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CROP RESIDUE MANAGEMENT AND ESTABLISHMENT SYSTEMS FOR ANNUAL RYEGRASS SEED PRODUCTION

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Introduction

Historically, a low-cost annual ryegrass (*Lolium multiflorum*) seed production system based on open field burning of post-harvest residue followed by no-till drilling to establish the subsequent crop has been very effective. With recent restrictions on open field burning, non-thermal crop establishment systems are needed that also provide an economical system for growing annual ryegrass seed. Starting in the Fall 1994, a three year study focusing on non-thermal crop residue and establishment systems was begun. This report summarizes research data collected during the third crop year (1996-97). Data from 1995 and 1996 as well as details on the background, methods, and field histories for these trials are in previous reports (Ext/CrS 106, 3/96; Ext/CrS 110, 4/97).

The experiment is designed to investigate low cost crop residue management and seeding practices for annual ryegrass seed production, and to determine the effects of straw removal and seeding practices on establishment, growth, development, and yield of subsequent annual ryegrass seed crops.

Procedure

Two on-farm sites near Halsey, OR were selected for field-scale experiments using grower-owned, commercial size farm equipment. One site, owned by John and David Smith, is a tiled, Woodburn silt loam soil that is moderately well drained. Gulf annual ryegrass has been grown on it continuously for at least the past twenty years. The other site, owned by Jack Pimm, is a poorly drained Dayton silt loam soil that has been planted to TAM 90 during the course of this study.

The experimental design is a randomized split-block, where each site has three main treatments: (i) plow and conventional drill, (ii) no-till drill, and (iii) volunteer. Each main plot treatment is split into two residue management options. Half of the plot is baled and the other half is flail chopped with the full straw load left on the soil surface. In total, six treatments were arranged in three replications at each site.

Plot size is 25 x 400 ft at Smith's and 22 x 600 ft at Pimm's, which allow plots to be harvested with the growers' swathers and combines. A weigh wagon was used to determine the bulk seed weight harvested from each plot. Clean seed yield is calculated from percent cleanout values obtained from sub-samples cleaned for each plot.

Straw was baled and removed from half the plots at both sites. The straw on the unbaled plots was flailed twice. The baled plots were flailed once to keep stubble height consistent in all treatments. Baling and flail chopping were completed August 29-30. Following these straw management practices, the conventionally tilled treatments were plowed on September 26-27 and subsequently worked into a seedbed at both sites.

Both on-farm sites were planted October 17 using a no-till drill. Plots were planted on ten inch row-spacing using 15 lb/a annual ryegrass with band-applied dry fertilizer (16-20-0) at 120 lb/a (broadcast equivalent). The drill was also used to apply banded fertilizer (no seed) on the volunteer plots to keep the fertilizer treatments consistent.

Roundup herbicide (1 qt/a) was applied October 17, the same day the planting was completed. The herbicide was applied to conventionally tilled and no-till plots at both sites for the control of volunteer seedlings that had germinated on the soil surface. This technique, known as a "sprout spray," can be effective in controlling stand density when there is a "sprout" of volunteer seedlings before the crop emerges. Timely fall rains during August and September resulted in a good volunteer sprout emergence. The growers' normal fertilizer management (135-140 lb N/a in early April) was also broadcast applied to all plots.

In February 1997, plants were removed from a 4 x 20 inch area and counted to determine the actual stand density established. In addition, plant biomass was dried and weighed. The stands were evaluated again in June (near peak anthesis) by sampling a 10 x 12 inch area from which fertile and vegetative tiller numbers were determined, as well as subsampled to determine spikelet and floret number per inflorescence. All treatment plots were swathed on June 23 at Pimm's farm. Swathing at Smith's farm was split: June 23 for the volunteer stand and July 1 for the no-till and plowed treatments due to crop maturity differences. Combine harvest was completed on July 12 and August 31 at Smith's and Pimm's, respectively.

