negative effect).

[2] Mean separation with Student-Newman-Kuels Test at P 0.05.

Table 3. Effect of herbicide treatments on stand reduction of native grass species evaluated November 2, 2001.

Treatment	Product rate/acre	Timing	Great basin wildrye	Bluebunch wheatgrass	Streambank wheatgrass	Big bluegrass	Idaho fescue	Indian ricegrass	Squirreltail	Prairie junegrass
Axiom	11 oz	fall	0.5[1] ab[2]	0.2 a	0.4	0.0 a	0.1 a	0.6	0.0 ab	0.1
Axiom	22 oz	fall	0.1 a	0.0 a	0.0	0.1 a	0.3 a	0.0	2.1 ab	2.2
Beacon	0.76 oz	fall	1.0 ab	0.0 a	0.6	0.0 a	0.3 a	0.0	0.4 ab	0.4
Beacon	1.52 oz	fall	0.2 a	0.6 a	0.3	0.3 a	0.0 a	0.0	0.0 ab	2.0
Clarity	4 pt	fall	0.5 ab	0.2 a	0.6	0.1 a	0.7 a	1.2	2.1 ab	1.3
Clarity	8 pt	fall	0.9 ab	1.4 a	0.1	0.0 a	1.4 a	1.7	0.8 ab	0.0
Diuron	1.8 lb	fall	0.0 a	0.0 a	0.0	0.0 a	0.1 a	0.9	0.0 ab	1.0
Diuron	3.6 lb	fall	1.3 ab	2.3 ab	0.5	0.1 a	1.7 a	2.1	3.8 ab	2.0
Frontier	32 fl oz	fall	1.8 ab	0.0 a	0.0	0.0 a	1.2 a	2.7	0.0 ab	0.0
Frontier	64 fl oz	fall	0.0 a	0.0 a	0.0	0.0 a	0.0 a	0.0	0.0 ab	0.4
Goal	10 fl oz	fall	0.0 a	0.0 a	0.0	0.0 a	0.3 a	0.9	0.0 ab	0.7
Goal	20 fl oz	fall	0.7 ab	0.2 a	0.0	0.0 a	0.1 a	0.9	0.0 ab	0.1
Kerb	0.4 lb	fall	1.8 ab	1.1 a	0.0	2.2 b	1.7 a	1.5	3.8 ab	0.1
Kerb	0.8 lb	fall	3.0 b	4.6 c	0.2	4.7 c	4.1 c	1.5	4.6 ab	2.9
Maverick	0.67 oz	fall	1.0 ab	0.2 a	0.0	0.3 a	1.2 a	0.9	1.3 ab	0.0
Maverick	1.34 oz	fall	0.9 ab	0.2 a	0.3	0.1 a	1.2 a	1.5	0.0 a	0.0
Maverick	0.67 oz	dormant	1.0 ab	0.0 a	0.0	0.0 a	0.7 a	0.9	0.0 ab	0.7
Milestone	2 oz	dormant	0.0 a	0.8 a	0.2	0.0 a	0.1 a	0.6	0.4 ab	0.1
Milestone	4 oz	dormant	0.5 ab	0.0 a	0.0	0.0 a	1.2 a	1.5	0.4 ab	0.5
Rely	3 pt	dormant	0.0 a	2.3 ab	0.0	0.0 a	0.3 a	0.6	0.0 ab	0.1
Roundup	1.5 pt	dormant	1.9 ab	5.0 c	3.0	4.9 c	3.0 b	1.5	5.0 ab	4.6
Sencor	0.4 lb	fall	1.0 ab	0.0 a	0.2	0.0 a	0.3 a	0.3	1.7 ab	0.7
Sencor	0.8 lb	fall	0.5 ab	0.0 a	0.6	3.9 c	1.2 a	0.6	0.8 ab	1.6
Sinbar	0.75 lb	fall	0.0 a	0.2 a	0.0	2.0 b	0.3 a	0.0	5.0 ab	1.0
Sinbar	1.5 lb	fall	3.0 b	3.5 bc	5.0	5.0 c	5.0 c	0.3	5.0 b	5.0
Surflan	3 qt	fall	0.8 ab	0.2 a	0.0	0.1 a	0.3 a	0.6	0.4 ab	0.0
Surflan	6 qt	fall	0.2 a	0.5 a	0.2	0.1 a	0.9 a	0.6	1.3 ab	0.1
Control	---	----	0.0 a	0.0 a	0.0	0.0 a	0.0 a	0.0	0.0 a	0.0

[1] Rating scale from 0 (no negative effect) to 5 (maximum negative effect).
[2] Mean separation with Student-Newman-Kuels Test at P 0.05.

ROW SPACING AND GRASS SEED YIELD IN THE WILLAMETTE VALLEY

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

Introduction

Seeding practices for cool-season grass seed crops grown in the Pacific Northwest have evolved for each of the species and differ somewhat among the various seed producing areas within the region. Nevertheless, modern stand establishment systems for grass seed crops are based on the use of management practices developed when field burning was the primary method of residue removal. While residue management and weed control practices have evolved to accommodate non-burning techniques of production, stand establishment practices have not appreciably changed over the past decade for perennial grasses while major changes have been observed in annual ryegrass seed crop establishment. Present Oregon State University recommendations for grass seed crop row spacings indicate that 12-inch rows are optimum for red fescue and perennial ryegrass, and 18-inch rows are best for tall fescue.

Crop competition can aid in the suppression of weeds in grass seed fields. Early canopy closure increases shading which can decrease weed seed germination, and also leaves fewer open niches for the growth of weeds. Vigorous growth and early closure of the crop canopy can be manipulated through changes in row spacing. Our goal is to improve stand persistence and seed yield in perennial grass seed crops, and improve crop competition with weeds. Identification of the best stand establishment practices under non-burning management may permit higher seed yields and longer, productive stand life in perennial grass seed crops.

Procedure

Field trials were established at Hyslop Farm to ascertain the effect of crop row spacing on yield and performance of tall fescue (Velocity), perennial ryegrass (Cutter), slender red fescue (Seabreeze), creeping red fescue (Shademaster), and Chewings fescue (SR5100). Four row spacings were examined in each of the seed crops: 6-, 12-, 18-, and 24-inch rows at constant within-row seeding rates. Furthermore, comparisons among these row spacings were made in burned and in non-burned plots in creeping red fescue and slender red fescue.

Seed yield components were determined on samples taken in each plot prior to harvest including fertile tiller number or spike number. In addition, spikelet and floret number, and seed weight were determined in perennial ryegrass. Seed yield was measured after harvest with our small plot swather and plot combine. Trials were conducted for 4 harvest seasons in Chewings fescue, slender red fescue, and creeping red fescue; and 6 harvest seasons in tall fescue and perennial ryegrass.

Results

Seed yields were averaged over the life of the stand for each grass seed crop and row spacing, and are reported in Figure 1. Our results indicate that there were no differences among row spacings for seed yield of creeping red fescue, slender red fescue, and Chewings fescue. Seed yields were only affected by row spacing in perennial ryegrass and tall fescue. Yields were the same regardless of row spacing in the 6-12 inch range for perennial ryegrass, but declined in 18- and 24-inch rows. Tall fescue yields were the same for all row spacings between 12 and 24 inches, while lower yields were noted in 6-inch rows. No interaction of residue management and row spacing was evident in the seed yield results of creeping or slender red fescue. In other words, seed yield responses of these crops to row spacing were similar whether they were burned or not, although field burned plots typically out-yielded non-burned plots in older stands. Seed yields of these crops for the various row spacings were maintained in proportion to the crop response to residue management.

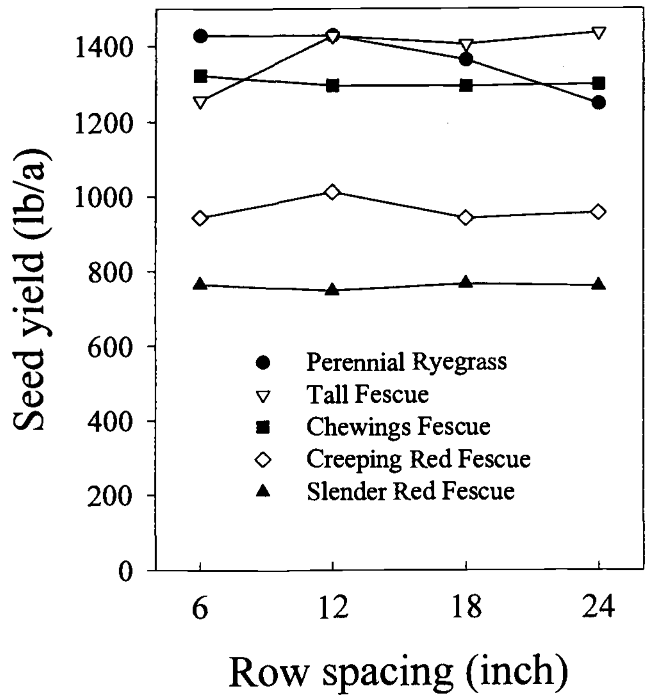

Figure 1. Row spacing and seed yield in cool-season perennial grasses grown in the Willamette Valley.

Fertile tiller number declined dramatically with increasing row spacing in Chewings fescue, creeping red fescue, and slender red fescue (Figure 2). Despite the reductions in fertile tiller number, seed yield was maintained across all row spacings regardless of row spacing or residue management method (Figure 1). Seed weight might have increased in wider rows to compensate for the loss in fertile tiller number with increasing row spacing. It is also possible that the number of spikelets and florets might have been increased by wider row spacing.

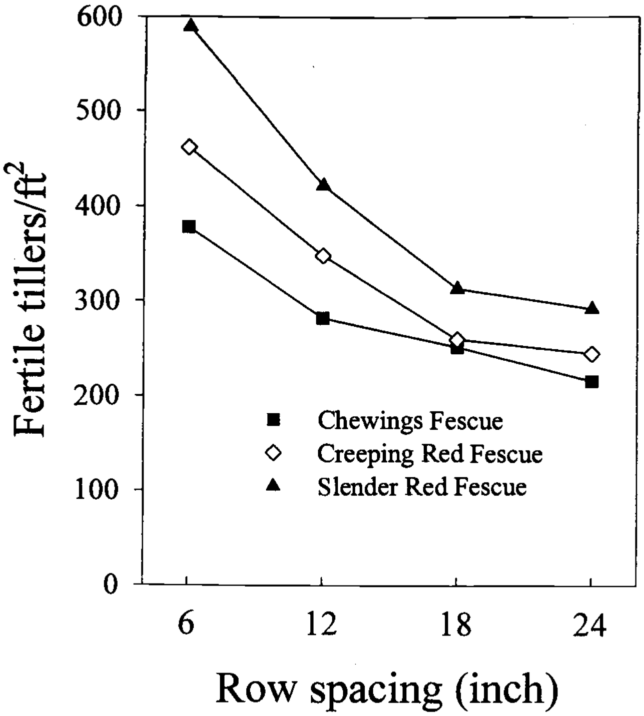

Figure 2. Fertile tiller number responses in Chewings fescue, creeping red fescue, and slender reed fescue to row spacing in the Willamette Valley.

Yield component analysis demonstrated the underlying reason for seed yield of perennial ryegrass seed crops being optimal in 6 or 12 inch rows (Figure 3). While the number of spikelets and florets increase with widening of the rows to 18 or 24 inches, these increases are not sufficient to compensate for the precipitous loss in spike number as row spacing was widened. A similar analysis for tall fescue showed that seed yield was diminished by narrowing to 6-inch rows as a result of loss in fertile tiller number and perhaps by the expression of other yield components (Figure 4). Other yield components such as seed weight, and/or spikelet or floret number might be involved in the compensation for the observed losses in fertile tiller number to maintain seed yield in wider rows in tall fescue.

Perennial ryegrass yields were equivalent in 6- or 12-inch rows, and tall fescue yields were the same in 12-, 18-, and 24-inch rows. By choosing the narrowest row spacing within these acceptable ranges for perennial ryegrass and tall fescue, seed growers might maximize the potential competitiveness of these crops with weeds without the risk of seed yield loss. Wide rows in perennial ryegrass (18- and 24-inch) and narrow rows (6-inch) in tall fescue should be avoided because of low seed yields.

Since seed yields were similar regardless of row spacing in Chewings fescue, slender red fescue, and creeping red fescue, choice of row spacing must be made on considerations other than seed yield. Again, narrow rows in these species might provide more competition of the crop with weeds by reducing the amount of non-crop area between rows.

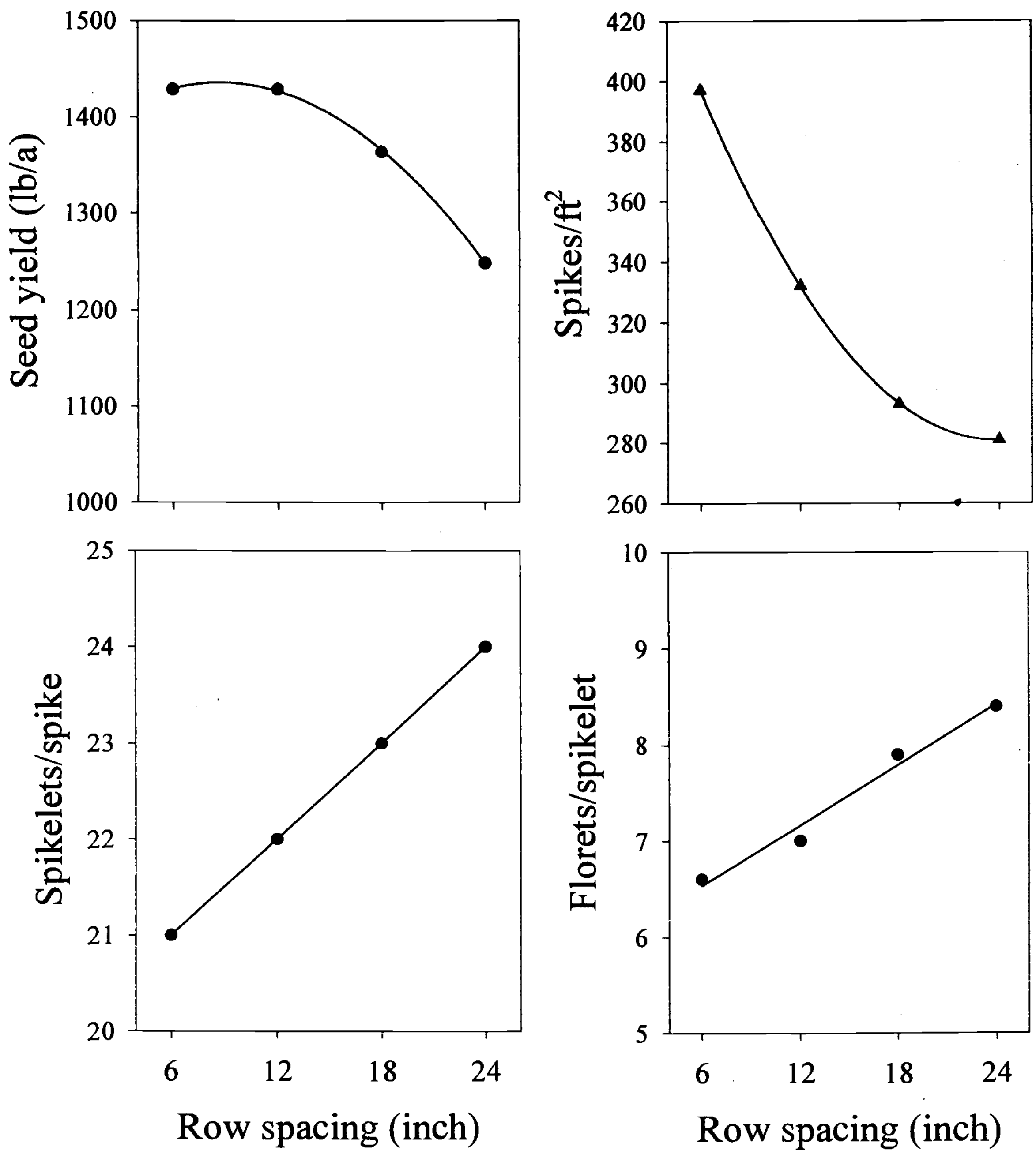

Figure 3. Row spacing effects on seed yield and yield components in perennial ryegrass grown in the Willamette Valley.

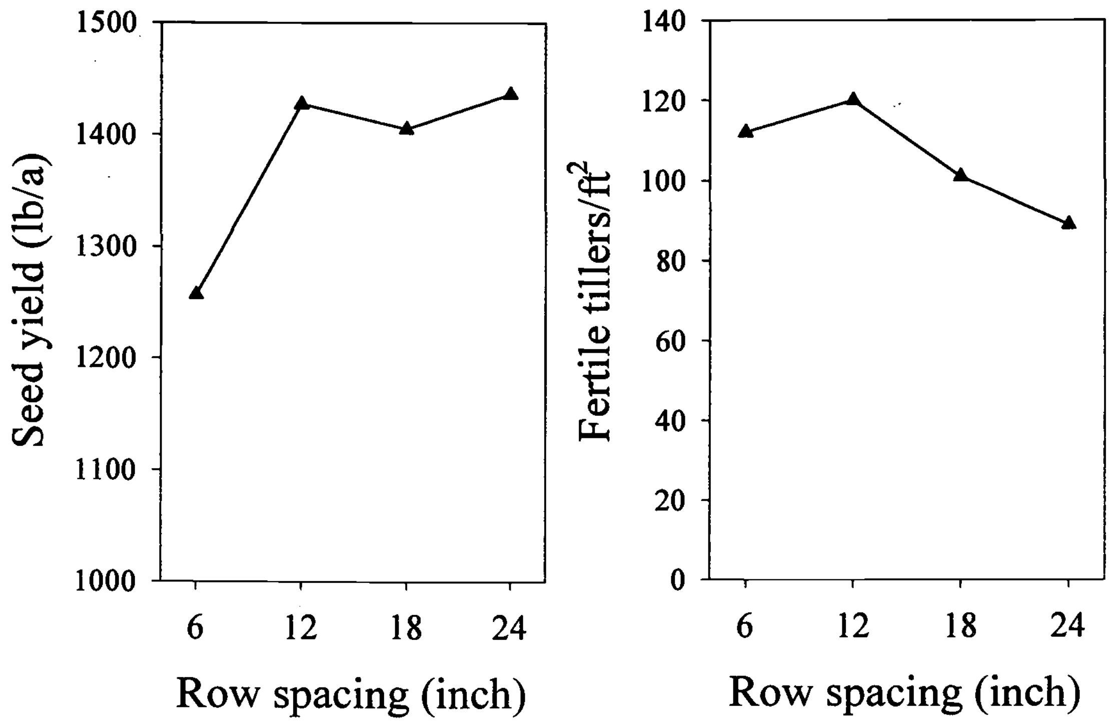

Figure 4. Seed yield and fertile tiller number responses to row spacing in tall fescue in the Willamette Valley.

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

S. Aldrich-Markham

Newly-planted grass seed fields are vulnerable to erosion during the fall and winter when rainfall is heavy and the grass is still small. Grass seed is typically planted into a smooth, finely-worked seedbed. Sheet and rill erosion occur even on a slight slope because there is not enough vegetative cover to protect the loose soil. A conservation practice that reduced the sediment running off newly planted fields would have a beneficial impact on water quality in the Willamette Valley.

Leaving a cloddy seedbed, with crop residue on the surface, could reduce runoff and erosion, but accurate shallow placement of the seed by the drill and accurate placement of the carbon band on the soil surface are not possible if the seedbed is too rough. Grass seed is typically carbon-band planted, with a one-inch wide band of activated charcoal applied as a slurry directly over the seed row, followed by an application of diuron herbicide over the entire field. Weed seedlings germinating between the seed rows are killed, while the carbon band protects the grass crop seedlings by absorbing the diuron. Where the band misses the seed row, the crop is killed.

Several growers have tried the conservation practice of planting a nurse crop of spring oats just prior to planting their grass seed. The oats quickly grow taller than the grass, providing some vegetative cover and root mass to hold the soil during the winter. The nurse crop may be planted across the sloping parts of the field in contour strips or planted in swales that are particularly susceptible to erosion. Oats are used because they can tolerate the diuron applied with carbon-band seeding. Oats can reduce erosion, but if left too long, they choke out the crop. In order to use this practice, growers must be able to remove the oats from the field at the right time. Spring oats might be killed by winter temperatures, but in case of a warm winter, growers need a herbicide alternative.

The goals of this research were: 1) to determine what herbicides could remove the oats without injuring the grass seed crop after the oats had become large enough to provide leaf material (living or dead) as cover for the soil, and 2) to verify that a nurse crop planted on a sloping area of a field could reduce erosion.

Methods – 1999-2000

The trial was established in a new perennial ryegrass field farmed by a cooperating grower in Yamhill County. The grower planted spring oats in a contour strip on October 21. The strip was comprised of two 12-ft-wide drill strips side-by-side, one of the variety Monida and one of Cayuse. The purpose of planting the two varieties was to see if the less winter-hardy Monida might winter kill and solve the problem of removing the nurse crop without herbicide treatment. The seeding rate for both was 100 lb/a, and the seeding depth was 1.5 in. On October 22 the grower carbon-band planted perennial ryegrass field over the top of the oats and applied 3.0 lb/a of Karmex (diuron) herbicide. After the oats emerged, the plots were flagged. The 9 x 24 ft plots were perpendicular to the seed rows in the oat strip, crossing the two varieties. There were six treatments plus a check, with four replications.