Results

Establishment. The highest stand density in February was in the volunteer established plots and the lowest was in the drilled plots (Tables 1 and 2). Stand density in the no-till plots was intermediate in relation to volunteer and conventionally tilled plow plots at Pimm's. At Smith's the no-till and volunteer treatments were about the same. Plants in the drilled plots developed more tillers than plants in the other establishment methods at both locations. At the Smith site, plants in the drilled treatment had a larger number of tillers than at Pimm's (2.9 tillers per plant vs 2.0) similar to the previous year. This could be attributed to varietal differences or soil conditions as the plots at Smith's were able to establish and grow more rapidly in the better drained soil. Though the dry weight per seedling was similar in the drill and volunteer treatments, the type of seedling, and hence the affect on yield was very different. The drilled seedlings were shorter and more developed by producing more tillers as compared to the volunteer seedling, which were tall, thin and dense (Tables 1 and 2). Higher total dry matter production in the volunteer plots can be attributed to the volunteer seedlings 'sprouting' and starting growth much earlier than seedlings in the drilled plots. Drilled plots were planted later and were affected by the cooler, wet weather. Density and size of seedlings were greater in the volunteer established stands at Pimm's than at Smith's, but in contrast the lower density of drilled seedlings at Smith's resulted in generally larger seedlings than at Pimm's.

Harvest. Seed yield decreased at both sites as the level of management was reduced (Table 5 and 6). The volunteer established plots averaged 72% of the drilled plots, and no-till plots yielded 91% of the drilled plots. Although volunteer plots had more fertile tillers per unit area, the yield per fertile tiller was reduced. This indicates the density of fertile tillers was more than optimum for this crop. Indication of overcrowding is shown in Table 3 where the volunteer and no-till sowing methods had more total tillers ($P \leq 0.10$) than the drilled plots. The higher yielding treatment tended to keep about the same total tiller population compared to the stand in February (or increase some) as compared the lower yielding treatments, which had higher winter tillers populations and decreased substantially by harvest (compare Tables 1 and 2 with Tables 3 and 4). This self-thinning was detrimental to yield and indicates above optimum plant densities. In addition, higher cleanout in the volunteer stands caused by more chaff and plant material may be from more seed sites not filling or effectively maturing to harvest. Both locations had a comparable ratio of fertile tillers in the stand at maturity; the stands had an average of 82% fertile tillers at Pimm's and 89% at Smith's (Tables 3 and 4). Volunteer establishment reduced yield an average of 28% (Tables 5 and 6).

At Smith's, drilled plots yielded the highest with no-till plots yielding about 5% less (though not statistically different), while the volunteer established crop yielded 74% of the drilled plots (Table 6). Seed yields close to industry averages were obtained across treatments at both sites for the drilled treatments It is likely that differences in soil drainage characteristics and varieties at these two sites could explain the different results observed.

Three year yield summary

Yields averaged over the three year study resulted in the plow treatment maintaining the highest overall yield by 5% over the no-till treatments and by an average of 16% over the volunteer treatments (Table 7 and 8). In the first year at Pimm's the plow treatment was the lowest yielding treatment. All treatments yielded well that year (1995). The differences are even more dramatic in the second and the third years. Seed yield (compared to the plow treatment) at Smith's in the volunteer stand was 19% less in the second year and 26% less in the third year. Likewise, at Pimm's, the volunteer treatment decreased 22% in the second year and 30% in the third year. By contrast, the no-till yields remained constant in the second and third year in relation to the plow treatment. The yearly differences is related to the plant densities and general vigor of the stand coming out of winter's cool and very saturated conditions, however, the gradual decline in the volunteer plots over the three years with respect to the plow treatment is not well understood.

Acknowledgments: This research was supported in part through funds from the Grass Seed Cropping Systems for a Sustainable Agriculture Special Grant program administered by USDA-Cooperative States Research Education and Extension Service. We are also appreciative of the assistance of John and David Smith, and Jack and Eric Pimm in providing equipment and labor to accomplish numerous farming operations.

Table 1. Effects of establishment cropping systems on stand density, tillering, and dry weight in TAM 90 annual ryegrass at Pimm Farm, February 1997.