Nortron (ethofumesate) and Horizon (fenoxaprop) herbicides were applied using a CO_2 backpack sprayer with TeeJet 8002 nozzles at 27 psi and 25 gal/a of water. The Nortron was applied on December 19, and the Horizon treatments were applied on December 28, January 18, February 24, and April 17. Roundup Ultra (glyphosate) was applied on April 10 using an 8-ft-wide Power Roll weed wiper. This weed wiper has a carpeted cylinder onto which a solution of 10% Roundup and 1.25% Foamline is sprayed by a set of nozzles. The cylinder rotates hydraulically and rubs against a carpeted backboard, causing friction and creating a foam like shaving cream. The foam adheres to the leaves of the plants wiped by the rotating cylinder as it passes over. The foam prevents the herbicide from dripping and damaging the crop plants below.

Tim Steiber of the Yamhill Soil and Water Conservation District provided technical assistance with measuring the erosion. He installed two 15-ft silt fences to provide a visual comparison of the amount of soil movement with and without the nurse crop strip. One silt fence was on the upper edge of the strip, catching sediment runoff from an area with perennial ryegrass alone, and the other was on the lower edge, catching runoff from an area with perennial ryegrass and nurse crop. Every two feet along the bottom on the uphill side of the silt fences, he drove large nails into the ground so that the heads were just at the soil surface. By measuring the depth of soil deposited on top of the nails in April, he could document soil movement and determine if the nurse crop was providing any erosion control benefit.

Results and Discussion

The winter of 1999-2000 was not cold enough to injure either variety of spring oat.

The herbicide treatments were evaluated on May 18 for percent control of the oat nurse crop. The results are summarized in Table 1. There was no crop injury from any of the herbicide treatments.

Table 1. Percent control of oat nurse crop on 5/18/00 in perennial ryegrass field

Herbicide	Rate	Date applied	Oat growth stage	% Oat Control
Nortron	3.0 pt/a	12/19/99	4-leaf	48
Horizon	1.6 pt/a	12/28/99	5-leaf	95
Horizon	1.6 pt/a	1/18/00	1-2 tillers	88
Horizon	1.6 pt/a	2/24/00	8 in	78
Roundup	10% solution	4/10/00	boot	95
Horizon	2.0 pt/a	4/17/00	boot	50
LSD 0.05				7

Only one treatment, the April 10 application of Roundup Ultra as a 10% foam solution using a Power Roll weed wiper provided both an adequate level of nurse crop control (95%) and an adequate level vegetative cover for erosion control during the winter months. By the evaluation time on May 18, the dead oat plants had fallen to the ground. The few surviving oat plants had stopped growing and were shorter than the oat plants that had survived the earlier Horizon treatments in the other plots.

The timing of this Roundup application is critical. The oats must be taller than the grass crop in order to selectively apply the herbicide. On April 10 the oats were about 12 in tall and the grass was only about 6 in tall, so the wiper height could be set at 8 in. One week later, many of the grass plants had produced seed stalks that were almost as tall as the oats. These plants would have been injured by a later Roundup wipe.

Oat plants flattened by the tractor wheels, were not touched by the wiper and were not controlled. The wheel tracks, which made up approximately 40 percent of the plot area, were not evaluated. In a commercial field, a grower would use a Power Roll weed wiper 30 feet wide, and the wheel tracks would make up a much smaller percentage of the treated area. The manufacturer recommends waiting a few days for the weeds to stand back up again, then making another pass over the field in the opposite direction in order to treat the wheel tracks.

The advantage of the Power Roll weed wiper over the older rope wick type wiper was observable on May 18 in the field. A farm worker had towed a rope wick weed wiper with a tractor over the rest of the nurse crop strip outside the plot area. He had also covered the rest of the field in an effort to control the annual ryegrass plants that were sticking up above the perennial ryegrass. Two weeks after the application, dead patches in the perennial ryegrass crop were visible. In the nurse crop strip, the liquid Roundup solution ran down the oat leaves onto the grass seed crop underneath. Elsewhere in the field, the tractor wheels had gotten wet with herbicide, and the crop was destroyed in the wheel tracks. Applying Roundup as a foam reduces the off-target injury from dripping. The foam is also easier to see on the weeds, which allows the operator to avoid driving on the treated area. The disadvantage of the Power Roll weed wiper is the expense. A 30-foot wide unit with three sections sold in 1999 for about $6,500. Few grass seed growers already own this specialized weed wiping equipment, and the cost would be a barrier to adoption of this practice.

Among the four Horizon treatments, only the earliest, applied on December 28, provided an adequate level of oat control (95%). At the 5-leaf stage, the oats were not big enough to leave much dead leaf material as mulch following the herbicide application. This treatment removed the nurse crop too early to provide an erosion control benefit.

Delaying the Horizon application by one or two months resulted in poorer oat control (88% and 78%), but a longer period of vegetative cover. Ideally, one would like to have good cover on the soil through March, but neither the January 18 nor the February 24 treatments provided this. Erosion control was still less than adequate with these treatments.

The Horizon on April 17 was applied at a higher rate. The 2.0 pt/a rate is labeled for fields established for at least six months. By May 18 the treated oat plants were orange and stunted, but they remained standing and could have produced oat seeds to contaminate the grass seed crop.

Growers often use a fall application of Nortron in perennial ryegrass to control grass weeds. The purpose of the Nortron treatment in this trial was to see if, by waiting later to apply the Nortron (December 19), it could be used without killing the oat nurse crop. The efficacy of Nortron for weed control at this application timing was not evaluated. About 50% of the nurse crop was killed, and the stunted survivors did not provide much vegetative cover for the rest of the winter. By May 18 the surviving oats had recovered.

Even with a 24-ft-wide contour strip of oats, there was still some soil loss from the plots. However the nurse crop cut the amount of erosion by more than half. Soil movement was measured in April. The average depth of soil deposited on the nail heads at the silt fence below the nurse crop strip was 0.33 in (a range of 0.20 to 0.50 in), while the average depth of soil deposited on the nails below the area without the nurse crop was 0.80 in (a range of 0.60 to 1.0 in). In November and December, the period when the oat plants had only five or fewer leaves, erosion was observable in the form of small rills in the plots.

The nurse crop did not cause a reduction in the perennial ryegrass stand, except in the check plots where the full stand of oats persisted until May 18. There the perennial ryegrass plants were smaller, but still alive. No seed yield measurements were taken. After the final evaluation, the grower mowed the area to remove the remaining oats. Grass seed production from the mowed area was lost for the year, but the perennial ryegrass would probably produce a normal yield in the following year.

Methods – 2000-2001

In 2000 the manufacturer stopped producing Horizon, so this herbicide was no longer an option for growers. However, Rely received a new 24c Special Local Needs label for grass seed. These trials compared the efficacy of Horizon and Rely, in combination with an earlier application of Nortron, for removing the oat nurse crop. The Power Roll weed wiper was not used in 2001 as planned. The Nortron application stunted the oats, so that there was never enough of a height difference between the oats and the grass seed crop to safely wipe Roundup foam on the oats without touching the grass.

The two trials were established in newly-planted tall fescue and perennial ryegrass fields with the same cooperating grower in Yamhill County. In the tall fescue field the grower planted Cayuse oats in a 24-ft-wide contour strip. In the perennial ryegrass field he planted the nurse crop as three 12-ft drill strips side-by-side, forming a contour strip with three spring oat varieties, Cayuse, Monida, and Kanota. Kanota was added to the trial because it is less winter hardy than Monida or Cayuse. The seeding rate for all was 100 lb/a, and the seeding depth was 1.5 in. The grower applied Nortron at 2.5 pt/a to both fields, including all the plots. Horizon at 1.6 pt/a and Rely and 3.0 pt/a were applied using a CO_2 backpack sprayer with TeeJet 8002 nozzles at 27 psi and 25 gal/a of water.

In one field, the grower planted the oats on September 21 and carbon-band planted tall fescue on the same day, with 2.5 lb/a of Karmex. He irrigated once following planting. The 9 x 24 ft plots were flagged after the oats emerged. There were two treatments plus a check and three replications. The grower applied Nortron on November 13. Horizon and Rely were applied on January 11.

In another field, the nurse crop was planted on October 18, and the perennial ryegrass was carbon-band planted on the same day, with 2.5 lb/a of Karmex. Plots were 9 x 36 ft, with two treatments plus a check and three replications. Nortron was applied by the grower on January 27. Horizon and Rely were applied on March 22.

In addition to planting the contour strip of oats for the herbicide trials, the grower also planted a nurse crop of Cayuse oats on the sloping side of a large swale in the tall fescue field. Three 50 x 50 ft plots were established in this area, one with no nurse crop, one with the nurse crop seeded at 100 lb/a, and the third with the nurse crop seeded at 150 lb/a. All three plots had the same degree of slope. Tim Stieber from the Yamhill Soil and Water Conservation District compared the soil erosion from the three plots. He installed a silt fence along the bottom edge of the plots, and in each plot, drove four sets of large nails into the ground so that the heads were just at the soil surface. Each set consisted of a nail at 3 in, 1 ft, and 2 ft distances from the silt fence. The depth of soil deposited on the tops of the nails was measured on December 22, when the oats were 8 in tall. He used the depth measurments to calculate the volume of the triangular wedge of soil accumulated at the silt fence. Then using a soil bulk density of 1.4, he translated this volume to weight of the soil eroded from the plots. These oats were treated with Nortron at 2.5 pt/a on December 13 by the grower along with the rest of the field. Stieber made the soil measurements on December 22, earlier than planned, because he thought the oats would be killed by the Nortron. They were only stunted.

Results and Discussion

The winter of 2000-01 was not cold enough to kill any of the oat varieties.

The herbicide treatments in the tall fescue field were evaluated on March 19 for percent control of the oat nurse crop. The results are summarized in Table 2.

Table 2. Percent control of oat nurse crop on 3/19/01 in tall fescue field.

Herbicide	Rate	Date applied	Oat growth stage	% Oat Control
Horizon	1.6 pt/a	1/11/01	12 in	80
Rely	3.0 pt/a	1/11/01	12 in	99
				NS*

* Not significantly different at P=0.05

Because these oats were planted in September and irrigated up, they were already 12 in tall on January 11 and shading out the tall fescue. The nurse crop needed to be removed. The combination of Nortron applied on December 13 plus the Rely applied on January 11 gave excellent control of the oats (99%). At the time of the visual evaluation on March 19, there was dead leaf material from the oats, some still standing and some lying on the ground, providing cover and protection for the soil. The oat control from the Nortron plus Horizon combination was less than adequate (80%). The difference in control from Horizon and Rely was not statistically significant however.

The tall fescue stand in the plots did not appear to be injured, although no seed yield measurements were taken to determine whether the plants had suffered from herbicide injury or competition with the nurse crop. However, where the grower had also seeded the nurse crop in the large swale and used a combination of Nortron plus Horizon (at 2.0 pt/a, applied January 6), he thought that the tall fescue was less vigorous than in the rest of the field. He had gotten less than satisfactory control of the oats. In addition, the grower noted that there was more damage from field mice in the nurse crop area than in the rest of the field. In September 2001, after the seed harvest, the tall fescue stand in the swale, including the herbicide trial and the erosion measurement plots looked as good as the rest of the field. There was little evidence of erosion in the bottom of the swale, where a gully would almost certainly have formed without the erosion control provided by the nurse crop.

The herbicide treatments in the perennial ryegrass field were evaluated on April 23 for percent control of the oat nurse crop. The results are summarized in Table 3.

Table 3. Percent control of oat nurse crop on 4/23/01 in perennial ryegrass field.

Herbicide	Rate	Date applied	Oat growth stage	% Oat control
Horizon	1.6 pt/a	3/22/01	12 in	85
Rely	3.0 pt/a	3/22/01	12 in	78
				NS*

* Not significantly different at P=0.05.

The oats stayed yellow and stunted from the grower's January 27 Nortron application for so long that it appeared another herbicide treatment might not even be needed to control them. They eventually grew out of it, however, and Horizon and Rely were applied late. Horizon performed about as well as it had earlier in the tall fescue field (85% control), while the Rely performed much worse, only 78% control compared to 99% control on January 11 in the tall fescue field. In September 2001, after seed harvest, it was evident that perhaps as much as 20% of the perennial ryegrass in the plot area was missing. The plants had been killed either by herbicide injury, competition from the oats, or both.

The amount of erosion from the 50 x 50 ft plots in the tall fescue field was estimated from the measurements of the depth of soil deposited on the tops of the four sets of nails placed at 3 in, 1 ft, and 2 ft from the silt fence at the bottom. On a per acre basis, the erosion amounted to 5.5 tons/a with the nurse crop and 8.9 tons/a without the nurse crop. The soil measurements were taken in on December 22, before the end of the winter rains, so one would expect that by the end of the winter the total amount of erosion would be higher and the difference between the plots with and without the nurse crop would be even greater. To help put the magnitude of this erosion in perspective, a value for "T," or tolerable yearly soil loss, is used by the US Department of Agriculture. For typical soils in the Willamette Valley, the "T" value is 5 tons/a. There was no apparent difference in amount of erosion from the plot with 100 lb/a and the plot with 150 lb/a seeding rates of oats.

Conclusions

An oat nurse crop can reduce erosion in newly-planted grass seed fields. In this research, the amount of soil loss was approximately double in the areas without the nurse crop compared to areas with the nurse crop. A nurse crop is not a complete solution to the erosion problem, however, because there was still some soil movement, especially during the first two months after planting the fall, when the oats plants were too small to offer much protection for the soil.

It is possible in some situations to remove the oat nurse crop satisfactorily with herbicides after the oats have provided vegetative cover for the soil for the whole winter. Those situations, however, are still unpredictable. At this point, we have no reliable herbicide program to recommend for growers. The Power Roll weed wiper gave excellent control in the first year, but in the second year, when the oats were stunted from an earlier Nortron application, there was never enough of a height difference between the oats and the grass seed crop to safely wipe Roundup foam on the oats. The Rely treatment gave 99% control of the oats in the tall fescue field as a January application, but only 78% control of oats the same size as a March application the perennial ryegrass field.

Nurse crop research needs to continue, investigating other possible crops besides oats, as well as herbicides and other methods of nurse crop removal. In additon, more practices need to be added to the growers' list of tools for controlling erosion in newly planted grass seed fields.

COMBINING PHOTOGRAPHIC AND PRECISION FARMING METHODS TO MEASURE GEESE GRAZING IMPACTS ON GRASS SEED PRODUCTION

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

Introduction

Conservation programs have resulted in an increase of Canada goose (*Branta canadensis*) wintering and resident populations in the lower Columbia River and Willamette River Valleys of southwest Washington and western Oregon. The increase has been from approximately 20,000 to 25,000 in the 1970s, historical average, to an estimate of over 250,000 by January 1999 (Oregon Department of Fish and Wildlife, 1998).

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

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

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

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

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

1. Constructed exclosures with poultry wire and electric fence posts to keep geese from entering small areas scattered throughout the test fields. These areas served as controls that provided the basis for knowing wheat production without goose grazing impacts. The exclosures were large enough for a commercial-size combine to harvest through them.

2. Aerial photographs taken throughout the growing season to see plant cover differences within the fields. Cover differences were generally due to goose grazing impacts, but were also due to soil differences and to standing water.

3. Ground-level photography and data collection to serve as ground truth verification for causes of the cover differences seen in the aerial photographs.

4. A yield-mapping-system equipped combine to record wheat yields throughout the field.

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

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

1. Identify timing (both season and frequency) and intensity of goose use of selected grass seed fields.

2. Develop reliable methods that farmers can use (or contract out) to document the impact on yield.

3. Provide an estimate of goose impact on grass seed yield on specific fields during the research period.

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

Methods

1. Goose-proof exclosures paired with naturally grazed plots are concentrated in parts of the fields in which heavy grazing is anticipated. Others are located in areas anticipated to have moderate to light grazing. Exclosures serve as controls. They have to be large enough to avoid edge effects and to allow a commercial combine to harvest through them.

2. Ground photos are taken from a camera mounted on a frame constructed to place the camera directly above, and at a given height from, ground level. Ground photos and associated data (e.g., goose droppings, plant height, category of grazing intensity, etc.) serve as ground-truth verification of cause of reduced yield where it occurs.

3. Aerial photos taken of entire fields to show grass cover differences within fields at field scale. Ground-truth photographs verify cause of cover differences.

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

Progress

We have cooperated with a mid-Willamette Valley farmer, who provided fields subject to goose grazing pressure for use in the project. We have used five fields in each of two crop years. We have used both perennial ryegrass and tall fescue fields, some newly seeded and some already established. We established 6 X 20-meter exclosures in all fields. The number of exclosures per field varied by field size.

We conducted ground-level photography and data collection along transects within each field during December or January through April in both years. Most of the geese depart the area around mid-April. During the 1999-2000 crop year, we took aerial photographs from a camera mounted on a fixed-wing aircraft during December, January, March and April, while geese were present, and during July, between swathing and combining of the grass seed. Aerial photographs were not as useful for grass-seed field evaluations as they had been for wheat. In the newly seeded fields, grass had not yet grown sufficiently to show in the aerial photographs until March. In established fields, grazing did not take the plants down to bare soil, so the contrast was not as obvious as it had been for wheat. For those reasons, we limited aerial photography to one (mid-April) in 2001.

Crops were swathed beginning in early July and continued through most of the month. Combining commenced during mid-July and continued through early August on the fields we were using. Each exclosure had one or two swaths through it. Depending on the field and crop, five to nine combines operated in a field. Of those, four were equipped with yield-mapping systems. Two of those were GreenStar® systems and two were AgLeader® systems. We encountered data recording and reporting differences between the GreenStar® and AgLeader® systems. During the second year, we encountered several data recording problems. The most serious problem was that the flagging option was either not used or was not programmed correctly for use on one of the fields. That resulted in exclosure data extraction difficulties for one of the fields. This has not been an insurmountable problem, but it has required considerable additional time and effort to extract the exclosure data for that field.

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

Preliminary Results and Discussion

In the initial study on wheat, we used a single combine equipped with a yield-mapping system. The analysis was fairly straightforward. In this second study on grass seed fields, we are using four combines and two different yield-mapping systems. We have machine-to-machine and system-to-system variability to consider in statistical analysis. We are still working at identifying the most appropriate analysis for the type of sampling involved with this study.

We have not yet completed data analysis for the fields used in the grass-seed phase of the study. Preliminary analyses show different yields by soil type. For example, a field with Amity, Dayton, Woodburn, and Waldo soils had 1777, 1507, 1949, and 1795 lb/a perennial ryegrass seed yields, respectively. Once we have adjusted for grazing impacts, these numbers might change.

We also have preliminary analyses for grazing impacts that have not yet been adjusted for soil types. In portions of a field that were grazed into March, tall fescue seed yield was 1452 vs. 1575 lb/a within exclosures. The 8% difference was statistically significant at $P=0.008$. In another tall fescue field in which the stand was very uneven due to substantial water ponding in areas, there was no apparent yield difference due to grazing into March. There were no yield differences apparent in areas of a perennial ryegrass field that were grazed into March, but not later. In the same field, areas that were grazed into April suffered a 17% (1427 vs. 1712 lb/a) yield reduction compared to exclosures. Because we are still refining our analysis procedures, these numbers are subject to change.

Calibration of the yield-mapping system is an important process for reducing system-to-system and machine-to-machine variability. Effective use of the flagging option for the yield-mapping system also greatly facilitates extracting data from specific areas. For example, if flagged, data from exclosures can be easily extracted and compared to grazed areas. Areas subject to water ponding can be easily extracted and excluded from the analyses.

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ECONOMIC IMPACTS OF NON-BURN CONSERVATION PRACTICES ON WESTERN OREGON PERENNIAL GRASS SEED PRODUCTION

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

This is a brief update regarding how direct seed (no-tillage) establishment and maximal post-harvest straw management impact creeping red fescue, tall fescue, and perennial ryegrass seed production in western Oregon. This research was part of a study done from 1992 to 2001 at the request of the Oregon seed industry and the Oregon Department of Agriculture in response to the phase down plan for open field burning. This work was performed at three sites in the Willamette Valley representing contrasting seed production conditions for perennial ryegrass (poorly drained Linn County soil), tall fescue (poor-to-moderate drained Benton County soil), and creeping red fescue (well-drained but erodable hill-land Marion County soil). Common to each site were comparisons of (i) conventional tillage vs. no-tillage establishment; (ii) minimal vs. maximal post-harvest straw amounts returned to the field; and (iii) monoculture grass seed vs. rotated systems. All treatments were applied without burning straw after seed harvest. At the time this study had begun, most perennial grass seed acreage was planted using extensive field preparation with plows or discs, and with burning to remove the straw from the fields after harvest.

The crops and rotation sequences used here were chosen among different options available to farmers in each production area. The specific treatments we chose were used as examples, and not meant to represent all options available. Growers should consider their specific farm situations and whether commodity prices would allow a positive net return when choosing alternative crops and rotations. It is also best to consider the costs and returns over entire rotations to consider the complimentary carry-over benefits of different production practices on each crop in the rotation sequence.