Cropping system	Seedlings per unit area	Tillers per seedling	Above-ground dry weight per seedling	Above-ground dry weight per unit area
	(no./sq. ft.)	--------(no.)--------	(mg/seedling)	(g/sq. ft.)
Sowing method				
Drill	122 b*	2.0 a	50 b	6 b
No-till	231 b	1.6 b	25 c	5 b
Volunteer	416 a	1.2 c	82 a	30 a
Residue removal				
Bale	281	1.6	54	14
No removal (flail)	232	1.5	51	13

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

Table 2. Effects of establishment cropping systems on stand density, tillering, and dry weight in Gulf annual ryegrass at Smith Farm, February 1997.

Cropping system	Seedlings per unit area	Tillers per seedling	Above-ground dry weight per seedling	Above-ground dry weight per unit area
	(no./sq. ft.)	--------(no.)--------	(mg/seedling)	(g/sq. ft.)
Sowing method				
Drill	56 b*	2.9 [1]	65 a	4 b
No-till	226 a	1.8	28 b	6 b
Volunteer	245 a	1.3	50 a	12 a
Residue removal				
Bale	205	2.3 [1]	48	7
No removal (flail)	146	2.0	47	7

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

[1]Significant Sowing method x Residue removal interaction

Table 3. Effect of establishment cropping systems on spring tiller density and dry matter production in TAM 90 annual ryegrass at Pimm Farm, June 1997.

Cropping system	Tiller density Total	Vegetative	--------Fertile--------		Above-ground dry weight
	--------------- (no./sq. ft.)		-----------------	(%)	(ton/a)
Sowing method					
Drill	116 (b)*	22	94 (b)	81 b	3.6
No-till	115 (b)	26	89 (b)	77 b	3.5
Volunteer	183 (a)	20	164 (a)	88 a	3.3
Residue removal					
Bale	134	24	110	81	3.6
No removal (flail)	142	21	121	83	3.4

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values P=0.05 (P=0.10)

Table 4. Effect of establishment cropping systems on spring tiller density and dry matter production in Gulf annual ryegrass at Smith Farm, June 1997.

Cropping system	Tiller density Total	Vegetative	--------Fertile-------		Above-ground dry weight
	--------------- (no./sq. ft.)		-----------------	(%)	(ton/a)
Sowing method					
Drill	101 (b)*	12	89 (b)	88	3.7
No-till	142 (a)	14	128 (ab)	90	3.5
Volunteer	123 (b)	15	108 (a)	88	3.1
Residue removal					
Bale	126	13	113	89	3.8 a
No removal (flail)	117	14	104	88	3.1 b

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values P=0.05 (P=0.10)

Table 5. Harvest characteristics of TAM 90 annual ryegrass established under different cropping systems at Pimm Farm, 1997.

Cropping system	Harvest index	Cleanout	Seed yield	Seed yield
	------------(%)---------		(lb/a)	(% of Drill)
Sowing method				
Drill	25	3.6 b*	2287 a	100
No-till	22	3.9 a	1956 b	86
Volunteer	20	5.9 a	1589 c	69
Residue removal				
Bale	22	4.0	1939	--
No removal (flail)	23	4.1	1949	--

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

Table 6. Harvest characteristics of Gulf annual ryegrass established under different cropping systems at Smith Farm, 1997.

Cropping system	Harvest index	Cleanout	Seed yield	Seed yield
	---------(%)--------		(lb/a)	(% of Drill)
Sowing method				
Drill	25	3.4 c	2408 a	100
No-till	25	4.3 b	2281 a	95
Volunteer	23	5.5 a	1791 b	74
Residue removal				
Bale	23 (b)*	4.7 a	2196	--
No removal (flail)	26 (a)	4.0 b	2123	--

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values P=0.05 (P=0.10)

Table 7. Effects of establishment cropping systems on seed yield in Gulf and TAM 90 annual ryegrass over time (1995-97) at Pimm and Smith farms.