Direct seed establishment, crop rotations, and residue management. During the course of the study, we found that direct seeding could be done with conventional planting drills under most conditions, so specialty no-tillage drills were not required and therefore would not have to be purchased. There may be other situations we did not pursue where no-tillage drills could be useful, but the suitability of conventional equipment greatly reduces the need for expensive, specialty equipment. The greatest single expense in the no-tillage system was the cost of the non-selective herbicide needed to kill the established perennial grass seed stands when changing crops. Non-selective herbicide was also used for volunteer crop and weed cleanup prior to planting the following crop in a rotation sequence.

Since tillage equipment for planting bed preparation was not needed in direct seed management, a significant saving in production costs occurred. A partial budget analysis of establishment costs showed the creeping red fescue system had the greatest establishment cost savings (Table 1). Significant, but lesser savings also occurred in the tall fescue and perennial ryegrass systems. Also, when using a strict no-tillage system, spring planting time can be more than a month earlier than in conventional tillage systems because of greater soil stability as a result of no autumn soil disturbance practices. This was critical to successful establishment on the poorer drained valley soils for spring-planted crops such as tall fescue, spring wheat, and clovers grown for seed. Early seeding also helped increase stand establishment success for creeping red fescue on well-drained hill-land soils.

Table 1. Partial budget cost analysis for three perennial grass seed crops grown in western Oregon comparing conventional and no-tillage establishment.

Establishment system	Perennial ryegrass[1]	Tall fescue[2]	Creeping red fescue[3]
Conventional	$176	$212	$398
No-till	$77	$77	$151

[1] Rotation system: Perennial ryegrass (PRG)-spring wheat-meadowfoam-PRG.
[2] Rotation system: Tall fescue (TF)-winter wheat-meadowfoam-TF.
[3] Rotation system: Creeping red fescue (CRF)-red clover seed-CRF.

In general, seed yield could be negatively affected by direct seeding when poor seedling establishment occurred. Greatest risks to establishment failure occurred when trying to direct seed rotation crops in autumn into tall fescue with large grass crowns or sod-bound conditions following creeping red fescue. Delayed planting times in spring also were more likely to result in poor stand establishment or crop failure than early planting times. As is done in commercial fields, poor stands following autumn planting can be over-seeded in spring. Due to poor soil drainage during the winter at the Linn County site, only spring-planted wheat succeeded in the perennial ryegrass system; autumn-planted wheat was successfully established, but wet soil conditions in spring caused severe stand decline.

Since there were no grass seed yield differences due to planting method (Figure 1), the cost savings accrued by implementing direct seeding resulted in increased net income when using existing planting equipment. Although direct seeding establishment has not been widely adopted at this time by western Oregon grass seed producers, some innovative farmers are establishing their fields using direct seeding methods, and are experimenting with ways to modify existing planting equipment for optimal establishment success.

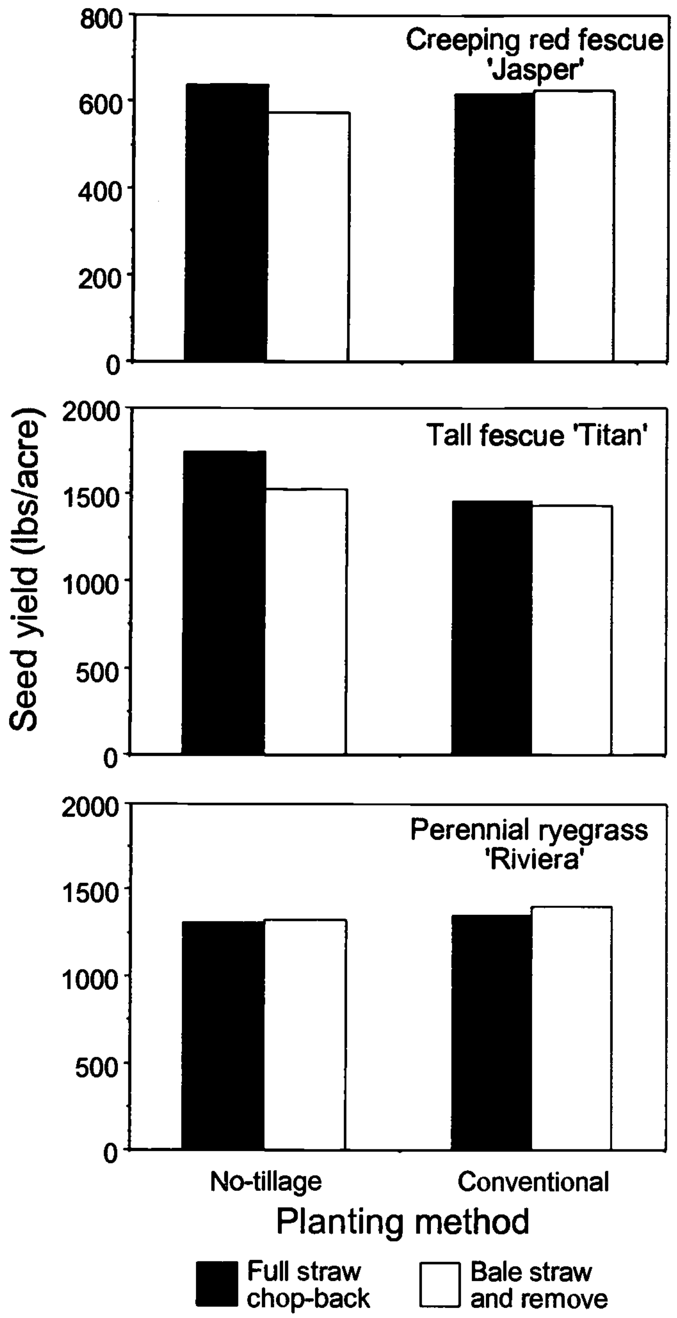

Figure 1. The effect of establishment method and amount of straw remaining after harvest on seed yield of creeping red fescue, tall fescue, and perennial ryegrass (PRG). CRF results are from two harvest years after two plantings in 1993 and 2000; TF results are from one harvest year after planting in 1996 and two harvest years after planting in 1999; and PRG results are from three harvest years in two sequences from 1998 to 2000 and 1999 to 2001 for perennial ryegrass.

In the absence of burning, maximal residue management using full straw chop-back compared to minimal management by baling did not affect grass seed yield in any of the three grasses over the entire nine-year study period (Figure 1). We used the best flail technology available as developed by local equipment manufactures and research reported by Oregon State University. The straw management treatments were applied as soon after seed harvest as possible. Specific details regarding the impact of establishment method and post-harvest straw management on creeping red fescue, perennial ryegrass, and tall fescue are given below.

Creeping red fescue. Even though creeping red fescue seed yield declined with increasing stand age (Figure 2), it was unaffected by the amount of straw residue remaining in this non-burned system (Figure 1). As has been shown by Oregon State University research, the decrease in seed yield with increased stand age was probably a function of the stand becoming "sod-bound," so the number of reproductive sites for seed production were fewer compared to stands that have been burned. For this reason, most creeping red fescue acreage continues to have the straw managed by burning after harvest.

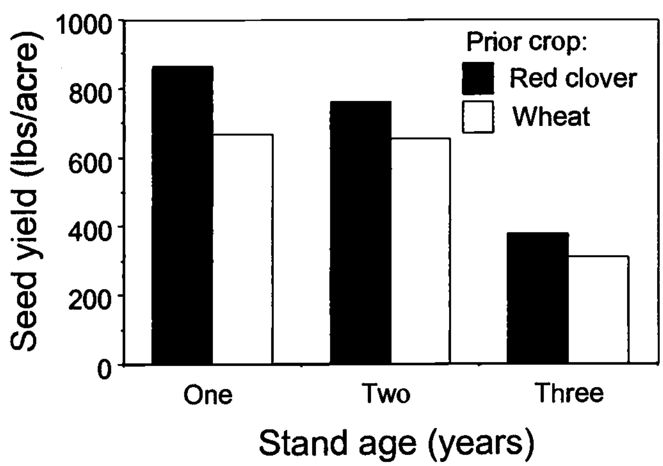

Figure 2. A comparison of creeping red fescue grown for seed after red clover seed and wheat. Note the decrease in seed yield with increasing stand age due to post-harvest management without field burning.

The typical approach for monoculture creeping red fescue seed production utilizing conventional tillage methods employs as many as 15 or more disturbance practices during the fallow period between crops to kill the established stand and prepare the seed bed for planting the next grass seed crop. To use direct seeded planting in creeping red fescue, a rotation crop is needed to ensure field sanitation for seed certification when changing cultivars. A direct seeded creeping red fescue in a monoculture system does not work because there is too much contamination from the previous seed crop in the rotation sequence.

In addition to helping field sanitation, a red clover seed crop in the rotation sequence resulted in greater creeping red fescue seed yields than with a wheat rotation crop (Figure 2). In the direct seed system, spring wheat may be preferable to winter wheat because in addition to the autumn non-selective herbicide application, a spring application can be made prior to wheat planting to ensure control of remaining fine fescue plants from the prior grass seed crop in the rotation sequence. Also, the sod-bound condition of the soil surface makes it very difficult to re-establish small-seeded crops in the autumn without additional time for thatch decomposition. Aggressive straw management after the last seed year harvest may improve autumn planting by no-tillage methods. Additionally, direct seeding and other conservation methods can greatly reduce soil loss from fields by water erosion. We know of no producers at this time who are direct seeding creeping red fescue. The cost savings when using direct seeding, compared to conventional establishment, are more than $240 per acre (Table 1).

Perennial ryegrass. There was no effect from establishment method or straw residue amount on perennial ryegrass seed yield (Figure 1). Cost savings in perennial ryegrass systems were less than those for creeping red fescue because of the reduced trade-off cost differences between non-selective herbicide and conventional disturbance practices (Table 1). Over an entire rotation sequence, the greatest non-selective herbicide costs occurred when changing from perennial ryegrass seed production to rotation crops such as wheat, meadowfoam, or white clover seed because higher rates were needed to control perennial grass control than the other crops. Also, autumn precipitation needs to begin before non-selective herbicides will kill established perennial grass plants. Autumn-planted meadowfoam and spring-planted wheat were relatively easy to establish with few problems from perennial ryegrass or weeds because of available registered selective herbicides and winter fallow non-selective herbicide options.

The grass straw management method may affect the yield of subsequent crops in rotations. Spring-planted wheat yields can be greater with full straw chop back than with minimal residue management approaches, but the effect differed in two experiments (Table 2). Comparing full straw chop back with straw removed by baling, spring wheat yield was 1300 lb/a more after three years of 'Prana' production, compared to wheat after two years of 'Riviera' production. We do not know if wheat yield response to straw management was due to the more than 4 tons/acre difference in the amount of straw that was returned to the soil in the second experiment, or due to difference in precipitation amount. More needs to be learned about the effects of full chop back straw management on grass seed rotation systems. At this time, a majority of perennial ryegrass seed growers remove as much straw as possible using bailing (80-85%) on the nearly 160,000 acres that are not burned.

Table 2. The effect of perennial ryegrass (PRG) straw management method on following direct seeded spring wheat yields in two production years. Wheat yields are the average of five varieties and four replicates. Note that the lack of a wheat yield difference in 1997 may have been due to less total residue returned to the soil after two grass seed crop, compared to following three grass seed crops for the 2001 wheat crop.

Wheat production year	Straw management method: Full straw chop-back	Bale and remove	Sig. level	April to August precipitation
	-------- (lb/a) --------			(in)
1997	5,547	5,882	NS	9.9
2001	6,006	4,647	**	6.7
PRG seed production period	Total straw returned	Total straw removed		PRG variety (Straw years)
1995-1996	13,217	11,922	NS	Riviera (2 yrs)
1998-2000	22,081	20,457	NS	Prana (3 yrs)

** indicates seed yield differences between straw management methods are significant at the 1% level.

Tall fescue. As with creeping red fescue and perennial ryegrass, tall fescue seed yield was not affected by planting method or straw amount (Figure 1). Tall fescue seed production also benefited from red clover seed grown as a rotation crop, compared to a tall fescue monoculture system. A first-year tall fescue seed crop required 90 pounds per acre less nitrogen after red clover, than the tall fescue seed monoculture system (Figure 4). The carry-over rotation effect is masked when higher nitrogen fertilizer amounts are applied. These findings support those reported by OSU Extension that field history can greatly affect the amount of nitrogen fertilizer that should be applied.

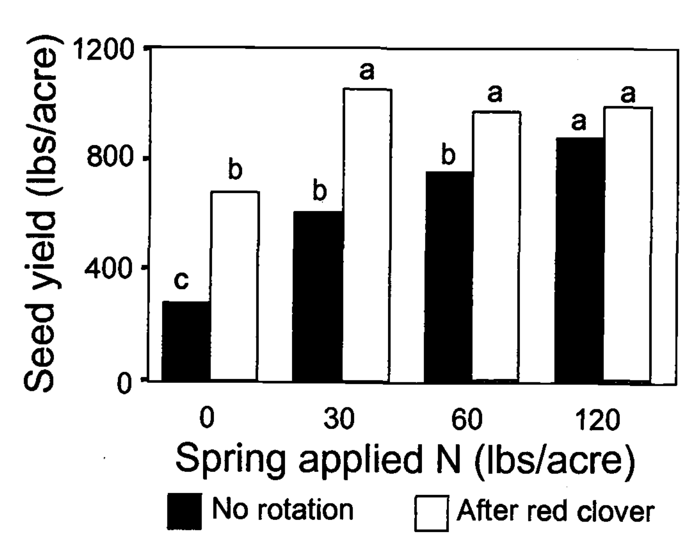

Figure 3. A comparison of spring nitrogen fertilizer rates on first year tall fescue seed yield after tall fescue seed monoculture and red clover seed rotation crops. Note how the red clover rotation crop provided the equivalent of 90 units of nitrogen, compared to the tall fescue monoculture rotation.

As mentioned above, by using no-tillage establishment, poorly drained fields can be planted earlier in spring than when fields have been tilled in autumn. A novel way to use this principle is to relay-plant tall fescue in early spring into a stand of meadowfoam that was planted in autumn. When planted before the meadowfoam plants begin to enlarge, the tall fescue seedlings can emerge with relatively little competition from already established meadowfoam. The meadowfoam seed yield is not affected by the relay-planted tall fescue. This method allows the grower to receive more income in the first year than from autumn-planted fescue after meadowfoam harvest (Table 3). Additional saving result from no additional herbicide costs incurred when relay-planting the tall fescue into meadowfoam, compared to charcoal establishment with autumn planting that requires diuron. This practice has been observed in Linn County with perennial ryegrass spring-planted into meadowfoam.

Table 3. A comparison of seed yields from tall fescue (TF) relay-planted by no-tillage into meadowfoam in early-spring after autumn establishment and conventional soil preparation with autumn planting after the meadowfoam has been harvested. Note that establishment costs for planting are the same for both methods, but no herbicides were used in the relay-planted method. The grower receives more income from the first tall fescue seed year with the relay system than the conventional autumn-planted system.

Crop rotation component	Establishment system: Relay no-tillage	Conventional	System difference
	-------------(lb/a)	-----------	
Meadowfoam	582	632	NS
Tall fescue:			
First	777	121	**
Second	1442	1419	NS
Total TF yield	2219	1540	**

** indicates first year seed yields are different at the 1% level of significance.

Impact of tillage and residue amount on soil quality. Estimated soil quality is generally improved by not tilling the soil and by utilizing crop residues in the field, rather than removing them by baling or other methods. Using the USDA-Natural Resources Conservation Service *Soil Conditioning Index*, we showed no-tillage establishment combined with maximum straw management is not only less expensive, compared to conventional establishment with the straw removed, but also has positive effects on soil quality through increased soil organic matter amount, reduced soil erosion, and decreased soil compaction (Figure 4). We are determining the actual effects of establishment method and straw residue amount on soil organic matter content, soil microbial composition, and soil insect activity that will provide us a more complete understanding about how grass seed production practices affect the long-term soil quality.

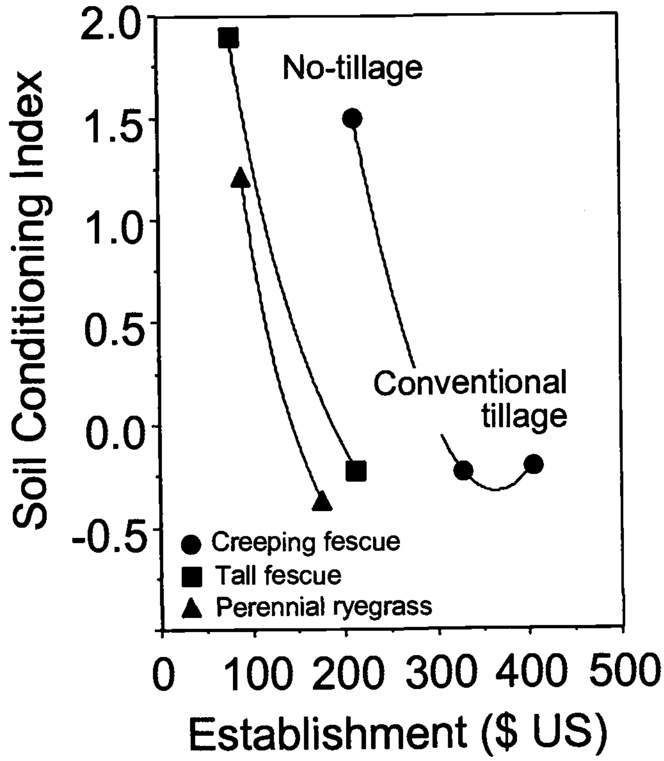

Figure 4. A comparison of no-tillage and conventional tillage on establishment expenses and resulting soil quality in creeping red fescue, tall fescue, and perennial ryegrass seed produced in Marion, Benton, and Linn Counties, respectively. The USDA-NRCS Soil Conditioning Index (SCI) estimates the combined effects for production operations on soil compaction, erosion, and organic matter content. The greater the SCI, the greater is soil quality.

ROW SPRAYING VOLUNTEER ANNUAL RYEGRASS WITH COMMERCIAL FIELD SPRAYERS

M.E. Mellbye, L.B. Gerig, and P.K. Boren

Producing annual ryegrass by the volunteer method of production can reduce costs $50 to $80/a. But seed yields can also be reduced 20% to 30% compared to conventionally worked and planted fields. One of the methods of improving seed yields on volunteer fields is by row spraying with herbicides to thin stands.

The OSU Extension Service, farmers, and industry representatives have cooperated in field research on annual ryegrass seed production since 1993. In addition to row spraying, a variety of agronomic studies were conducted during that time. Experimental plot work with volunteer production and row spraying showed that the practice could increase seed yields when the stand was too dense, and that the greatest benefit occurred when at least 70 to 80% of the stand was sprayed out (see references at the end of this article). In recent years, a variety of row sprayers have been designed for commercial and farm use, but questions remain in the industry about the safety and efficacy of the practice under field scale conditions. The purpose of this study was to demonstrate the effectiveness of row spraying under field conditions typical to annual ryegrass seed production in the southern Willamette Valley. Specific objectives were: (1) determine if seed yield can be improved using different row sprayer designs; (2) measure the response to band applied fertilizer applied over the crop row during row spraying; and (3) obtain efficacy and crop safety data to support labeling of Diurex and Axiom for use on annual ryegrass seed fields.

Methods

Field trials were established on commercial volunteer annual ryegrass stands at 8 locations in Linn and Benton Counties between November 2000 and February 2001. Seven fields were Gulf and one was Surrey annual ryegrass. **Replicated trials:** At field 1 and 2, five treatments were replicated three times in a randomized block design, with individual plots 22 ft wide by 250 feet long. These two trials were designed to compare different row spray herbicide and fertilizer treatments (Table 2). **EUP trials:** The remaining six fields were set up as EUP (EPA-ODA Emergency Use Permit) trials to obtain crop safety data on Axiom and Diurex to support registration efforts, and also to help demonstrate the effectiveness of the row spray practice across a range of farm conditions. Most of these sites included two row spray herbicide treatments (Table 1). The plots ranged in length from 300 ft to 1000 ft and were not replicated at each location. Both sets of field trials included an unsprayed volunteer control treatment. All but field 1 and 7 were grazed. Herbicide applications rates on a sprayed acre basis were: Roundup Ultra 1 qt/a, Diurex 1 qt/a, and Axiom 10 oz/a. Liquid fertilizer was included as a separate treatment only at the two replicated field trials, and was applied as a band over the unsprayed 3 inch crop row at 10 gpa of 20-3-3-3.

Three sprayers used were: **(1) Roth Even-Nozzle Sprayer:** Used on fields 1,2, and 4. A tractor or buggy pulled sprayer with no shields and equipped with flat fan even nozzles (TP 8002 EVS) on 10-inch centers adjusted to spray 6.5-7 inches, calibrated at 18 gpa (per sprayed acre), 30-35 psi spray pressure, and 8-10 mph travel speed. **(2) Western Farm Service Row Sprayer:** Used on fields 3,5, and 8. A tractor pulled sprayer with no spray shield, set up with 4002 FF nozzles on 10-inch centers set to spray 7 inches, 20 psi spray pressure, 8 gpa, and driven at 11 mph. **(3) Shielded Sprayer:** Used on fields 6 and 7. An lightweight ATV pulled sprayer with flat fan nozzles (TP4001E-SS) on 10-inch centers with a curved shield extending to the front and to the sides of each nozzle, 25 psi spray pressure, 6.7 gpa, and set to travel at 8.5 mph.

At harvest, the plots were swathed and combined with grower equipment. Seed yield was measured at most sites with the OSU weigh wagon (a Brent YieldCart) and adjusted for clean seed yield based on cleanout of a representative harvest sample. At one location, field 8, seed yield was obtained from yield monitor data. In this case, 4 paired locations in the field were randomly selected to obtain a yield mean for the two treatments at this field location.

Results

Row spraying had a positive effect on seed yield at all locations, with an average increase in seed yield of 460 lb/a (Table 1). Under the dry conditions of 2001, volunteer fields that were grazed were responsive to row spraying. Field 1, the lowest yielding field in this test and the least responsive to row spraying, was not grazed in 2001, but may also have been damaged by frost during flowering. In previous trials, grazing has reduced the response to row spraying, but both practices seemed to be of benefit to seed production on volunteer fields in this production year.

While the sprayers themselves were not compared side by side in this study, the three different designs were able to create rows in each of the volunteer ryegrass fields. In general, application on fields that were shorter and more uniform in height looked better and had more consistent rows compared to those that were taller and less uniform in height. We also made some observations about controlling spray drift, which is probably the biggest challenge to row spraying. Visually, the least drift problems were from the Roth Even-Nozzle Sprayer. Both the Western Farm Service Row Sprayer and the Shielded Row Sprayer appeared to have occasional drift problems due to windy conditions or turbulence from equipment. Use of even nozzles at low pressure without shielding appeared to be a fairly consistent and reliable way to establish rows. In the fall of 2001, several changes were made in the Western Farm Service sprayer (operation and equipment) that appeared to make a positive improvement in drift control and in obtaining more consistent row patterns in the field: (1) slowing the ground speed from 11 mph to 6-8 mph, (2) addition of a drift retardant agent at a rate of 0.25 to 0.5 oz/100 gallons, (3) addition of a front shield, and (4) narrowing the spray pattern behind the wheels to reduce stand loss in wheel tracks. While the addition of a shield on this sprayer appeared to help, their usefulness depends on the sprayer design and speed. In some cases, shields may be counterproductive because of the turbulance they create.

The three herbicide treatments used to create rows were effective, but Roundup alone was adequate on the volunteer fields selected for this study (Table 2). There was no seed yield advantage to including Diurex or Axiom in the tank mix, nor was there any advantage to applying a band of liquid fertilizer over the remaining crop row at the two locations where this treatment was applied. Including one of the residual herbicides, however, should provide better weed control where annual bluegrass or other weeds are a problem, and our results indicate that either can be used safely with Roundup to row spray in annual ryegrass. Currently, both Roundup and Diurex are labeled for this use, and a 24c label has been submitted to ODA for Axiom.

Acknowledgments:

Thanks to Curt Dannen, Western Farm Service, for spraying EUP trials and providing information on equipment modifications. Thanks to Tom Silberstein and Bill Young, OSU Department of Crop and Soil Science, for help in the harvest of these field trials.

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Table 1. The effect of row spraying on the seed yield of volunteer annual ryegrass, 2001.

Field	Variety of annual ryegrass Location	Row spray herbicide[1]	Spray date	Cleanout	1000 seed wt.	Clean seed yield
				(%)	(g)	(lb/a)
1	Gulf (volunteer)	Check	Dec. 5, 2000	16.0	2.31	711
	Lochner Rd., Linn Co.	Roundup + Diurex		13.0	2.41	817
	Not grazed, frost injury	Roundup + Axiom		15.0	2.31	797
2	Gulf (2nd year volunteer)	Check	Dec. 4, 2000	4.0	2.76	1906
	Seven Mile Lane, Linn Co.	Roundup + Diurex		4.0	2.82	2397
	Grazed	Roundup + Axiom		4.0	2.66	2411
3	Gulf (volunteer)	Check	Nov. 2, 2000	3.0	2.84	2252
	Along I-5, Albany, Linn Co.	Roundup + Diurex		2.9	2.86	2684
	Grazed	Roundup + Axiom		2.3	3.10	2527
4	Gulf (volunteer)	Check	Dec. 5, 2000	3.0	2.71	1443
	Lochner Rd, Linn Co.	Roundup + Diurex		4.1	2.90	1950
	Grazed	Roundup + Axiom		2.5	3.01	1859
5	Gulf (volunteer)	Check	Nov. 10, 2000	2.9	2.80	1784
	Falk Rd, Halsey, Linn Co.	Roundup + Diurex		2.6	2.63	2684
	Grazed	Roundup + Axiom		2.3	2.73	2714
6	Gulf (volunteer)	Check	Feb. 28, 2001	13.8	2.36	1100
	Gibson Hill Dr., Benton Co.	Roundup + Diurex		7.9	2.70	1400
	Grazed	Roundup + Axiom		11.5	2.58	1660
7	Gulf (volunteer)	Check	Jan. 16, 2001	NA	NA	1450
	Lebanon, Not grazed.	Roundup		NA	NA	1680
8	Surrey (3rd year volunteer)	Check	Nov. 17, 2000	3.0	NA	1659
	Tangent, grazed	Roundup + Diurex		3.0	NA	2134
	Average across locations	Check		7.1	2.63	1521
		All row spray treatments		5.8	2.70	1980

[1]Herbicide rates: Roundup Ultra 1 qt./ acre, Diurex 4F 1 qt./acre, Axiom DF 10 oz./acre.

Table 2. The effect of row spraying herbicides and banding liquid fertilizer on the seed yield of volunteer annual ryegrass (Gulf) in Linn County, Oregon, 2001.

Treatment	Herbicide (December 5, 2000)	Clean seed yield Field 1	Field 2
	(product/a on sprayed strip basis)	---------------- (lb/a)	----------------
Volunteer no row spraying	None	711	1906
Volunteer + row spray	Roundup 1qt.	835	2456
Volunteer + row spray	Roundup 1qt. + Diurex 4F 1 qt.	817	2397
Volunteer + row spray	Roundup 1qt. + Axiom 10 oz.	797	2411
Volunteer + row spray + fertilizer in the band	Roundup 1 qt. + Diurex 1 qt. 10 G of 20-3-3-3 liquid	803	2509
LSD 0.05		NS	250

EVALUATION OF ORCHARDGRASS, FINE FESCUE AND BROME VARIETIES IN CENTRAL OREGON, 2001

M.D. Butler, P.J. Sexton, C.K. Campbell and R.R. Bafus

There is a continuing search by the agricultural community in central Oregon to explore new crop opportunities. Since this area is heavily invested in grass and vegetable seed production, evaluating opportunities to expand into additional grass seed crops would be a logical area to pursue. In cooperation with industry representatives, plots were established plots to evaluate varieties of orchardgrass, fine fescue, tall fescue and bromes at the Central Oregon Agricultural Research Center in Madras, Oregon.

Plots were seeded August 11, 2000 at the Central Oregon Agricultural Research Center to evaluate 8 varieties of orchardgrass, 6 varieties of hard fescue, 5 varieties of tall fescue, and 3 varieties of brome. Eighteen foot plots by four rows for all varieties except hard fescue (with 8 row plots) were replicated four times in a randomized block design. None of the tall fescue plots were harvested due to a drop in interest for that species.

Plot harvest was determined by varietal maturity. Eureka hard fescue and Quatro sheep fescue were harvested June 23, followed by harvest of Scaldis II, SR 3100 and Warwick hard fescue and CAS-FCS1 chewings fescue on July 2. All orchardgrass varieties were harvested July 12, along with CAS-AZ11 and BCAPN-1 bromes. There was some shatter in the orchardgrass varieties, but it was slight and appeared to be similar across varieties. BCAPN-1 was overmature with significant shatter and should have been harvested a week earlier, while the timing on CAS-AZ11 appeared correct. One variety of brome was not harvested due to severe shatter.

Seed yields for fine fescue (Table 1), orchardgrass (Table 2) and brome grasses (Table 3) were significantly different between varieties for each of the grass types. Hard fescue variety Warwick produced significantly higher yields (1249 lb/a) than Scallis II (778 lb/a) or Eureka (662 lb/a). SR 3100 hard fescue produced the second highest yield at 1079 lb/a, with the greatest seed yield per biomass. Chewings fescue variety CAS-FCS1 yielded 945 lb/a and Quatro sheep fescue produced 892 lb/a. These yields are competitive to the Willamette Valley production of 775 lb/a.

Table 1. Performance of fine fescue varieties planted August 2000 at the Central Oregon Agricultural Research Center and harvested in 2001.

Variety	Harvest date	Seed yield	Biomass
		(lb/a)	(t/a)
Warwick (hard)	July 2	1249 a[1]	7.7
SR 3100 (hard)	July 2	1079 ab	5.8
CAS-FCS1 (chewing)	July 2	945 ab	6.8
Quatro (sheep)	June 23	892 ab	5.9
Scaldis II (hard)	July 2	778 b	5.8
Eureka (hard)	June 23	662 b	6.4
			NS

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

Table 2. Performance of orchardgrass varieties planted August 2000 at the Central Oregon Agricultural Research Center and harvested in 2001.

Variety	Harvest date	Seed yield	Biomass
		(lb/a)	(t/a)
Quantam	July 12	621 a[1]	4.2
Orion	July 12	487 b	3.9
Frode	July 12	444 bc	4.2
Ambassador	July 12	406 bcd	4.3
Pizza	July 12	388 bcd	3.5
Stampede	July 12	374 bcd	4.0
Mammoth	July 12	367 cd	4.0
Justus	July 12	320 d	3.2
			NS

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

Table 3. Performance of brome grass varieties planted August 2000 at the Central Oregon Agricultural Research Center and harvested in 2001.

Variety	Harvest date	Seed yield	Biomass
		(lb/a)	(t/a)
BCAPN-1 (mountain)	July 12	1683 a[1]	6.3
CAS-AZ11 (smooth)	July 12	781 b	6.7
			NS

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

Orchardgrass varieties Quantam (621 lb/a) and Orion (487 lb/a) yields were significantly higher than either Mammoth (367 lb/a) or Justus (320 lb/a). However, all varieties were significantly lower than the 850 lb/a production in the Willamette Valley.

Mountain brome variety BCAPN-1 produced an outstanding yield of 1683 lb/a despite significant shatter at harvest, which was estimated to be about a week late. Smooth brome variety CAS-AZ11 was harvested in a timely manner and produced 781 lb/a.

TESTS OF PROPANE BURNING OR FUNGICIDES TO REDUCE ORCHARDGRASS CHOKE DISEASE

W.F. Pfender and S.C. Alderman

Introduction

The pathogen *Epichloë typhina* has recently become established in orchardgrass seed production fields in Oregon. Choke disease, caused by this fungus, can be a limiting factor for orchardgrass seed production because it effectively prevents emergence of the seed head. It does not affect forage quality.

E. typhina grows without symptoms in the host until the time of flowering, when it rapidly engulfs the floral apex and surrounding leaves. It develops a felt-like stroma which starts out white and changes to bright yellow. Spores from the stroma, when dispersed to other plants, initiate the next yearly infection cycle. However, the timing and site(s) of infection have not been conclusively determined. The only published reports of experimental inoculations producing orchardgrass choke disease in the next season were achieved by application of spores to the cut ends of stems after harvest, and this infection process is currently accepted as the pathogen's mode of entry. After a plant becomes infected, the pathogen can colonize new tillers that develop from the originally-infected tiller(s). The rate and timing of this within-plant spread has not been determined. Despite the fact that the pathogen cannot persist outside of host tissue, and moves from plant to plant only during a relatively short period of the year, *E. typhina* can increase significantly from year to year in a stand. An important component of epidemic management is reducing the rate of increase for each yearly infection cycle.

If it is true that the pathogen enters through stubble at or after harvest, it may be possible to reduce spread of the disease by interfering with establishment at this infection site. It is noteworthy that the fungal stroma dries quickly after being cut from the plant during harvest, and loses the ability to release infective spores within hours of cutting if it is not supplied with water. Therefore a reasonable management strategy would be treatment of the presumed infection site after harvest, when the airborne spore load has essentially disappeared. Also, because the fungus is able to spread from plant to plant only during the relatively brief period when spores are produced (mid-May to June), it might be possible to apply fungicides that could reduce spore production or viability.

In a search for methods to slow the epidemic, we tested fungicides in laboratory and field experiments. We also conducted field trials to test treatments that could disrupt establishment of post-harvest infection, thereby slowing epidemic rate.

Procedures

Laboratory and greenhouse tests of fungicide activity. Stroma (choke) formation was induced in infected plants that had been transplanted into a greenhouse. Plants were sprayed with fungicide or water (check) just before heading, shortly before most chokes would become visible. The fungicide was a tank mix of Tilt (propiconazole) and Quadris (azoxystrobilurin), applied at a rate equivalent to 6 and 9 oz per acre, respectively, in 20 gal water with 1% surfactant. The number of chokes produced per plant was counted. To determine if fungicide sprays to the stroma would reduce viability of newly-formed spores, spores were collected from sprayed and non-sprayed chokes 4 days after treatment, and compared for germination.

To determine the effect of fungicide concentration directly on spore germination, spores were collected from several chokes that were not sprayed with fungicide. The spores were placed in drops of fungicide at various dilutions, and germination was measured.

Field study of residue treatments. Orchardgrass was planted at Hyslop experiment farm, and standard fertilizer and herbicide treatments were applied. At the end of June each year, the stand was swathed with a cycle-bar mower. The cut material was removed from the plots approximately 1 week after swathing, just before the first treatments were applied each year.

To provide inoculum for epidemic development, actively-sporulating chokes of *E. typhina* were placed into the plots for several days immediately after harvest in 1998, 1999 and 2000. Individual replicate plots were marked out in the planting after harvest in 1998. Each plot received one of the following 7 treatments: early burn, late burn, early reclip, late reclip, early fungicide, late fungicide, non-treated check. Treatment dates are shown in Table 2. The early treatments were not repeated for the 2000-2001 year, because there was no statistical difference in the June 2000 results between early and late treatments.

The burn treatment was accomplished with a hand-held propane torch. Sufficient flaming was applied to burn most of the dead straw and to kill green leaves back to approximately 1 inch above the ground surface. Reclipping was done with a cycle-bar mower to a height of approximately 2 in. Fungicide applications were made with a backpack sprayer. The application was a tank mix of Tilt (propiconazole, 6 oz per acre), Quadris (azoxystrobilurin, 9 oz per acre) and surfactant (1% by volume) in 20 gal of water per acre.

Choke in the plots was counted in June of 1999, 2000 and 2001.

Results

The fungicides propiconazole and azoxystrobilurin were ineffective in preventing stroma formation on infected plants, even when applied shortly before stroma emergence (Table 1). Conidia produced on chokes that had been treated with fungicide 4 days previously showed only slight reduction in germination. When the spores produced on non-sprayed chokes were exposed to fungicides during germination, both fungicides were inhibitory. Propiconazole was somewhat less effective than azoxystrobilurin. Almost all spores exposed to a mixture of the two fungicides at full or 1:10 concentration were inhibited from germination, and germination at 10-fold dilutions from 1:100 to 1:10000 was 15%, 30% and 62%, significantly less than the check.

In field tests, there was almost no visible choke disease in June 1999, despite inoculation of the plots in July 1998. In June 2000, a substantial amount of choke was evident (Figure 1). In plots with no stubble treatment (check), there were 38 choked tillers per yd^2 (Table 3). The average number of total flowering tillers per yd^2 (diseased + healthy) was 360 (data not shown), so this incidence in the check plots represents approximately 11% diseased tillers. Disease incidence in plots where stubble was treated either by fungicide spray or reclipping in July 1998 and 1999 was similar to that in non-treated plots. There was no significant effect of treatment timing; fungicide or reclipping treatments were ineffective whether applied within a week after harvest or after a delay of 2-3 weeks (Table 3). In plots where stubble was burned with the use of a propane torch, the incidence of choke in 2000 was significantly lower than in the non-treated check or other treatments. There was no significant difference between early and late burning. Early treatments were not applied in July 2000, as their disease levels had not differed from late treatments, and they have limited practical applicability since field operations typically must wait at least 7-10 days after cutting while the windrows dry.

Statistical analysis showed the rate of yearly increase to be significantly lower for the burn treatment (9.6 chokes/yd^2/year) than for the non-burn treatments (31-35 chokes/ yd^2/year) (Table 3 and Figure 1). These rates correspond to 2.7% and 9.2% choke per year, respectively.

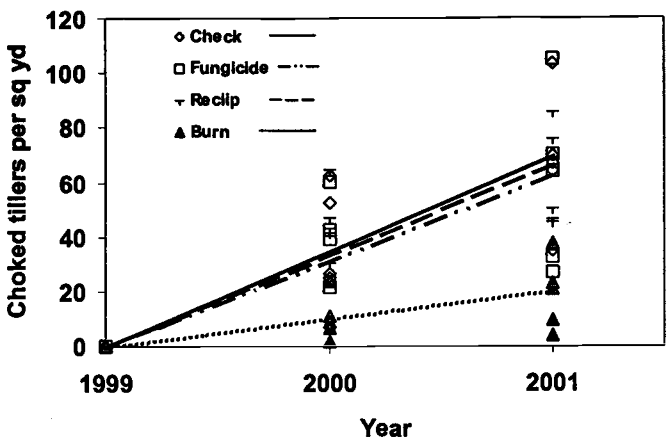

Figure 1. Choked tillers per square yd in plots of orchardgrass where the indicated treatments were applied after harvest in the prior year (1998, 1999, and 2000). Each point represents one replicate plot. Each line is the mean of 5 slopes per treatment (1 per replicate plot) for the increase in choke disease over the years 1999-2001.

Discussion

Epichloë typhina colonizes a newly-infected plant by getting into the meristematic tissue, where it grows with and finally destroys the floral apex the following season. The observed epidemic increase apparently was due to successful meristematic infection by spores of the fungus each year, possibly by initially growing down through the pith from the cut ends of reproductive tillers after harvest as suggested by other researchers, and subsequent within-plant increase.

Our investigations show that currently-available systemic fungicides are not useful to interrupt the infection process. Stroma formation by the endophytic fungus apparently is not vulnerable to applications of propiconazole and azoxystrobilurin (Table 1), despite the toxicity of these materials to the fungus. Even when the fungicides are sprayed directly onto the stroma at a typical application rate, production of viable spores continues. The slight reduction in viability of these conidia is of no practical significance. Given the inhibition of spore germination by direct fungicide exposure, we tested the use of fungicide applied to the putative infection site (the cut tillers) but saw no resultant interference with epidemic development (Figure 1), even when the application was made within several days of presumed inoculation (Table 3). These failures of fungicide efficacy are probably due to insufficient tissue concentration of fungicide at the target sites.

If the infection truly occurs via the cut stems, it might be possible to disrupt the infection process by reclipping the stubble to remove the slowly-growing fungus before it can reach the crown of plant. However, our field experiments demonstrated that reclipping was completely ineffective in reducing rate of disease increase (Figure 1). Although it is possible that the fresh wounds caused by reclipping could themselves have become infected, this is unlikely because sporulating stroma had been removed from the field at least two weeks before the second (late) reclip treatment was done, and all orchardgrass stands within several miles of the test site had been cut at least two weeks before this reclip treatment, removing other sources of inoculum. This result suggests that there are sites of entry for *E. typhina* other than, or in addition to, the cut ends of tillers in the stubble.

Burning, which destroys stubble and some of the lower leaves but does not damage the crown and meristems, is effective in reducing the infection rate (Figure 1). This observation indicates that the pathogen resides for a time in tissues near the crown from which it can later infect meristematic tissue. The fact that infection rate was not eliminated but reduced (3% per year, compared to 9% per year for the checks) suggests that, within a few days to 2 weeks after harvest, some infections are established in the crown or lower part of plant not reached by subsequent flaming. Investigation is needed to identify the time and site(s) of infection by this pathogen.

The observed reduction in epidemic rate due to burning (Figure 1) is significant. Reducing the yearly infection rate from 9% to 3% would prolong the economically useful life of the stand for seed production, thereby limiting the recurrence of stand establishment costs. Although propane-assisted burning of stubble has not been widely adopted, the results suggest that other treatments such as chemical burning or biological control in the stubble should be investigated. Open-field burning of post-harvest straw and stubble was tested in three fields of one grower for three years. In only one of those trials was there a notable reduction in the spread of choke disease within the field. It may be significant that this one test was the only case among the 9 trials in which burning was accomplished within several weeks of harvest, the burning in the other cases having been delayed until 4-10 weeks after swathing.

Acknowledgments

We thank Sheila Seguin for technical assistance.

Table 1. Number and size of *Epichloe typhina* stroma on orchardgrass plants treated with fungicide shortly before stroma emergence.