Cropping system	1995	1996	1997	3 year average
	(lb/a)			
TAM 90				
Sowing method				
Drill	2218 b*	2878 a	2287 a	2461 a
No-till	2507 a	2474 b	1956 b	2312 b
Volunteer	2605 a	2248 c	1589 c	2147 c
Gulf				
Sowing method				
Drill	2596	2586 a	2408 a	2530 a
No-till	2421	2534 a	2281 a	2412 a
Volunteer	2257	2083 b	1791 b	2044 b

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

Table 8. Effects of establishment cropping systems on seed yield relative to drill treatments in Gulf and TAM 90 annual ryegrass over time (1995-97) at Pimm and Smith farms.

Cropping system	1995	1996	1997	3 year average
	(% of Drill)			
TAM 90				
Sowing method				
Drill	100	100	100	100
No-till	113	86	86	94
Volunteer	117	78	70	87
Gulf				
Sowing method				
Drill	100	100	100	100
No-till	93	98	95	95
Volunteer	87	81	74	81

THE EFFECT OF STRAW REMOVAL AND DIFFERENT ESTABLISHMENT SYSTEMS ON SOIL FERTILITY LEVELS IN ANNUAL RYEGRASS SEED FIELDS

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

Introduction

A three-year study of crop residue and establishment systems in annual ryegrass was completed in 1997. This report summarizes the effects on soil chemical properties following three consecutive years of these treatments. Of particular interest was the effect of straw removal on soil organic matter and nutrient levels, especially the important fertilizer elements phosphorus (P) and potassium (K). (Effects on seed yield and other agronomic characteristics are discussed in another paper in this report – Crop Residue Management and Establishment Systems for Annual Ryegrass Seed Production.)

Very little annual ryegrass straw is removed by baling at the present time; however, potential markets for straw could develop. An advantage of baling straw off annual ryegrass fields is to reduce the cost of flail chopping the full straw load. One disadvantage is loss of nutrients, resulting in potential added fertilizer costs. Nutrient uptake surveys have shown that tall fescue and perennial ryegrass seed crops can remove substantial amounts of K from soils. Phosphorus, S, and other nutrients are also removed, but uptake is usually less than K or N. Nutrient uptake by annual ryegrass, based on a limited number of studies, appears to be less than that removed by established perennial ryegrass and tall fescue crops, especially for K (Table 1).

Table 1. Nutrient uptake at swathing time. The wide range in uptake is related to differences in biomass production and soil fertility (Hart et al., 1988).

Crop	P Range	P Mean	K Range	K Mean	Site years
	---- (lb/a) ---		----- (lb/a)-----		
Annual ryegrass	8-16	11	25-80	45	6
Perennial ryegrass	8-24	13	51-261	127	35
Tall fescue	7-34	15	33-399	165	35

To determine P_2O_5 and K_2O uptake, multiply P by 2.29 and K by 1.2.

Procedure

Two fields near Halsey, Oregon were selected for this study in 1994. One site was situated on a moderately well drained Woodburn silt loam soil, and Gulf annual ryegrass was grown (John and David Smith Farm). The second site was on a poorly drained Dayton silt loam in production of Tam 90 annual ryegrass (Jack Pimm Farm). The experimental design was a randomized split-block. Each site had three main establishment treatments (plow, no-till, and volunteer). These main plots were split, and straw was baled and removed from half the plots at both sites, while the remaining half had the full straw load flail chopped. Fertilizer applications at planting were the same across all treatments. Each farmer applied spring fertilizer across all the plots at the normal field rate. (See the companion article previously mentioned for additional details on the design and management of this field experiment). Soil samples were taken in the winter prior to any spring fertilizer applications each year at 0-2 inch and 2-8 inch soil depths, and analyzed for pH, P, K, Ca, Mg, and organic matter.