Treatment[1]	Trial 1 Sprayed twice		Trial 2 Sprayed once		Trial 3 Sprayed once	
	Stroma per plant	Stroma size (cm)	Stroma per plant	Stroma size (cm)	Stroma per plant	Stroma size (cm)
Fungicide	8.4	5.9	14.0	7.7	10.0	9.9
Check	11.4	6.8	14.8	7.3	10.8	8.5
.	NS	NS	NS	NS	NS	NS

[1]Fungicide was a mixture of propiconazole and azoxystrobilurin at a rate of 6 and 9 oz/acre, respectively, in 20 gal/acre of water. Plants were in pots, 1 plant per pot and 8 pots per replicate, grown under greenhouse conditions.

Table 2. Post-harvest treatment times in orchardgrass choke trials.

Year	Harvest date	Stubble height	Introduced inoculum		Irrigation or precipitation (date:amount)	Treatment[2] dates	
			Source[1]	Dates		Early	Late
1998	6/30	8 in.	Potted plants	6/30 – 7/2	6/30: 0.6 in. 7/1: 0.4 in.	7/3	7/16
1999	6/30	8 in.	Cut stems in water	7/1 – 7/3	7/1: 0.6 in. 7/2: 0.4 in.	7/6	7/20
2000	6/29	4 in.	Cut stems in water	6/30 – 7/5	6/30: 0.1 in. 7/3: 0.2 in. 7/4: 0.2 in.	--[3]	7/21

[1]Mature, ascospore-bearing stroma were on orchardgrass stems collected from an infected field, either as whole potted plants or as cut stems projecting from vessels of water.
[2]Fungicide, reclip, burn or check treatments were applied to post-harvest stubble in each plot once per year (either early or late).
[3]No early treatments were applied in 2000.

Table 3. Yearly increases in orchardgrass choke disease, and overall mean rate of increase, for post-harvest stubble treated with burning, reclipping or fungicide.

Stubble treatment	Timing[1]	Diseased tillers per sq. yd. Single-year increase 1999-2000	2000-2001	Mean increase per year, 1999-2001
Non-treated check		38.4 a	30.0 a	34.8 a
Fungicide	Early	49.2 a		
	Late	37.4 a	22.8 a	31.2 a
Reclipped	Early	37.3 a		
	Late	45.3 a	22.4 a	33.2 a
Burned with propane	Early	7.0 b		
	Late	10.4 b	8.8 b	9.6 b
P value		0.014	0.029	0.004

[1] Early treatments were applied within 1 wk after harvest, late treatments at 2-3 wk after harvest (see Table 1).

WEATHER CONDITIONS THAT DETERMINE INFECTION BY THE STEM RUST FUNGUS IN GRASSES

W.F. Pfender

Introduction

Disease advisory systems increasingly have become an important tool for crop disease management, and an advisory system for managing stem rust (caused by *Puccinia graminis* subsp. *graminicola*) would be beneficial. Stem rust is not equally severe in all years, and fewer fungicide applications undoubtedly are warranted in some years. Furthermore, for those applications that are made, timing could be optimized for maximum efficacy if epidemic development processes were well quantified. An essential component of most disease warning systems is assessment of the likelihood of infection. For rust fungi and many others, temperature and moisture are typically the weather factors most closely correlated with infection likelihood. For stem rust, infection occurs during the night and early morning, so the weather between sunset and mid-morning of the following day is the key influence on daily infection.

The objective of this work was to develop an infection model, based on the infection biology of *P. graminis* subsp. *graminicola*, that can be used easily in disease advisory calculations for stem rust of perennial ryegrass grown for seed.

Procedures

The basic approach to obtain data for the model was to apply an abundance of inoculum to plants, then expose them overnight in the field while monitoring weather conditions. Many such exposures were done, and the disease severity in each case was compared with weather measurements taken during exposure.

Plants were grown to 11 weeks of age in a greenhouse, and inoculated with rust spores. Then they were placed in a field of perennial ryegrass at the Hyslop experiment farm, at approximately 4 p.m. on each test date. At noon the following day, all plants were returned to a greenhouse where they were maintained in such a way that the leaves were never wet. This procedure prevented any infections from occurring subsequent to field exposure. Two weeks after exposure to field conditions, the plants were scored for rust severity. Tests were conducted approximately every two weeks during March-July in 1998, 1999 and 2000, and September-October 1999. In summer of 2001, several inoculations were conducted as part of another study. In these cases, inoculum was applied to plants in a stand of perennial ryegrass sown the previous fall. Inoculations were performed on April 26, May 16, May 29, and June 6. As a check treatment, some plants received no inoculum. Each of these tests was scored shortly after the rust pustules became evident.

Weather conditions at the field site were monitored with an electronic weather station. The following measurements were made: air temperature at canopy height, leaf wetness duration (estimated with flat-plate resistance sensors facing west, placed approximately 5 cm below the top of the canopy), relative humidity 5 ft above the ground, and precipitation. In spring and summer of 1998 and 1999, weather factors were recorded every 30 min. In fall 1999 and spring-summer 2000, the weather station was programmed to make calculations of wetness degree-hours (see below) from weather factors measured at 5-minute intervals.

Results and Discussion

A model was developed based on the following ideas: 1) The fungus activity necessary for infection happens only in the presence of moisture; and, 2) The time required for infection depends on temperature – that is, nothing happens if the temperature is too cold, and the process goes increasingly faster at warmer temperatures. Also, there are separate events that occur in the dark (spore germination) and after sunrise (penetration of the leaf), and both are required for infection. The best fit between temperature data and infection was obtained by using degree-hours with a base temperature of 1.5°C (35°F). Degree-hours were summed only during intervals of leaf wetness (i.e. "wet degree-hours," designated DH_w), and were the basis for predicting infection.

Infection was more strongly affected by morning DH_w than by nighttime DH_w , although a minimum of each appeared necessary. Also, infection severity was proportional to nighttime DH_w up to some point, after which additional DH_w had no additional effect. Cumulative morning DH_w was calculated for the 150 min following sunrise. Also, I observed that several trials having less infection than predicted from degree-hr calculations had an interrupted nighttime wetness period, so a correction factor for interrupted wetness period was included.

The wetness duration and temperature data for selected infection trials are illustrated in Figure 1, together with the respective infection severity that occurred in the trial. The most likely conditions for infection are warm temperatures during nighttime and, especially, early morning periods (Figure 1A). Infection likelihood is decreased if the nighttime wet period is interrupted (Figure 1B), or if DH_w are reduced because of short wetness duration (Figure 1C) and or cold temperatures (Figure 1D). Infection generally did not occur if wet degree-hours were close to zero in either the nighttime or post-sunrise periods (Figure 1E, 1F).

The final equations for predicting amount of infection from the weather data are being developed and tested. Preliminary analysis shows that the model does a good job of predicting infection amounts on inoculated plants in the various trials, including the tests of older, field-grown plants.

In the model being developed, I do not provide for a decrease in infection probability at high temperatures. Such a decline undoubtedly could occur, but only when temperatures exceed about 82°F. In 4 years of weather records (1998 - 2001) for the Willamette Valley there were no nights or mornings (within 150 min of sunrise) warmer than 80°F during the seed-crop growing season (September 15 - July 15).

Note that the model provides information only about the favorability of weather for stem rust infection, assuming there is a lot of inoculum present. Eventually, the infection model will have to be combined with estimates for inoculum availability. It will also have to be adjusted for cultivar and fungicide effects to construct an epidemic model useful for stem rust management.

Acknowledgment
I thank Sheila Seguin for excellent technical assistance in this research.

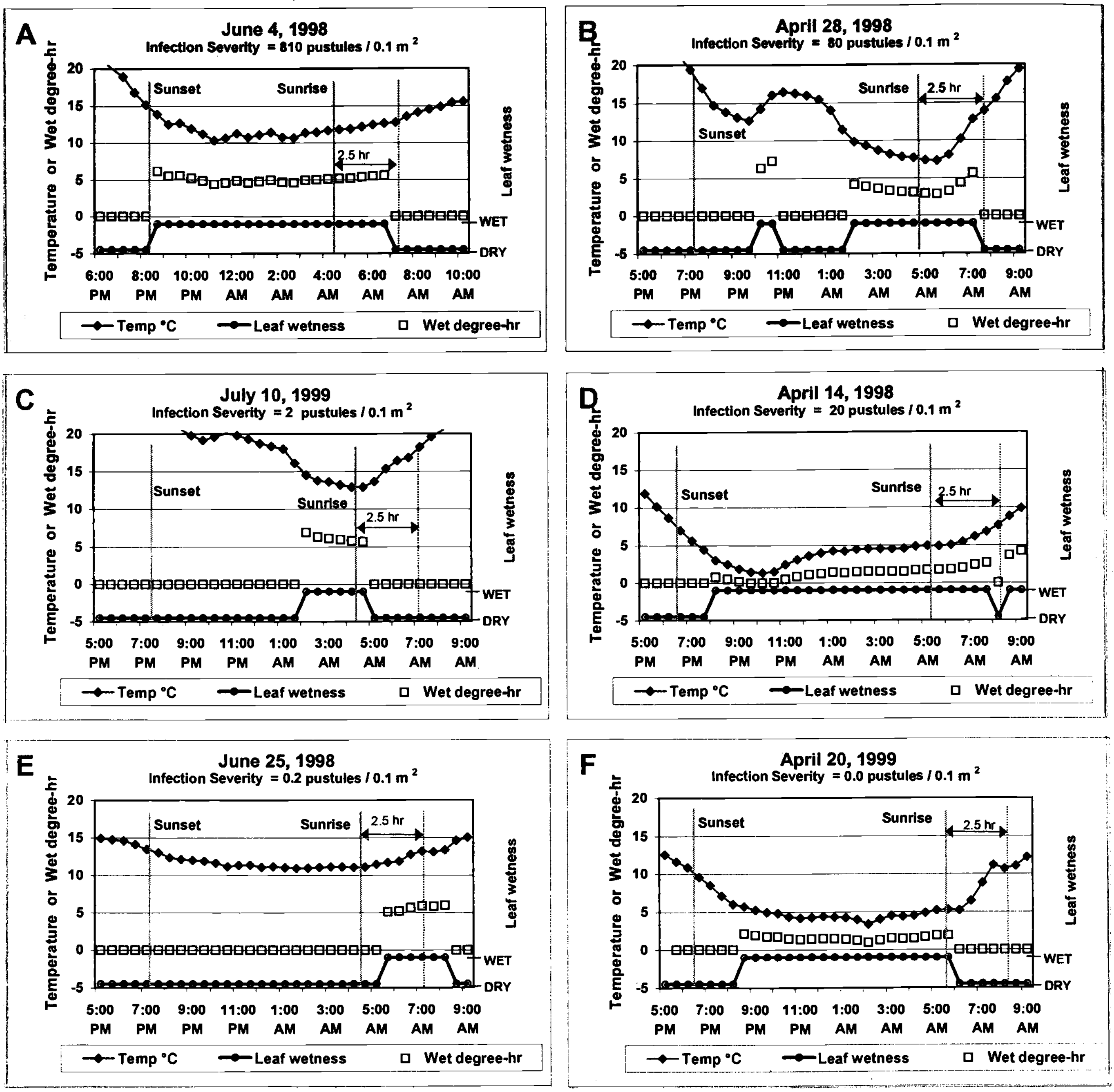

Figure 1. Weather factors correlated with stem rust infection severity in perennial ryegrass. In each figure, half-hour readings for canopy air temperature and leaf wetness are shown. Wet degree-hours (DH_w) are calculated at 0.5-hour intervals as: (temperature°C - 1.5) X 0.5 **A,** Infection severity from the applied standard inoculum is high after continuous leaf wetness and warm temperatures. The other examples show conditions less favorable for infection due to: **B,** interruption in wetness duration; **C,** reduced DH_w from short duration or **D,** cold temperatures; or absence of leaf wetness during either the **E,** nighttime or **F,** morning periods. To convert temperatures to °F: 0°C = 32°F, 5°C = 41°F, 10°C = 50°F, 15°C = 50°F, and 20°C = 68°F.

SEPARATION OF *ANGUINA* FROM ORCHARDGRASS SEED

S.C. Alderman and D.M. Bilsland

The genus *Anguina* includes nematodes that cause galls in grasses. In bentgrass, *Anguina agrostis* replaces seed with hard, elongated, black, needle like galls that extend from the grass flowers. A different, and to date, uncharacterized species occurs in orchardgrass. Galls in orchardgrass are somewhat shrunken, smaller than healthy seed, and purplish in color. However, they are typically covered by lemma and palea and the covered galls look identical to healthy seed.

The average weight of a nematode gall from orchardgrass was 0.12 mg and weight of a healthy seed was 0.86, suggesting that separation of galls from seed samples, based on difference in weight (terminal velocity), may be possible. An air column was used to investigate the separation of galls from orchardgrass. A hot-wire anemometer was used to determine air velocity at column air flow settings. A dissecting microscope with dark-field illumination was used to differentiate galls from healthy seed. Galls were verified by carefully lifting the palea and confirming the shape and color of the suspect galls.

Fifteen galls were colored with a fluorescent marker to facilitate visual inspection and hand separation of galls. The galls were mixed with 3 grams of seed from a seed lot of Potomoc orchardgrass and fractions separated in an air column at 1.7, 2.0, 2.3, 2.5, 2.8, and 3.1 m/s. Weights of lifted and remaining fractions were determined. The process was repeated with three other lots of Potomoc.

All galls were separated from seed at 2.8 m/s (Figure 1). However, about 11% of the initial seed weight was included in the fraction. For a 50% reduction in galls, a 2-5% reduction in seed could be expected. These results suggest that removal of galls of *Anguina* from orchardgrass, based on air flow velocity, is possible, although complete removal could be accompanied with a significant loss of lighter-weight seed.

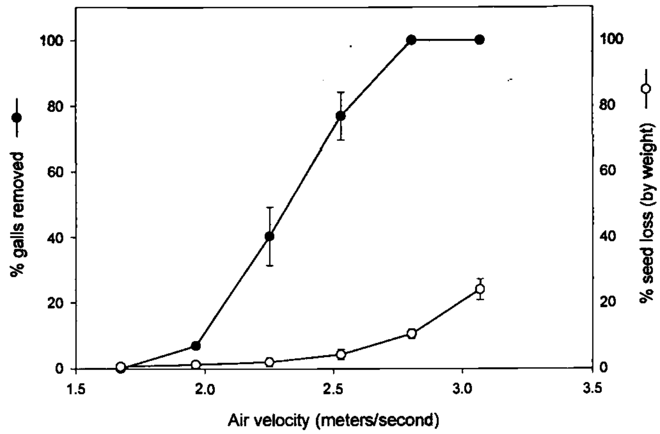

Figure 1. Percentage removal of *Anguina* seed galls from orchardgrass seed and associated seed loss at various air velocities within an air-column separator.

EVALUATION OF INSECTICIDES FOR CONTROL OF WESTERN ORCHARDGRASS BILLBUG

G.C. Fisher, J.T. DeFrancesco and S. Rao

Introduction

The western orchardgrass billbug (*Sphenophorus venatus confluens* Chittenden), is a serious pest of our orchardgrass grown for seed in the Willamette Valley (Kamm 1969; Fisher *et al.* 2002). This pest is a beetle, more specifically a weevil, not a "bug". In the spring the beetles that overwintered in or near the field margins become active. At this time they mate and feed on developing grass blades that are still folded longitudinally and just beginning to emerge from the plant crowns. As these leaves grow and elongate in March and April, distinctive, paired feeding holes about 1/4 to 1/3 inch in diameter become noticeable.

Females insert eggs into the bases of differentiating stem tissue in the plant crown or between the leaf sheath and stem from early May through early July. Eggs hatch in one or two weeks and the larvae feed in stems and crowns through September. This larval feeding damage is quite serious and often results in significant die-out in heavily infested fields if control measures are not taken. Needless to say, seed yields drop drastically after a field becomes infested.

Even though there is but one generation per year and the life cycle of the billbug is fairly simple, few effective control strategies have been developed other than proper timing of an effective insecticide timed to kill the adults in the spring. The application is timed so that most of the overwintered beetles are in the field and actively feeding but before females begin to deposit eggs (early May).

Although post-harvest open field burning would seem to be an effective control, it really isn't. This is because at the time of burning, the billbugs are usually still deep in the crowns and roots of the orchardgrass and fairly well protected from the short-lived fires. Example: one of last year's burns in part of a heavily infested field resulted in a reduction of only about 1/3 of the field population when compared to the population of billbugs in the unburned parts of the field. In fact, burning orchardgrass fields seriously infested with billbugs has in the past often resulted in large "dead areas" because the weakened crowns are unable to rebound from the damage caused by both billbug and fire.

A succession of insecticides beginning with the chlorinated hydrocarbons (Aldrin, Dieldrin), followed by diazinon 14G and most recently Lorsban 4E, have been the most cost effective means of controlling billbugs in orchardgrass grown for seed. Lorsban 4E is applied at 1 quart per acre, usually in late April just before heavy machinery will damage the differentiating crowns of the orchardgrass. The goal is to apply insecticides in late April when billbugs are active in the spring but before significant egg laying has begun (early May).

It is essential that Lorsban (and any other insecticide that will be developed to control this pest) be applied during a light rain. This insures the insecticide will reach the crown where the billbugs live, feed, seek cover and reproduce. If it is not raining during application, the insecticide residue dries on the leaves above the billbugs. Furthermore, Lorsban essentially does not rehydrate with subsequent rain showers. It stays where it dried, above and away from the billbugs.

Poor control of billbug with Lorsban over the last few years has been observed in many commercial fields as well as in our field trials. Insecticide tolerance, poor coverage, and possibly applying product too early – before billbugs have all come out of hibernation appear to be the most likely underlying causes.

Objective

A major objective of our research in orchardgrass has been to find and label new insecticides to control this serious pest. Few, if any, biological control agents other than isolated epizootics of a naturally occurring fungus disease of billbugs have been observed to exert much control of the western orchardgrass billbug. It is highly likely that certain strains of endophytic fungi exist that could provide effective control of this billbug. Obviously an endophyte containing orchardgrass variety would not be acceptable as livestock pasture or feed!

Discussed below are results of trials conducted on grower fields with "challenging" infestations of the western orchardgrass billbug. The objective was to compare promising insecticides with a likely fit in our grass seed industry for control of billbug.

Methods - Trial 1:

A field trial was conducted in 1999 in a 5-year old commercial field of orchardgrass (cv. Pennlate) in Linn County near Corvallis. Treatments included: thiacloprid (Calypso 2E) @ 0.125 lb. a.i./a, bifenthrin (Capture 2EC) @ 0.1 lb. a.i./a, chlorpyrifos (Lorsban 4E) @ 1.0 lb. a.i./a, Spinosad (Success 2SC) @ 0.094 lb. a.i./a, and lamda-cyhalothrin (Warrior) at 0.03 lb. a.i./a. An untreated control was included for comparison. Insecticides were applied on 4/20/99 with a CO_2 backpack sprayer equipped with a 3-nozzle boom (TeeJet 80003vs flat fan) at 30 psi, at a rate of 38 gallons of water per acre. Treatments were applied to 25 x 25 ft plots in a completely randomized design with five replicates.

On 4/28/99, treatments were evaluated by digging and breaking apart five crowns (each approximately 1.0 sq. ft.) per plot for detection of billbugs. A series of three screens were used to collect and remove billbugs from each sample.

Commercial harvest of the orchardgrass seed occurred on 7/15/99. On 7/23/99, five crowns (each approximately 1.0 sq. ft.) were dug from all plots, placed in a greenhouse and watered to stimulate regrowth. On 9/1/99, the number of new, viable shoots per sample was recorded. On 9/8/99, crowns from the Capture, Warrior and untreated plots were broken apart and sieved through a series of three screens to determine billbug population (adults, pupae and larvae).

Methods - Trial 2:

In 2000 the trial was repeated in a 6th year orchardgrass field (cv. Pennlate) using larger plots to counteract the effects of adult migration into the more effective plots from the less effective plots and the adjacent untreated areas of the field. Treatments were applied by the grower to 100 x 450 ft strips. Treatments included: bifenthrin (Capture 2EC) @ 0.078 lb. a.i./a applied either once or twice, chlorpyrifos (Lorsban 4E) @ 1.0 lb. a.i./a, Spinosad (Success 2SC) @ 0.094 lb. a.i./a. Insecticides were applied in the equivalent of 28 gallons of water per acre as broadcast sprays using a 50 ft boom. Treatments were applied on 4/14/00; a second Capture application was made on 4/21/00. An untreated control was included for comparison.

Treatments were evaluated on 5/4/00 by digging and breaking apart ten crowns (each approximately 1.0 sq. ft.) per plot, using a series of three screens to collect and remove billbugs from each sample.

Also in 2000, and again in 2001, two 3-acre plots were treated with Capture 2EC Insecticide/Miticide in late April with 5 and 6.4 ounces product per acre (0.09 to 0.10 lb a.i./a) to control western orchardgrass billbug. Sprays were applied during light rains with commercial sprayers using 25 to 35 gallons of water per acre.

Results - Trial 1

Table 1. Effect of insecticides on western orchardgrass billbug population and shoot regrowth in orchardgrass in 1999.

Treatment		Live adult billbugs 8 days after treatment	Shoot[a] regrowth
(lb a.i./a)		---- (Number/sq. ft.)--	
0.125	Calypso 2E	8.8	42.2
0.1	Capture 2EC	3.4	45.7
1.0	Lorsban 4E	12.4	35.8
0.094	Spinosad 2SC	7.0	38.1
0.03	Warrior 1E	5.6	42.8
Untreated		10.8	32.9
		NS	NS

[a] Crowns removed from field 7/23/99 (after harvest) and evaluated on 9/1/99

Table 2. Effect of insecticides on western orchardgrass billbug population in crowns of orchardgrass after regrowth in 1999.