Results

Sowing method

Volunteer and no-till sowing methods used to establish annual ryegrass resulted in pH and nutrient stratification in both soil types (Tables 2 and 4). Without tillage, P and K levels tended to increase in the surface 0-2 inch soil samples due to topdress fertilizer applications (Tables 3 and 5). The surface layer in the no-till and volunteer treatments also became slightly more acidic (lower pH and Ca levels) on the Woodburn soil type. This pattern of pH and Ca stratification was reversed on the Dayton soil because lime had been applied in Fall 1993 after rotating out of tall fescue into annual ryegrass. The lime was shallow harrowed into the top 2-3 inches of the soil surface which resulted in significantly higher surface pH and Ca levels on the no-till and volunteer plots. In general, pH and nutrient distribution through the root zone was more uniform on the plots where the soil was worked in a conventional manner (the plow treatment).

Organic matter distribution in the soil was also affected by sowing method, although none of the levels in any of the treatments were low for cultivated agricultural soils. On both soil types, the organic matter was higher in the surface 0-2 inch soil samples on the no-till and volunteer treatments compared to where the straw had been plowed in after harvest. Soil organic matter increased in the 2-8 inch soil depth on the plow treatment as a result of the residue being mixed into the soil during tillage and seedbed preparation.

Total organic matter through the plow layer (0-8 inch soil depth) was about the same under the plow and volunteer treatments, indicating these establishment system treatments were having little effect on the overall soil organic matter content. There were, however, some differences between the sites in how organic matter in the soil responded to the no-till establishment system. On the poorly drained Dayton soil, organic matter in the soil on the volunteer and plow treatment was greater than the no-till. This appeared to have been related to less biomass production on the no-till plots and to slower organic matter decomposition on the poorly drained soil.

Residue management

Removal of straw by baling, versus chopping back on the field, did not have any effect on soil pH, Ca, Mg, or P levels in this study, even after three years of straw removal (Tables 2 through 5). Residue management did, however, affect the soil K and organic matter on both soil types.

Soil K levels decreased over time with continuous baling (Figure 1). The initial decline was not very dramatic, but after three years of straw removal the soil tests (0-8 inch) were 5-10% less compared to where the straw had been plowed in during this same time period. The decline in K was most significant from a management point of view on the Dayton soil, where the soil test actually dropped below the 100 ppm critical level. Although reductions in soil K were measured on these annual ryegrass seed fields due to straw removal, the decline in the soil test levels were not as dramatic as that observed on some perennial ryegrass and tall fescue seed fields (Horneck et. al, 1992).

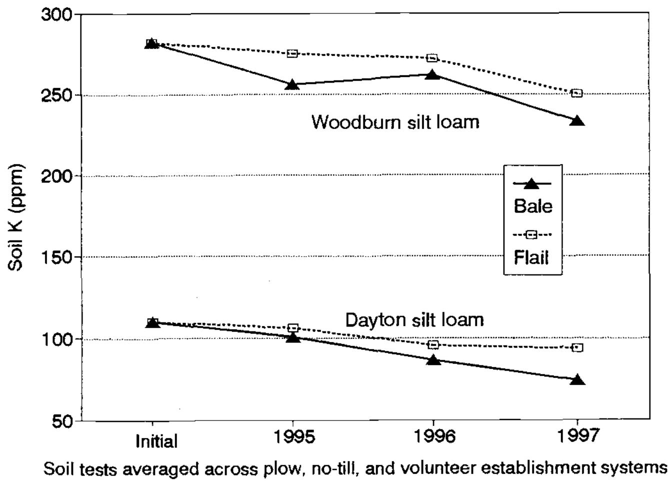

Figure 1. The effect of straw removal by baling vs flail chopping it back on soil K levels (0-8 inches) on two annual ryegrass fields.

Baling also resulted in a small decrease in soil organic matter on both soil types. The average reduction in the 0-8" samples was from 5.83% to 5.68%. This is equivalent to a loss of about 1,400 pounds per year during the coarse of this study (assuming 2,000,000 pounds soil per 0-6 inch acre-furrow-slice). The small loss of organic matter due to baling in this trial did not affect seed yields.

Summary

This study has shown that annual ryegrass seed yields are not affected when straw is removed by baling on these typical Willamette Valley floor soils. However, soil K levels will decline over time and soils need to be tested for this nutrient if straw is removed, especially on soils like Dayton silt loam, which tend to be lower in K than other valley floor soils. The amount of K removed from a field when annual ryegrass straw is baled will vary with soil type, fertility levels, and biomass production.