Treatment		Billbug population[1]			
		Larvae	Pupae	Adults	Total
(lb a.i./a)		-------------(Number/sq. ft.) -----------			
0.1	Capture 2EC	4.0	1.3	0.6 a[2]	5.9
0.03	Warrior 1E	3.1	1.0	1.0 a	5.1
Untreated		2.2	1.5	2.3 b	6.0
		NS	NS		NS

[1] number of billbugs determined on 9/8/99

[2] means in columns followed by the same letter are not significantly different at the p=0.05 level.

At first glance, Capture 2EC does not appear to be the highly effective product it is for controlling billbugs. However, we believe plot size was too small, allowing immigration of billbugs from plots sprayed with less effective products and untreated areas occurred for at least 30-40 days post spray. This effect blurred both adult control (Table 1) and subsequent reduction of larval numbers (Table 2) that should have been noticed.

Regardless, single applications of either Capture® 2EC or Warrior® 1E did result in substantial reduction of billbugs after 8 days (Table I). 2).

Results - Trial 2

In trial 2, there was a significant difference between treatments the results of which indicate just how effective Capture 2EC can be in controlling adults of the western orchardgrass billbug (Table 3).

Interestingly, spinosad (Success 2SC) from DowAgrosciences appears to have good activity on billbug, too. Spinosad is an insecticide derived from the fermentation process of an Actinomycete, *Saccharopolyspora spinosa*, and is a "reduced risk" insecticide. Note that Lorsban 4E apparently did not provide control of western orchardgrass billbug in either trial.

Table 3. Effect of insecticides on western orchardgrass billbug infesting a commercial stand of orchardgrass produced as a seed crop, 2000.

Treatment	Live Billbug Adults
	(Number/sq. ft.)
Capture 2EC, one application	1.0
Capture 2EC, two applications	0
Lorsban 4E	6.0
Spinosad 2SC	2.0
Untreated Check	8.0
	NS

Field observations in 2000 and 2001 on 2 and 3 acre size plots treated with Capture® 2EC for control of western orchardgrass billbug.

Within hours of applying Capture insecticide to orchardgrass fields, disoriented billbugs are observed between rows. However, it has been our experience that it takes one to two weeks to begin seeing the full effect of a Capture application. In two heavily infested fields where 40% or more of the plant crowns displayed adult feeding damage just before an application of Capture in the third week of April, it was difficult to find more than 1 or 2 % of the crowns with adult feeding damage the subsequent spring.

Discussion

A crisis exemption for Capture 2EC was determined appropriate and granted by the Oregon Department of Agriculture beginning at 6 AM on April 3, 2002. As with Lorsban, when used to control this pest on orchardgrass, it is necessary and highly recommended that this application be made during a light rain to insure penetration of product through canopy to the crowns of the grass where the billbugs are active.

In brief, one application of 6.4 fl. oz/a of product may be applied to orchardgrass for billbug control. Capture 2EC Insecticide/Miticide is a Restricted Use Insecticide due to toxicity to aquatic invertebrates and certain fishes. It must be applied by ground only and must have a 25 foot buffer zone between sprayed areas and water. It is also highly toxic to bees if sprayed directly over them or onto bloom that bees are actively foraging upon.

A special note of thanks is extended to Western Farm Service's Bob Schroeder as well as the Rohner family and James VanLeeuwen for the service, support and patience that made these trials possible. In addition, Mr. David Priebe of the ODA worked tirelessly in developing this crisis exemption and through his efforts growers were able to use Capture during the spring, 2002.

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FIELD EVALUATION OF CEREAL LEAF BEETLE PHEROMONE IN OREGON

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

Introduction

Oats, barley, wheat, and a wide range of grasses are prone to damage by a new pest in Oregon, the cereal leaf beetle (CLB), *Oulema melanopus* (L.) (Coleoptera: Chrysomelidae) (Royce and Simko, 2000). CLB was first found in Oregon in 1999 but it is spreading rapidly. Statewide surveys by the Oregon Department of Agriculture indicated that it was present in eight counties in 1999, ten in 2000, and 14 in 2001 (Bai *et al.*, 2002).

In Oregon, CLB has one generation per year. Adult beetles overwinter in field debris, grass crowns, wooded areas and other sheltered places (Royce and Simko, 2000). They emerge in spring and mate soon after emergence. Each female then lays several hundred eggs. After the eggs hatch, the larvae feed for several weeks before pupating in the ground in earthern cells within the top 5 cm of soil. Adults that emerge in June feed but don't mate. As summer progresses, the adults become less active. In fall, they disperse to sheltered areas and remain inactive until the following spring.

Adults and larvae can cause significant damage by feeding on the upper leaf surfaces of cereals and grasses. Feeding by CLB can result in significant yield loss. One larva per flag leaf can lead to a 5-6 bushel yield loss per acre. Yield losses as high as 55% in spring wheat and 23% in winter wheat have been reported. Research in the affected counties in Oregon indicates that insecticide usage to control CLB has increased dramatically from zero acres in 1999 to 12,217 acres in 2001 (Bai, pers. comm.). An additional concern is the quarantine imposed by California restricting the movement of material, including hay, grain and nursery stock, from CLB infested areas, into California.

Monitoring of adults soon after emergence in spring will be beneficial for management of the pest. At present adults are monitored by visual examination of plants. If simple traps are available for catching adults, monitoring of CLB as it spreads to new areas will also be facilitated. A trap using the aggregation pheromone of CLB was developed by Allard Cosse, Robert Bartelt and Bruce Zilkowski at the USDA-ARS laboratory in Peoria, IL, after isolation and identification of the pheromone. Laboratory bioassays indicated that the addition of hexenyl acetate (HA), a compound released from plants after feeding by CLB adults, increased the efficacy of the pheromone in attraction of CLB adults.

Our objective was to determine the efficacy of the pheromone and HA in trapping CLB adults in cereal fields in Oregon.

Procedures:

The experiment was conducted in late summer 2001 in a field with spring planting of Alpowa soft white wheat at a location east of LaGrande, OR in Union county. CLB pheromone and HA were evaluated by attachment to yellow sticky traps placed in the field (Figure 1). The traps were attached to bamboo sticks and placed perpendicular to the prevailing wind, so that they were oriented with an upwind and a downwind surface. The bottom edge of the trap was at the same level as the tops of the plants. Four treatments were tested: CLB pheromone, hexenyl acetate (HA), a combination of CLB pheromone + HA, and control (no pheromone or HA). CLB pheromone was added to a rubber septa that was attached to the trap with a paper clip. Hexenyl acetate was added to a plastic capsule with a hole in it. The CLB pheromone, HA, sticky traps, and accessory material were provided by C. Allard and R. Bartelt, USDA-ARS, Peoria, IL.

The traps were set randomly 5-10 m apart in 2 lines. There were 10 replicates in the study. The traps were monitored regularly for two weeks. The numbers of adult CLB on the downwind and upwind sides of each trap were recorded and removed.

Results:

CLB adults were recovered from all traps including the control (Table 1). In addition, soft-winged flower beetles, that are similar in appearance to CLB, were detected on the traps. The attraction of CLB adults to all traps could be due to attraction to yellow color of the trap. The data were transformed and analyzed using ANOVA. There was no statistical difference in numbers of CLB adults on the various treatment and control traps. However there was a trend which suggests that perhaps the pheromone and HA may have activity in the field. The trial needs to be repeated to determine if the activity of the pheromone and HA are significant.

Table 1. Mean number of cereal leaf beetle adults captured on pheromone traps placed in wheat field in Union county OR in summer 2001.

Treatment	Number CLB adults trapped
Pheromone	3.3
Pheromone + Hexenyl acetate	3.9
Hexenyl acetate	2.6
Control	2.0
LSD 0.05	NS*

*NS = not statistically different at $\alpha = 0.05$ level.

The impact of the pheromone was low in the field compared with laboratory studies conducted in Peoria, IL. The experiment was conducted at the end of the season and this could be a factor responsible for low captures of CLB adults since mating and aggregation are high early in the season. In addition, due to the irrigation system in the field, several beetles were dislodged from traps. A trap that is better at retaining CLB adults under irrigation conditions will enhance the efficacy of the traps.

Summary:

The trial needs to be repeated in early spring during migration of CLB adults from overwintering sites. A more efficient trapping system that retains CLB adults under irrigation conditions also needs to be developed. However, the trends from data in the preliminary study conducted in 2001 indicate that there may be potential for development of a trap using CLB pheromone and HA in the field. If significant activity is observed in the field, pheromone traps can be used as monitoring systems and also for development of an attract-and-kill trap.

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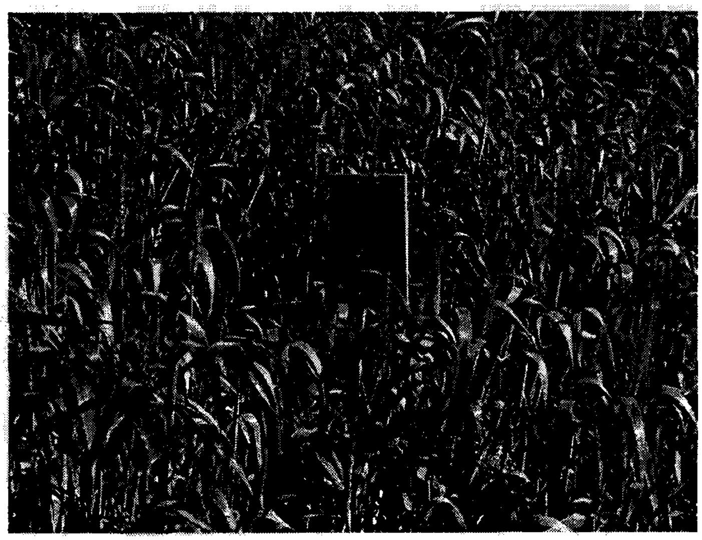

Figure 1. Sticky trap with pheromone lure placed in the filed for evaluating efficacy in capturing CLB adults.

GRASS-FEEDING MOTHS COLLECTED IN KENTUCKY BLUEGRASS SEED FIELDS TREATED WITH POST-HARVEST BURNING OR BALE ONLY IN THE GRANDE RONDE VALLEY, 2001

M.D. Butler and P.C. Hammond

A fifth year of study was conducted in 2001 to assess the composition and population dynamics of grass-feeding moths in commercial Kentucky bluegrass seed fields in the Pacific Northwest. The first studies in 1996 to 1998 were more qualitative and examined the species composition in three different regions; central Oregon, the Grande Ronde Valley of northeast Oregon, and the Rathdrum Prairie of northern Idaho (Butler et al., 2001). A more quantitative study was conducted in 2000 to follow the seasonal phenology and actual abundance of different moth species in central and northeast Oregon (Butler & Hammond, 2001).

The results from 2000 suggested a follow-up study would be helpful to assess the effects of post-harvest burning on the composition and abundance of the moth fauna. This was conducted on July 6, 2001 in a field near LaGrande in Union county. Part of the field had received the usual post-harvest burn treatment during 2000, while the remainder of the field was not burned and the straw was baled. One blacklight trap was operated in the burned portion of the field, and a second trap was operated in the baled portion. The results of 2001 are shown in Table 1 and are compared with the 2000 results from other fields in the same region.

These five years of studies have identified a complex community of grass-feeding moths that occupy Kentucky bluegrass fields in the Pacific Northwest, and this community is comprised of three distinct feeding guilds as follows.

1. The sod-webworms belong to the family Pyralidae, subfamily Crambinae. They included two species, *Chrysoteuchia topiaria* and *Pediasia dorsipunctella*. Of these, *C. topiaria* was sporadically common in different fields but was never abundant. During 2001, it was twice as common in the burned treatment compared to the baled treatment, but this may not be significant in view of the low numbers in general. *Pediasia dorsipunctella* was always present in every field but was always quite rare.

2. The climbing cutworms belong to the family Noctuidae, subfamily Hadeninae. Their larvae feed on leaves, inflorescences, and developing seed-heads. They included two species, *Aletia oxygala* and *Leucania farcta*. During 2000, *A. oxygala* was relatively common in several fields, but it was scarce in 2001. *Leucania farcta* was uncommon during 2000 and rare in 2001. These moths were never abundant enough to be of much economic consequence, and were of virtually no significance in the 2001 field study.

3. The largest group is the soil cutworms that feed at the soil surface or burrow into the soil, feeding on roots, rhizomes, and stems. They belong to the family Noctuidae, subfamily Amphipyrinae. Four species were present including *Protagrotis obscura, Apamea amputatrix, Agroperina dubitans*, and *Crymodes devastator*. Of these, *A. dubitans* was common on the Rathdrum Prairie in Idaho, but it was always quite rare in Oregon fields. *Apamea amputatrix* was also a rare species, while *C. devastator* was frequent to common. However, the only species present at epidemic outbreak levels that could have inflicted serious economic damage in the fields during this study was *P. obscura*.

Massive numbers of *Protagrotis obscura* were present in the Kentucky bluegrass fields of Union county during 2000, indeed one trap in the Coventry field yielded close to 10,000 moths on a single night. By contrast, all other species were only present at very low numbers, certainly well below any economic thresholds. It was thought that post-harvest burning practices might be a major factor in keeping most species at low levels. However, *P. obscura* is a burrowing cutworm, so its larvae might be well protected in the soil during burning treatments.

The objective of the 2001 study was to compare the effects of post-harvest burning with straw baling only on the moth community. These results are shown in Tables 1 and 2. Aside from *P. obscura*, all of the moth species were present equally in very low numbers in both the burn and bale treatments. No treatment effects were evident on these species. For example, *Crymodes devastator* had 30 individuals in the burn trap and 32 in the bale trap.

The major effect was evident on the epidemic species, *P. obscura*, with 2007 individuals in the bale trap and only 717 in the burn trap. This represents almost a two-thirds reduction of 64% in the number of moths within the burned treatment compared to the baled treatment.

While this is only a single experiment in a single field, it is suggestive that post-harvest burning can have a beneficial effect in reducing numbers of cutworms in these fields. With these results in mind, it is perhaps difficult to explain the massive numbers of *P. obscura* present in the 2000 study fields, particularly the Coventry field. It is possible that the timing of post-harvest burning may be critical to the success of cutworm control. If burning is done shortly after harvest, the eggs and newly hatched larvae may suffer heavy mortality, but if burning is delayed for a month or more, most larvae may have burrowed into the soil where they would be protected from the fire.

One interesting question concerns the effects of high *P. obscura* numbers on the other species of grass-feeding moths. For example, *Crymodes devastator* might potentially exist at much higher numbers if not for the presence of so many *P. obscura*. Of particular interest is the competitive interaction of high densities of cutworms with sod-webworms. If *P. obscura* was much less common, sod-webworms such as *Chrysoteuchia topiaria* might be more common in these fields. Both the 2000 and 2001 field data tend to suggest this possibility as shown in Table 1.

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Table 1. Total numbers for all grass-feeding moths collected near La Grande, OR near July 1, 2000 and 2001 in Kentucky bluegrass seed fields.

	2000			2001	
Genus species	Abbey (north)	Abbey (south)	Coventry	Burn	Bale only
	(number)				
Protagrotis obscura	4339	2205	9431	717	2007
Apamea amputatrix	1	1	6	0	0
Agroperina dubitans	1	0	0	1	0
Crymodes devastator	5	6	10	30	32
Aletia oxygala	6	12	31	4	2
Leucania farcta	4	4	4	0	1
Chrysoteuchia topiaria	7	22	1	16	6
Pediasia dorsipunctella	2	4	1	3	3
Totals	4365	2254	9484	771	2051

Table 2. Identification, feeding type and number of grass, hardwood and herb-feeding moths collected in Kentucky bluegrass treated with post-harvest burning or bale only near La Grande, OR, 2001.

		Black light location	
Genus species	Feeding type	Open burn	Bale only
		(number)	
Protagrotis obscura	grass	717	2007
Crymodes devastator	grass	30	32
Chrysoteucia topiaria	grass	16	6
Aletia oxygla	grass	4	2
Pediasia dorsipunctella	grass	3	3
Agroperina dubitans	grass	1	0
Leucania farcta	grass	0	1
Paonias excaecatus	hardwood	1	0
Sericosema juturnaria	hardwood	1	0
Hessperumia sulphuraria	hardwood	1	0
Caenurgina erechtea	herbs	12	6
Anagrapha falcifera	herbs	5	1
Euxoa idahoensis	herbs	1	0
Loxostege cereralis	herbs	1	0
Grammia ornata	herbs	0	2
Platyyerigea montana	herbs	0	1
Spodoptera praefica	herbs	0	1
Totals		793	2062

SEED CARROT ABOVE GROUND BIOMASS AND NUTRIENT ACCUMULATION, 2001

M.D. Butler, J.M. Hart, B.R. Martens and C.K. Campbell

Abstract

A commercial field of 'Nantes' hybrid carrots grown for seed near Madras, Oregon was sampled for nutrient uptake during the 2000-2001 growing season. Three feet of the outside female row was removed at ground level at four representative locations in the field. Total nitrogen accumulation was approximately 165 lb/a, total K was 182 lb/a and more than 8500 lb/a of biomass was generated. The greatest increase in biomass was during mid-June to mid-July, with over two-thirds of the total biomass production. Peak N uptake of over 3 lb/a/day occurred in late June, at the beginning of flowering. The peak K uptake rate of 2 lb/a/day occurred a week later than peak N uptake.

Introduction

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

Before nutrients are applied to a crop, four decisions must be made: how much to apply, when to apply the nutrient(s), what source to use, and how to make the application. Measuring plant growth and nutrient accumulation provides information about time of nutrient application. In addition, an estimation of the amount of nitrogen needed by the crop can be made.

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

Methods and Materials

A commercial hybrid 'Nantes' seed carrot field was identified for sampling north of Madras, Oregon. Flags were place at four representative locations in the field and samples were collected near these flags to control variability. Three feet of the outside female row were removed at ground level at each location; samples were dried and then analyzed for N, P, K, S, Ca, Mg, S, B, Mn, Cu, and Zn. Sampling dates from the fall of 2000 through the summer of 2001 were October 19, March 5, April 23, May 11, June 12, June 26, July 10, July 31, and August 20.

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

Results and Discussion

Average biomass and nutrient accumulation for each sampling date is presented in Table 1. The peak nitrogen accumulation, approximately 165 lb/a, is consistent with the amount found in many other crops grown in the northwest (Sullivan et al., 1999). The peak or largest amount of nitrogen was measured before harvest and is also consistent with measurements made in other crops grown for seed. Lower leaves are shaded, senesce, and are sloughed by the plant. The cumulative effect is a measured loss of aboveground nitrogen accumulation.

Table1. Average above ground biomass and nutrient accumulation of Nantes hybrid carrots grown for seed in central Oregon. Carrot seed was planted in 2000 and harvested in 2001.

Sampling date	Biomass accumulation	Nutrient accumulation N	P	K	S	Ca	Mg	B	Zn
	(lb/a)	(lb/a)							
10/19	108	4	0.4	3	0.4	1.5	0.5	0.003	0.003
3/5	244	7	0.9	4	0.6	3.8	1.1	0.006	0.007
4/23	586	24	2.3	17	2.3	13	3.7	0.023	0.024
5/11	657	25	2.1	19	3.3	15	5	0.03	0.02
6/12	1618	51	5.2	48	7.3	28	8	0.07	0.06
6/26	3608	100	11.7	96	15	61	18	0.15	0.09
7/10	6806	149	18.4	172	25	95	31	0.26	0.17
7/31	8974	167	23.4	201	30	135	40	0.35	0.21
8/20	8207	146	21.0	182	25	113	34	0.34	0.18

Carrot seed yield increased with nitrogen application in three Indian N rate/plant spacing trials. The seed yield increase was linear with rates to 67 lb/a, Kumar and Nandpuri (1976). Higher N rates, 0, 50, and 100 lb/a, were used by Malik and Kanwar (1969). They reported that maximum carrot seed yield was produced with the application of 50 lb N/a when soil test N was 90 lb/a and maximum seed was produced with the application of 100 lb N/a when soil N was 75 lb/a. Sharma and Singh (1981), reported little increase in carrot seed yield from the application of 45, 90, or 135 lb N/a, but found significantly more seed produced with the application of 90 lb N/a compared to plots receiving no N. Soil N at this site was 200 lb/a. The amounts of N supplied by soil and fertilizer reported in this literature are consistent with the amount of N measured in the carrot seed crop we sampled.

Potassium accumulation that is greater than nitrogen is routinely reported for crops grown in an environment of sufficient to high levels of soil potassium.

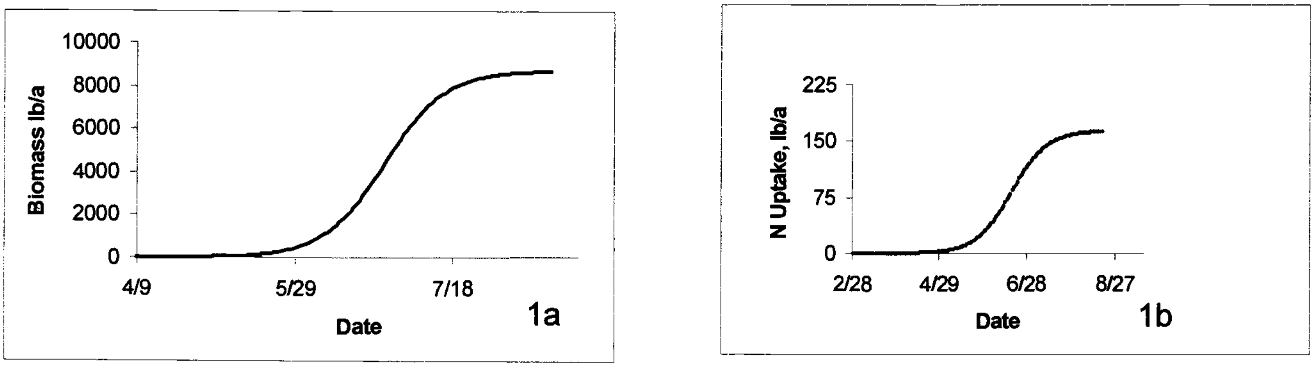

Figure 1. Total biomass (Figure 1a) and nutrient accumulation (Figure 1b) for Nantes hybrid carrots grown for seed in 2001.

Biomass: Seed carrots grow slowly in the fall and spring, producing only 500 to 600 lb biomass/a by late April – early May (Figure 1a). From mid-June to mid-July, the growth is rapid and linear, accounting for two-thirds of the total biomass. Less than 20 percent of the biomass is produced after mid-July. Peak biomass production of more than 200 lb/a/day occurs in late June.

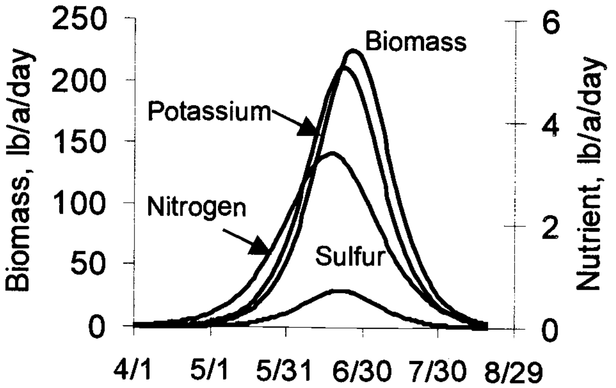

Figure 2. Daily accumulation of biomass, nitrogen, potassium, and sulfur for Nantes hybrid carrots grown for seed in 2001.

Nutrients: N uptake is rapid during June and essentially complete by early July, approximately 5 to 6 weeks before harvest (Figure 1b). The amount of N taken up by carrots grown for seed is variety dependent, primarily a function of biomass production. Total N uptake was 140 and 175 lb N/a for a single field of Nantes hybrid carrots in 2001.

Peak N uptake of slightly more than 3 lb/a/day occurred in late June (Figure 2). The peak N uptake rate occurs as bloom is beginning and before bees are placed in the field. The peak uptake rate of potassium and sulfur coincided with the peak production of biomass and was approximately one week later than the peak N rate. Potassium uptake rate was 2 lb/a/day more than N. The higher K uptake rate resulted in the total K uptake of approximately 40 lb/a more than N at harvest.

Management: After the beginning of July or after seed set, nutrient uptake decreases rapidly. Nutrients should be supplied well in advance of need, mid-May at the latest. If sufficient nutrients are supplied during the early growing season, late season applications are not efficient or effective. Some N should be applied in mid- to late-April to support early growth. The bulk of the N is accumulated during June. A combination of available soil and fertilizer N totaling 150 to 200 lb/a seems a logical rate.

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RYEGRASS GROW-OUT TESTS IN RELATION TO SEEDLING ROOT FLUORESCENCE

R.E. Barker, S.E. Warnke, S.G. Elias, A.E. Garay and R.L. Cook

Abstract

The seedling root fluorescence (SRF) test has been used for over sixty years to distinguish annual ryegrass (*Lolium multiflorum* Lam.) from perennial ryegrass (*L. perenne* L.). The trait, however, is not closely genetically linked to other characteristics that distinguish the two grasses. The SRF test is a general indicator of seed lot physical and genetic purity, but is not adequate for specific determinations and a replacement test is needed. The primary distinguishing characteristics between these two species are persistency and growth habit, both traits that are hard to measure quickly. SRF tests were conducted, and fluorescent seedlings from ten perennial ryegrass cultivars, along with non-fluorescing control plants, were transplanted to small pots. The pots were arranged in two randomized complete block (RCB) experimental designs with four replications each and grown under controlled continuous light (125 to 500 µmol $m^{-2}s^{-1}$) for 70 days in a greenhouse and in a growth chamber. Less than 20% of the perennial ryegrass seedlings with fluorescence produced heads in 42 days, while nearly 100% of the annual ryegrass check plants headed. Plants grown under lower light conditions measured as photosynthetically active radiation (PAR) had longer leaf blades and were slower to head, but heading was equally achieved between the two growth environments given enough time. These grow-out conditions provide a possible supplemental test to SRF for predicting growth type distinction.

Background—Importance of a Supplemental Grow-out Test (GOT)

The Federal Seed Act (FSA) and Association of Official Seed Analysts (AOSA) Seed Testing Rules, along with some state-specific laws for seed quality and purity, require the use of the SRF test to quantify the amount of annual ryegrass seed contamination in perennial ryegrass seed lots that will be used in high quality turf. In Oregon however, $5 to 7 million is discounted annually to perennial ryegrass seed growers based on erroneous results of SRF tests. Recent research by USDA-ARS and Oregon State University scientists in Corvallis, demonstrated that 75 to 80% of these discounts might not be warranted because SRF does not correspond in all cases to annual ryegrass contamination in the seed lot. Loss of revenue from unwarranted discounts represents undo hardship to many family owned farms. In addition, inaccuracies associated with the SRF test can cause inadvertent mislabeling of ryegrass seed lots. A supplemental or alternative testing method to assess quality of perennial ryegrass seed lots is needed.

A grow-out test to distinguish ryegrass growth types is listed in the AOSA Cultivar Purity Testing Handbook. It is not, however, recognized as a supplement to the SRF test. In preliminary testing on perennial ryegrass seed lots with abnormally high fluorescence levels, the grow-out test has consistently shown the number of plants with annual characteristics to be far less than indicated by SRF. In these cases, the supplemental grow-out test provided a more accurate measure of annual ryegrass seed contamination in perennial ryegrass seed lots.

This study was conducted to define and standardize steps involved in conducting supplemental grow-out tests.

Materials and Methods

With consent of cultivar owners, ten perennial and two annual ryegrass cultivars being tested at the OSU Seed Testing Laboratory or from samples provided by the breeder were used in SRF tests (Table 1). Standard SRF tests were conducted on 400 seeds, with 100 seeds per germination box to provide four replications. All perennial seedlings with fluorescence, plus 20 non-fluorescent perennial plants per rep were transplanted to small plastic pots. Twenty fluorescent 'Floregon' annual ryegrass plants, plus all non-fluorescent plants were treated in the same way as the perennial ryegrass cultivars. 'Gulf' annual ryegrass was used as a check cultivar with a single plant marked and placed at random in each rep of every other entry. Plants were arranged in RCB designs and the study was conducted twice, once in the winter 2000-2001 (October through March) and again in late spring 2001 (April through July).

Table 1. Annual-type contamination in ten perennial ryegrass cultivars determined by seedling root fluorescence (SRF) and grow-out tests (GOT) when grown in growth chamber and greenhouse.

				Annual-type in the perennial sample[3]			
		TFL[2]		Chamber		Greenhouse	
Cultivar	VFL[1]	Chamber	Greenhouse	SRF	GOT	SRF	GOT
	(%)						
SR Exp A	N/D	1.04	0.52	1.03	0.26	0.52	0.26
Tove	17.48	16.05	19.16	0.00	0.00	2.03	0.00
Repell III	0.80	0.52	0.03	0.00	0.00	0.00	0.00
Express	4.00	1.93	1.87	0.00	0.82	0.00	0.27
Derby Supreme	2.85	8.62	7.09	5.91	3.64	4.34	0.26
Divine	4.14	0.26	1.02	0.00	0.00	0.00	0.00
Pleasure	4.09	5.56	3.57	1.52	2.27	0.00	1.08
PST 3BK	N/D	0.00	0.00	0.00	0.00	0.00	0.00
SR Exp B	N/D	0.26	0.03	0.26	0.00	0.03	0.26
Buccaneer	7.44	10.78	10.79	3.59	3.49	3.60	4.45

[1] Assumes 99.5% purity and number of fluorescent seedlings headed in grow-out at 42 d.
[2] VFL=Variety Fluorescence Level as published by Association of Official Seed Certifying Agencies National Grass Variety Review Board, N/D = not determined.
[3] TFL=Test fluorescence level as reported on seed testing reports.

Plants were grown under continuous light in two sites. The greenhouse site had supplemental light by sodium vapor, PAR at 125 µmol $m^{-2}s^{-1}$ in winter test, >500 µmol $m^{-2}s^{-1}$ during day in the spring because of increased natural light. The controlled environment growth chamber site had cool-white florescent tube light with incandescent supplement, PAR 425 µmol $m^{-2}s^{-1}$ during each test period. Temperatures were maintained at 25°C, but the greenhouse varied widely because of ambient temperatures. Plants were maintained in good growing conditions with fully balanced nutrients and adequate water to avoid any stress.

Seedlings were transplanted to the small pots within one week after SRF tests were complete, then held for another week to allow the plants to establish before being placed in test conditions. Plants were held an additional week in the spring test because they were cut at 0.5 cm height to record leaf vernation. Timing was started when the plants were actually placed in test conditions.

Results

Contamination of perennial ryegrass from annual ryegrass can be either physical (actual mixing of seeds) or genetic (genes from annual being incorporated into perennial by pollen flow or artificial crossing). Rapid heading of plants in a grow-out test is primarily an indication of physical contamination. Plants from perennial ryegrass seedlings with fluorescent roots (F+) usually did not head until after a threshold of 80% annual heading (Figures 1 and 2). For physical contamination we recommend that grow-out tests be run long enough for at least 80% or more of annual check plants to head, 28 to 35 days (at 25°C and PAR > 230 µmol $m^{-2}s^{-1}$). Perennial F+ plants headed faster and more consistently in the chamber when light was at least PAR 425 µmol $m^{-2}s^{-1}$, but plants responded similarly in the greenhouse in late spring when PAR was increased at least during part of the day.

Annual ryegrass is used as a check treatment in order to judge test efficacy and to determine length of the test. Overall, annual plants responded as expected by producing heads rapidly when grown under continuous light (Figure 3). Gulf plants produced heads faster than Floregon and eventually all Gulf plants produced heads, while those of Floregon did not. An important consideration in developing a standardized protocol is choosing a standard annual cultivar as a check that will be consistent over tests. A Foundation class seed lot of Gulf seed has been designated as the source for all future grow-out tests.

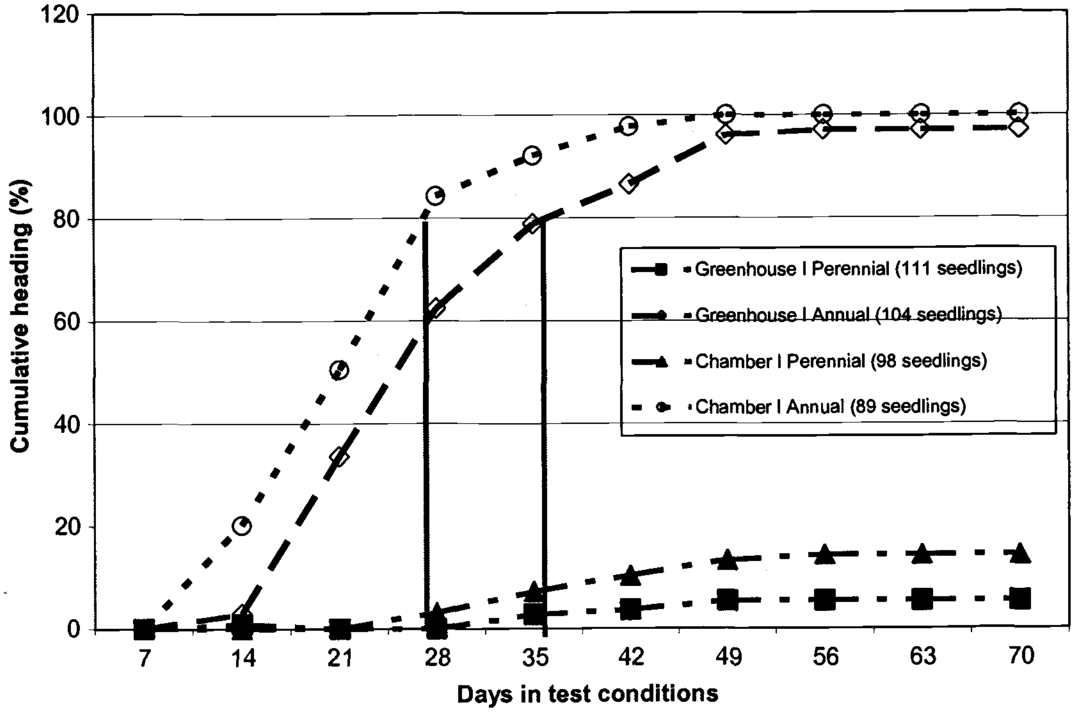

Figure 1. Cumulative heading of annual and perennial ryegrass plants grown from seedlings with fluorescent roots in winter 2000-2001 tests. Vertical bars indicate 80% of annual seedlings had headed.

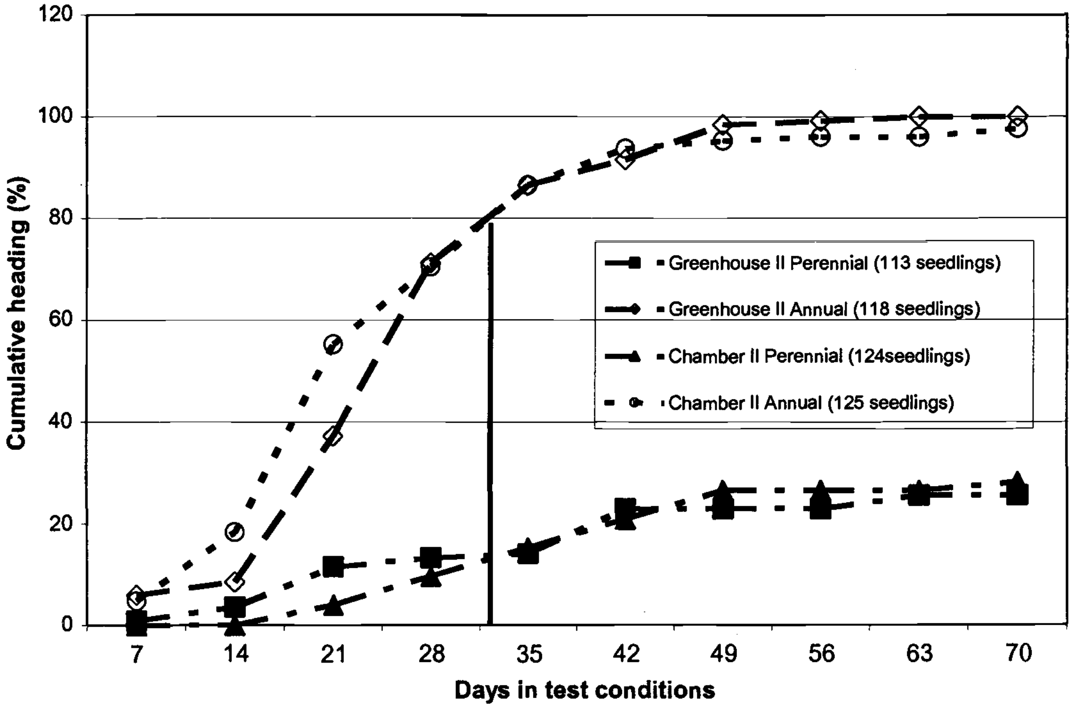

Figure 2. Cumulative heading of annual and perennial ryegrass plants grown from seedlings with fluorescent roots in spring 2001 tests. Vertical bar indicates 80% of annual seedlings had headed.

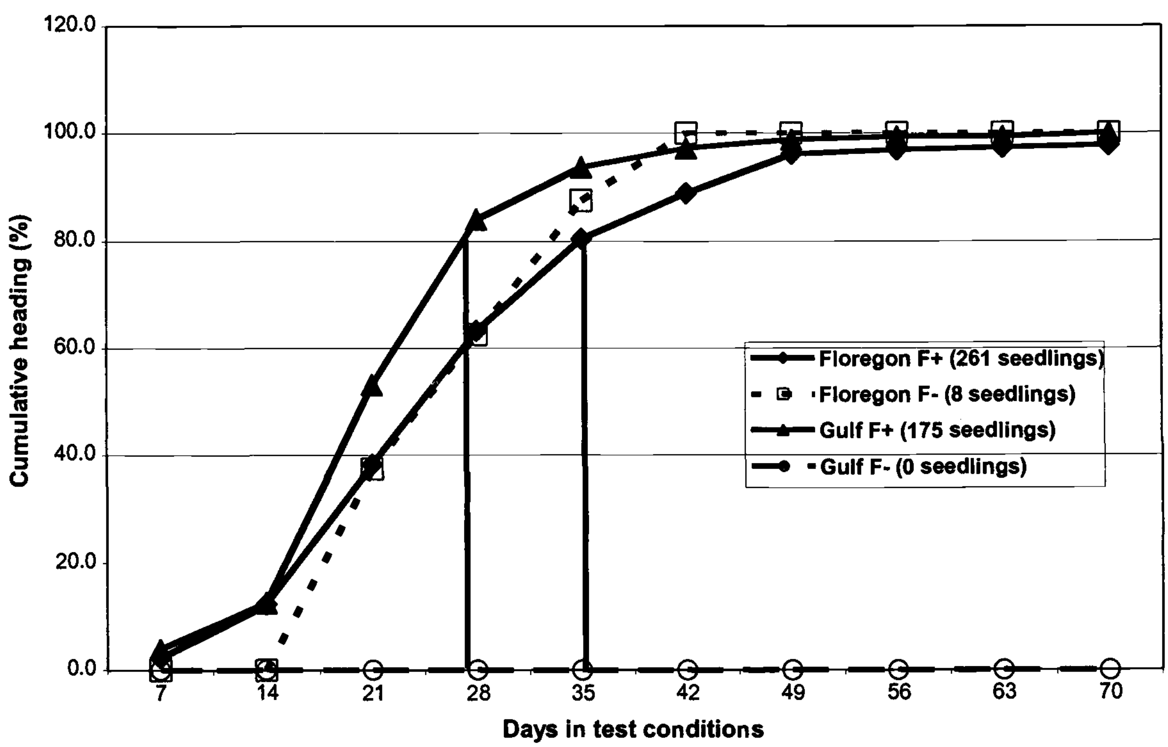

Figure 3. Cumulative heading of Gulf and Floregon annual ryegrass cultivar plants grown from seedlings in winter 2000-2001 and spring 2001 tests. Vertical bar indicates 80% of annual seedlings had headed.

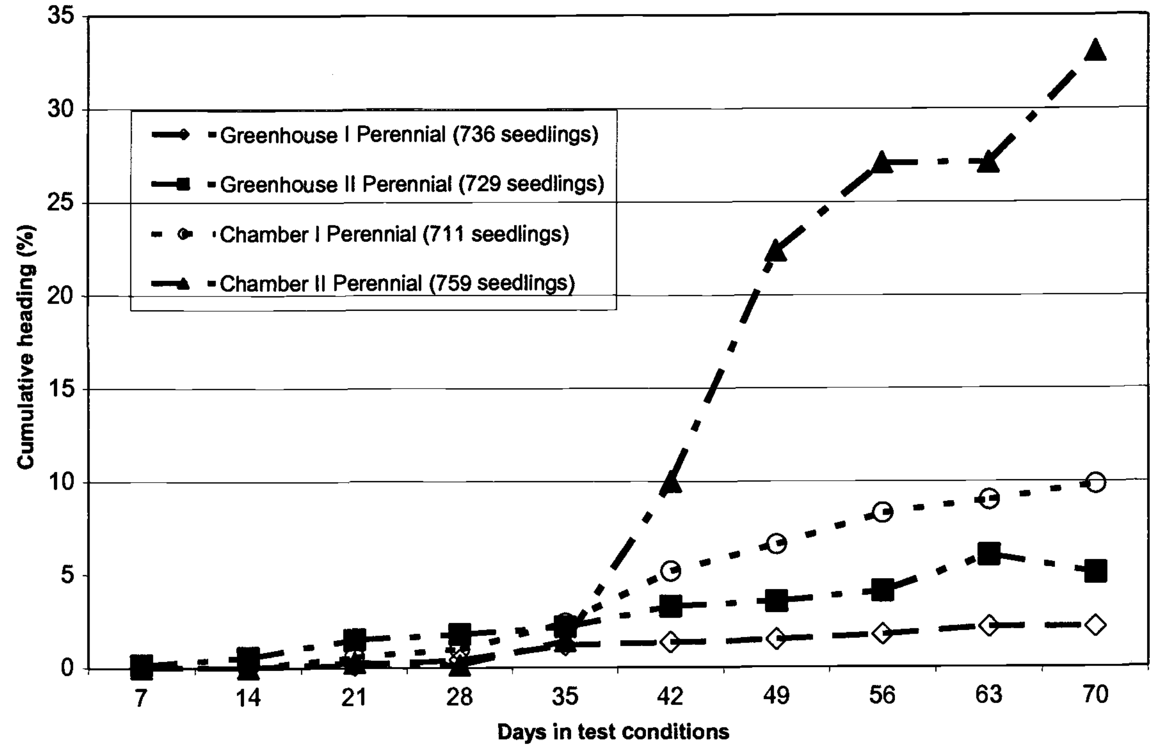

Figure 4. Heading of perennial ryegrass plants used as check plants that had non-fluorescent seedlings in fluorescence tests.