More uniform nutrient and pH distribution through the root zone could be one reason the plow treatment in this study had higher seed yields. The development of pH and nutrient stratification measured after several years of no-till management should be taken into consideration in a liming and fertilizer program for annual ryegrass seed crops. Lime, P, and K do not move down very far in the soil following broadcast application. Therefore, if soil tests show a need, they should be incorporated before shifting to a system of annual ryegrass production that does not involve tillage for a number of years.

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Table 2. Soil test values for pH, Calcium (Ca), and Magnesium (Mg) following three years of different residue management and establishment systems on a Woodburn silt loam at Pimm Farm, 1997.

Cropping system	pH		Ca		Mg	
	0-2"	2-8"	0-2"	2-8"	0-2"	2-8"
			(meq/100g)			
Sowing method						
Drill	5.9 b*	6.1 a	8.3 a	8.3 a	1.18 a	1.47
No-till	6.7 a	5.3 b	13.6 b	6.5 b	0.98 b	1.37
Volunteer	6.6 a	5.5 c	14.2 b	7.1 b	0.87 b	1.37
Residue removal						
Bale	6.4	5.6	12	7.3	1.01	1.42
No removal (flail)	6.4	5.7	12	7.3	1.01	1.38

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

Table 3. Soil test values for Phosphorus (P), Potassium (K), and Organic Matter following three years of different residue management and establishment systems on a Woodburn silt loam at Pimm Farm, 1997.

Cropping system	P		K		Organic Matter		
	0-2"	2-8"	0-2"	2-8"	0-2"	2-8"	0-8"
	(ppm)				(%)		
Sowing method							
Drill	18 b*	15	77 b	107	5.08 b	4.83 a	4.89 (a)
No-till	23 a	16	109 a	71	5.35 b	4.36 b	4.61 (b)
Volunteer	20 ab	15	91 b	66	6.09 a	4.61 a	4.98 (a)
Residue removal							
Bale	20	15	81 a	72 a	5.15 a	4.56 (a)	4.71 a
No removal (flail)	20	16	104 b	90 b	5.86 b	4.64 (b)	4.94 b

* Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values P = 0.05 (P=0.10)

Table 4. Soil test values for pH, Calcium (Ca), and Magnesium (Mg) following three years of different residue management and establishment systems on a Woodburn silt loam at Smith Farm, 1997.

Cropping system	pH 0-2"	pH 2-8"	Ca 0-2"	Ca 2-8"	Mg 0-2"	Mg 2-8"
			(meq/100g)			
Sowing method						
Drill	4.6 a*	4.8	2.9 a	3.2	0.35 a	0.39
No-till	4.4 b	4.7	2.2 b	3.4	0.28 b	0.42
Volunteer	4.5 b	4.7	2.5 b	3.5	0.34 a	0.41
Residue removal						
Bale	4.5	4.7	2.5	3.4	0.31 b	0.42
No removal (flail)	4.5	4.7	2.6	3.3	0.34 a	0.40

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

Table 5. Soil test values for Phosphorus (P), Potassium (K), and Organic Matter following three years of different residue management and establishment systems on a Woodburn silt loam at Smith Farm, 1997.

Cropping system	P 0-2"	P 2-8"	K 0-2"	K 2-8"	Organic Matter 0-2"	Organic Matter 2-8"	Organic Matter 0-8"
	(ppm)				(%)		
Sowing method							
Drill	44 b*	46	168 c	242	6.76 b	6.75 a	6.76
No-till	48 ab	49	280 b	221	7.35 a	6.44 b	6.67
Volunteer	51 a	49	377 a	230	7.38 a	6.44 b	6.67
Residue removal							
Bale	48	47	280	218 a	7.05	6.50 a	6.64
No removal (flail)	47	49	269	244 b	7.27	6.59 b	6.76

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

ESTABLISHMENT OF ROWS IN VOLUNTEER ANNUAL RYEGRASS SEED CROPS USING A SHIELDED SPRAYER

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

Introduction

With reductions in the acreage allowed for open field burning, annual ryegrass (*Lolium multiflorum*) growers are changing the methods used for establishing this crop. In the past, open field burning followed by no-till establishment methods were used for sequential cropping of annual ryegrass over several years. This provided a cost conserving method of establishment in this low profit margin seed crop. One of the non-burning methods of establishing a subsequent crop is to allow the shattered seed from the previous crop to germinate resulting in a "volunteer" stand.