Heading of the annual ryegrass check assists with detecting physical contamination of perennial ryegrass seed lots, but care should be taken because genetic contamination is harder to detect, thus, the need for longer test periods. We recommend that plants remain in test conditions under high light for at least 42 days. Annual plants could usually be distinguished when grown under high light by faster growth, wider leaves, and lighter green color than perennial plants; however, care again must be taken in observation of vegetative characteristics because some perennial cultivars may have genetically lighter color and wider leaves (e.g., 'Tove', data not shown). When grown under lower light conditions, leaves of all plants were longer and lighter color than when grown under high light making it harder to detect differences in these other vegetative characteristics.

Less than 20% of the perennial F+ plants produced heads prior to the suggested 42 day end of testing period (Figures 1 and 2), but nearly all annual plants produced heads, including those that did not have fluorescent seedling roots (Figure 3). There was high variability among perennial ryegrass cultivars for heading of plants that did not have fluorescent seedling roots (F-). In general, every perennial F- ryegrass cultivar headed faster and had more headed plants in the spring 2001 test than in the other test conditions (Figure 4). This was especially true of the plants grown in the controlled environment growth chamber where the number of plants with heads continued to increase after 42 days.

We do not have an explanation why number of plants with heads continued to increase in the chamber in the spring, but this result indicates the need to further optimize the grow-out test conditions. Plants do produce heads if left in light long enough, and will produce more heads under higher PAR. Our grow-out test conditions are actually an adaptation of those used in barley to test for vernalization requirement. Plants are grown under continuous light for 100 days in barley tests. When F- perennial ryegrass plants headed faster in the chamber than in the greenhouse, it indicated there is a "trade-off" for maximum expression of heading from annual-type plants, and minimum expression of heading in truly perennial plants that require little vernalization. This is the difficult area of detecting genetic contamination, that is, contamination from pollen or other sources of annual ryegrass genes crossed into perennial ryegrass.

The purpose of the GOT is to supplement SRF in determining actual contamination from annual-type plants in a perennial ryegrass seed lot. Except for the particular lots we tested of Derby Supreme and Buccaneer, none of the seed lots tested would have required a GOT to meet Certified seed standards (test fluorescence level, TFL 3% points > VFL, variety fluorescence level) (Table 1). When the SRF test in our studies was used to determine annual-type growth habit, contamination for these two cultivars was > 3% in both the chamber and greenhouse. The GOT in all but Derby Supreme in the greenhouse also determined annual-types to be > 3%. All other cultivars had low enough annual-type plants to pass Certified seed standards. Of the lots we tested, only Tove and PST 3BK have annual ryegrass in parentage. Tove has high SRF but little heading; and PST 3BK has low SRF as well as no heading.

Conclusions

The grow-out test conditions we used were similar to the standard test for vernalization requirement in barley. In other research, we have shown that ryegrass has similar vernalization response as barley, and thus, the GOT should produce similar results. Annual ryegrasses generally have no or little vernalization requirement so they will produce heads faster than perennial-type plants. Both physical and genetic contamination can be detected in a GOT if care is taken. Light quality is one of the important variables in conducting maturity GOT; poor light (low PAR) will require longer testing time, and plants may not reach optimum reproductive expression. Depending on light intensity, the ryegrass GOT can be completed in 35 to 42 days after plants are put in test conditions.

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THE ISOZYME SUPEROXIDE DISMUTASE (*SOD-1*) IN PERENNIAL AND ANNUAL RYEGRASS AS A SUPPLEMENT TO SEEDLING ROOT FLUORESCENCE TESTING

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Abstract

Identifying annual ryegrass contamination in perennial ryegrass seed lots has been of major interest in seed testing laboratories and for seed regulatory agencies for many years. This study was conducted to characterize an enzyme, superoxide dismutase (*Sod-1*), and determine its potential to distinguish cultivated ryegrass species. Inheritance of *Sod-1* was evaluated in a three generation annual X perennial ryegrass genetic mapping population and segregation data fit the expected ratio for a single gene with two alleles. The molecular form of the *Sod-1* isozyme, and another independently segregating locus, was determined by H_2O_2 and KCN inhibitor assays and both were found to be Cu/Zn Sod enzymes. The common alleles at the *Sod-1* locus were scored in 13 annual and 24 perennial ryegrass cultivars to determine the potential of using this gene for ryegrass species separation. The *Sod-1b* allele was homozygous in 98% of the individual plants from 24 perennial ryegrass cultivars indicating that this allele is a good indicator of perenniality. All eight annual ryegrass cultivars originating in Europe or Asia had a low frequency of *Sod-1b* homozygous individuals, but the five cultivars originating in the Western Hemisphere had genotype frequencies for homozygous *Sod-1b* up to 56%. Ideally, the annual ryegrass contaminant should have little or no homozygous *Sod-1b* plants. The ability of the *Sod-1* locus to separate the two growth forms in ryegrass seed testing depends on the source of the annual-type contamination. Because of no apparent genetic linkage with flowering control, the primary characteristic used to distinguish annual from perennial ryegrass, *Sod-1* will not likely be an adequate stand-alone replacement test for seedling root fluorescence (SRF), but could serve as a supplement to SRF.

Introduction

Perennial ryegrass (*Lolium perenne* L.) and Italian, or annual ryegrass (*Lolium multiflorum* Lam.) are two of the most widely cultivated grasses used for turf and forage throughout the world. These two outbred species of the *Lolium* genus are interfertile where their flowering dates overlap. In fact, researchers in Europe have proposed that these two species be grouped under a common species name and be regarded as subspecies, and at least one group has suggested that the European *Loliums* represent a hybrid swarm with perennial and Italian ryegrasses representing the extreme types. Research in France has shown that *L. perenne* evolved from a bottleneck of *Lolium rigidum* Gaud. Populations, and further, that *L. multiflorum* may have also arisen from the common ancestor, *L. rigidum*. This common ancestry and the genomic similarities indicate that these two main species are very closely related.

With about 90% of the worldwide supply of certified seed of perennial and Italian ryegrass being produced in Oregon's Willamette Valley, this close genetic similarity of the two species is of concern to seed certification agencies as well as seed growers. Seed producers have their payments discounted because either or both genetic and physical contamination of turf-type perennial ryegrass by forage-type annual ryegrass is objectionable for high quality turf use. Identifying annual ryegrass contamination in perennial ryegrass seed lots has been of major interest in seed testing laboratories and for seed regulatory agencies for many years. USA seed regulatory agencies utilize the seedling root fluorescence (SRF) test to identify annual ryegrass contamination of perennial ryegrass seed lots. The SRF test is based on the finding that seedling roots of Italian ryegrass secrete an alkaloid compound called annuloline that produces a blue fluorescence under ultraviolet light, however, perennial ryegrass roots do not normally fluoresce. Ever since the discovery of SRF, it has been used as a test in the USA to determine the purity of perennial ryegrass seed samples. Some breeders, however, have been able to develop fluorescent perennial ryegrass, indicating that the fluorescent trait does not influence growth habit and is not tightly genetically linked to any trait that conditions annuality.

Several morphological and chemical differences between the two species have been shown over the years, but many of the chemical tests were based on bulked samples and bulked seed lacks the necessary sensitivity for adequate replacement tests to the SRF test. Morphologically, leaf vernation differences between perennial and Italian ryegrass have been used, but this test is time consuming and can be inconclusive. Researchers in France examined 13 leaf isozymes in eight *Lolium* species and *Festuca pratensis*. Two leaf isozymes were identified that could be utilized as species indicators. A phosphoglucose isomerase locus (*Pgi-2*) and a superoxide dismutase locus (*Sod*) showed frequency among individuals that were different between *L. perenne* and *L. multiflorum*. Eight different alleles were reported at the *Pgi-2* locus, with the *Pgi-d* allele much more common in *L. rigidum* and *L. multiflorum* populations than in *L. perenne* populations. The complex allelic structure of the *Pgi-2* locus, however, makes it difficult to develop a non-gel based replacement test. The relative frequency of the *Sod-1a* and *Sod-1b* alleles possibly allows one to discriminate *L. perenne* from all other *Lolium* species.

Superoxide dismutase is a well-studied enzyme with three forms as classified by the metal ions present at the active site: copper/zinc (Cu/ZnSOD), manganese (MnSOD), and iron (FeSOD). These three enzymes are distributed throughout different subcellular locations and must therefore be dealt with at their sites of production. The three forms of SOD can be distinguished on electrophoretic gels by exploiting their differential sensitivities to KCN and H_2O_2. Cu/ZnSOD is characterized as being sensitive to both H_2O_2 and KCN, FeSOD is sensitive only to H_2O_2, while MnSOD is resistant to both inhibitors.

Objectives of this research were to 1) study the segregation of the *Sod-1a* and *Sod-1b* alleles in an annual X perennial ryegrass mapping population, 2) establish the allelic frequency of the *Sod-1a* and *Sod-1b* alleles in a range of *L. perenne* and *L. multiflorum* cultivars, and 3) determine the isozyme form of SOD represented by the *Sod-1* locus.

Materials and methods

Mapping population. Segregation of SOD was conducted on a three-generation ryegrass pseudo testcross population. Crossing one grandparent perennial ryegrass plant from cv. Manhattan with an annual ryegrass grandparent plant from the cv. Floregon to produce an F1 population developed the mapping population. Crossing a different Manhattan grandparent plant with a different Floregon plant generated a second F1 population. Random F1 clones were selected from each Manhattan maternal F1 population and these clones were crossed to produce a segregating genetic mapping population containing 167 individuals. SOD segregation was tested on 162 progeny.

Data for time to flowering without vernalization was obtained by growing two replications of each clone in the mapping population in a growth chamber under a 24 hr photoperiod (425 μmol $m^{-2}s^{-1}$ PAR) at 25°C for 116 days. The time of head emergence was recorded for each plant. Plants with no head emergence at 116 days were given a value of 116 days in the evaluation.

Seed source for cultivars. Seed of perennial and annual ryegrass cultivars was obtained from seed testing samples maintained by the Oregon State University Seed Laboratory, from commercial seed companies, and from Oregon Seed Certification Service voucher samples of OECD cultivars. The annual cv. LE 284 was obtained from Uruguay.

Starch gel electrophoresis. Isozyme analysis was performed on individual annual and perennial ryegrass seedlings at the three to four leaf stage of development. A crude protein extract was obtained by macerating five to six, one centimeter long leaf pieces in 80 μl of chilled extraction buffer. The extraction was performed in chilled, 12-sample porcelain plates with a Plexiglas rod rounded on one end. The crude extracts were absorbed onto 2-mm by 8-mm blotter paper wicks and stored at -20° C.

Super Oxide Dismutase (SOD) isozymes were resolved in potato starch gel slabs as described in the AOSA (Association of Official Seed Analysts) Cultivar Purity Testing Handbook. SOD activity stains were prepared according to Wendel and Weeden (1989). Gel slices were incubated in the dark for 30 min then placed under a light box with two 60W fluorescent bulbs until white bands could be visualized against a dark blue gel.

Results and discussion

Three *Sod-1* genotypes were observed in the annual X perennial ryegrass mapping population (Fig. 1). The perennial grandparents from the population had the common *Sod-1b* band and the F1 parents were both three-banded heterozygotes. The annual grandparents from this population died prior to Sod genotyping, however, the fact that both F1 parents have the *Sod-1a* allele indicates that both annual grandparents must have had this allele also. The segregation from 162 individuals of the mapping population was 44aa:85ab:33bb that fit the expected 1:2:1 ratio for single locus with 2 alleles (χ^2=1.88, 0.5>p>0.1).

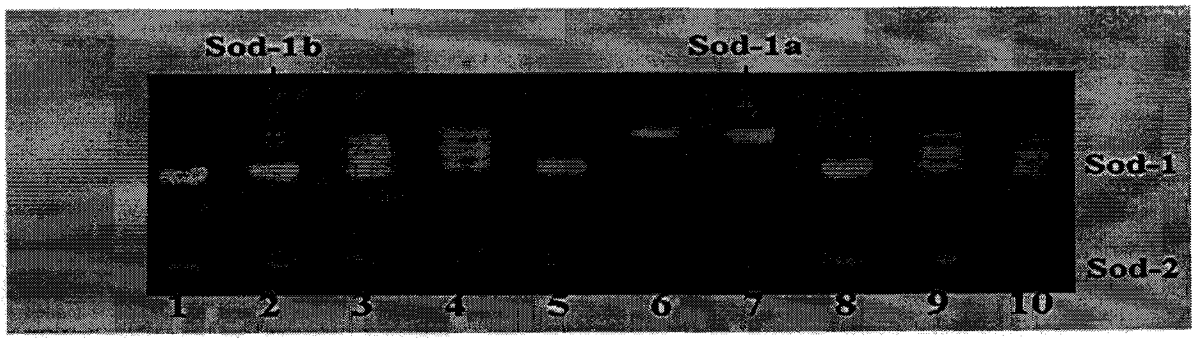

Figure 1. Polyacrylamide gel of superoxide dismutase from an annual X perennial ryegrass mapping population. Lanes 1 and 2 perennial grandparents; Lanes 3 and 4 F1 parents; Lanes 5 and 8 = bb genotype; Lanes 6 and 7=aa genotype; Lanes 9,10 = ab genotype.

The *Sod-1* locus was inhibited by both H_2O_2 and KCN clearly indicated that *Lolium Sod-1* is a Cu/Zn Sod. *Sod-1* was the primary locus, however, a slower migrating locus marked *Sod-2* was also present (Figure 1). *Sod-2* was also sensitive to H_2O_2 and KCN indicating that it is a Cu/Zn Sod as well.

Screening for the *Sod-1a* and *Sod-1b* allele frequencies in 13 annual and 24 perennial ryegrass cultivars confirmed the findings of Charmet and Balfourier (1994). The *Sod-1b* allele is almost monomorphic in perennial ryegrass cultivars (Table 1). The most notable exceptions were 'Linn', a very old perennial ryegrass cultivar that almost meets the definition of a landrace in the USA, and Derby Supreme, a cultivar with some seed lots that have exhibited variable SRF. Absence of the heterozygote genotype (*Sod-1ab*) in Derby Supreme and Aquarius II suggested physical contamination because plants resulting from a cross between annual and perennial ryegrass would be expected to have the *Sod-1ab* genotype. Plants having the common annual ryegrass (*Sod-1a*) homozygous bands from these two cultivars, as well as those from Linn, had an annual like growth habit (light green color and flowering without vernalization).

Most of the annual ryegrass cultivars had a very low frequency of homozygous *Sod-1bb* individuals (Table 1). The reason for the low frequency of the *Sod-1bb* individuals is not obvious from this research. Initial data does not indicate a selective survival advantage for any particular *Sod-1* genotype. Cultivars originating in Europe or Asia had either a low frequency, or no homozygous *Sod-1b* genotypes. While we do not have the information to confirm breeding history, we suspect that European and Asian cultivars are more closely Westerwold types. On the other hand, the cultivars from the USA had homozygous *Sod-1b* genotype frequencies ranging from 0.11 to 0.56. All of the Western Hemisphere cultivars are long-term reseeding cultivars and similar to the Italian ryegrass type. Westerwold grasses are generally characterized as fast growing, early flowering, but not long lasting. These types originated in Norway, while it is believed that Italian types originated in Italy. Our results confirm the evolutionary relationships and patterns proposed by Charmet et al. (1997) and Balfourier et al. (2000). It is interesting to note that the frequency of *Sod-1bb* individuals seems to be associated with longevity. The shorter-lived Westerwolds having a low frequency of homozygous *Sod-1bb* individuals, a higher frequency in the almost biennial types characterizing the Italians, and finally the perennials being almost completely homozygous *Sod-1bb* individuals.

Results indicated that the *Sod-1a* allele could be a good indicator of both physical and genetic contamination of perennial ryegrass seed lots by Westerwold type annual ryegrass, but may not be applicable for contamination from Italian types. It would be particularly difficult to separate Gulf contamination from the perennials tested. We tested four lots of Gulf, including LE 284, which was the original progenitor of Gulf. Frequencies of the homozygous *Sod-1bb* genotype ranged from 0.23 to 0.56 for these four seed lots, demonstrating that while the frequency remained high for the cultivar, there is variability among seed lots based on history of that particular seed source. Gulf is also the annual ryegrass cultivar longest grown in the Oregon seed production area and the soil seed bank would contain considerable amounts of this type.

Homozygosity of the *Sod-1b* allele appears to be a good indicator of perenniality, however, the locus is not linked to loci controlling time to flowering without vernalization in the annual/perennial ryegrass mapping population. The *Sod-1* locus has been reported to be associated with seedling leaf length, area and dry weight (Hayward et al., 1994), however, those seedling data were not collected from this population. In addition, our data for plant survival under field conditions (not shown) does not indicate a selective advantage for any of the *Sod-1* genotypes.

These results indicate that the *Sod-1* locus, like seedling root fluorescence, is a good species indicator in the ryegrasses. However, because of no apparent linkage with flowering control, the primary characteristic used to distinguish annual from perennial ryegrass, it will not likely be an adequate stand alone replacement test for seedling root fluorescence. Actual utility as a test will depend on the source of the annual contamination. These results also indicate that any potential replacement test for seedling root fluorescence should be carefully examined for linkage with loci influencing annual growth habit. Linkage tests should be done using adequate segregating populations and should not be based on association studies of pooled annual and perennial ryegrass populations.

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Table 1. Genotype frequencies of the *Sod-1* locus for annual and perennial ryegrass cultivars.

Cultivar	Country of maintainer[1]	VFL[2]	No. of plants tested	*Sod-1* genotype		
				aa	ab	bb
Annuals						
Ace (4N)	JPN	--	19	.32	.68	0
Avance (4N)	NLD	--	20	.30	.70	0
Fabio (4N)	NLD	--	22	.55	.46	0
Jeanne (4N)	DNK	--	20	.50	.50	0
Tenor	NLD		20	.30	.70	0
Waseyutaka	JPN	--	24	.50	.46	.04
Zorro (4N)	DNK	--	21	.19	.76	.05
Aubade (4N)	NLD	--	17	.41	.53	.06
Jackson	USA	98.80	19	.31	.58	.11
Marshall	USA	96.00	20	.20	.65	.15
Gulf (141940)	USA	99.02	43	.16	.61	.23
Grazer	USA	99.78	19	.63	.11	.26
La Estanzuela 284	URY	--	21	.24	.48	.29
Gulf (857)	USA	99.02	40	.23	.45	.33
Gulf (L19)	USA	99.02	71	.07	.37	.56
Totals	--	--	396	.28	.51	.21
Perennials						
Linn	USA	5.00	20	.10	.20	.70
Derby Supreme	USA	2.85	16	.13	0	.88
Caddieshack	USA	1.57	11	0	.09	.91
Aquarius II	USA	--	19	.05	0	.95
Brightstar II	USA	2.24	16	0	0	1.00
Buccaneer	USA	7.44	27	0	0	1.00
Calypso II	USA	0.47	17	0	0	1.00
Cutter	USA	1.65	26	0	0	1.00
Dancer	USA	0.78	19	0	0	1.00
Delaware Dwarf	USA	2.60	15	0	0	1.00
Divine	USA	3.09	19	0	0	1.00
Express	USA	4.00	12	0	0	1.00
Lorettanova	DEU	--	11	0	0	1.00
Lowgrow	USA	1.31	23	0	0	1.00
Palmer	USA	1.04	22	0	0	1.00
Pennfine	USA	--	21	0	0	1.00
Pleasure	USA	4.09	16	0	0	1.00
Racer	USA	1.23	18	0	0	1.00
Repell III	USA	0.80	20	0	0	1.00
Saturn	USA	--	17	0	0	1.00
SRX4801	USA	--	15	0	0	1.00
Sunshine	USA	2.65	20	0	0	1.00
Top Hat	USA	0.77	16	0	0	1.00
Totals			416	.01	.01	.98

[1] Country of cultivar maintainer as recorded in OECD <http://www.oecd.org/agr/code/seeds/seeds1.htm> or Oregon Seed Certification Service <http://www.oscs.orst.edu/index.html> on-line lists verified 1 August 2001. DEU=Germany, DNK=Denmark, GBR=United Kingdom, JPN=Japan, NLD=Netherlands, NOR=Norway, URY=Uruguay, USA=United States.

[2] Variety fluorescence level as reported by the USA Association of Official Seed Certifying Agencies National Grass Variety Review Board

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