Since shattered seed losses can easily be 10%, a volunteer seeding of 200 lb/a (10% of 2000 lb/a yield) can result in very dense stands compared to 15-20 lb/a normally planted in rows. This ultimately results in reduced yields caused by too much inter-plant competition for limited resources. One of the ways that has been suggested and tried on a limited basis is to use herbicides on a staggered spacing to make "rows" by spraying out inter-row regions leaving the non-sprayed strips as "rows" in the field. In order to find how much of the stand needs to be sprayed out, we began a trial at the OSU Hyslop Research Farm in the fall of 1995. (Data from last year's trial are reported in Ext/CrS 110, 4/97). Data in this report discusses the second year's result from row spraying a volunteer stand using a shielded sprayer.

Procedure

A 2.4 acre field located at the OSU Hyslop Research Farm was seeded in September 1995 for a stand density study. Following plot harvest in 1996, half of the plots had straw baled and removed and on the other half straw was flail chopped (2-3 passes) and left on the field. The stubble left from the baling operation was also flailed. A volunteer crop was allowed to germinate in these main plots. Four subplot treatments were applied to both the baled and the full straw load strips in each replication. The four treatment were an untreated check, and three spray widths of 3, 6, and 9 inches wide on 12 inch center spacing in an effort to leave a solid stand, and rows 9, 6, and 3 inches wide, respectively. Each plot was 15 x 200 feet organized in a split-plot design with residue (full straw load and baled) as main plots and the spray widths as subplots. All treatments were replicated three times. Rows were sprayed on December 19, 1996 with a shielded row sprayer using Roundup at 2.0 pt/a (with 0.25% surfactant) applied at 55 gal/a. The sprayer was adjusted to spray the appropriate widths for each treatment A fall application of 200 lb/a of 16-20-0-14(S) was broadcast applied on October 10. Spring fertilizer applications were 70 lb/a N (as urea) on March 26, and 80 lb/a N (as urea) on April 8, 1997.

The stand was sampled in March for plant counts and in June (near peak anthesis) for fertile and vegetative tiller numbers and total biomass. Subsamples to determine spikelet and floret number per inflorescence were also taken in June. Yield assessment was determined from a 14 ft swath cut through the center of each 200 ft plot. Plots were swathed June 23 and combine harvested July 15, 1997. Both operations were conducted using grower equipment. A weigh wagon was used to determine the bulk seed weight harvested from each plot. Clean seed yield was calculated from percent cleanout values in subsamples obtained during harvest.

Results

Using a shielded row sprayer to change plant population in the annual ryegrass stand resulted in a 64% decrease at the widest sprayband of 9 inches (Table 1). As expected, the other two row spray widths were intermediate in their effect on plant population. The unsprayed plots averaged over 1000 seedling plants per square foot compared to 370 in the most severe stand reduction treatment. The plants in the solid stand were tall and thin, and too densely populated to allow individual plant tillering. This overcrowding resulted in smaller sized fertile tillers as observed by tiller specific weight and spike length (Table 2). Seed yield was improved by using herbicides to create rows, thereby reducing volunteer plant populations (Table 3). Seed yield improved as the sprayed bands became wider. The highest yield was obtained when a 3 inch row remained (75% of the solid stand removed), which resulted in an 18% yield increase over the solid stand. However, the difference in tiller populations observed in the winter were mostly diminished by harvest. Total tiller number decreased in all treatments to result in comparable levels of fertile tillers at maturity. This indicates much higher tiller mortality in the volunteer stand and subsequent loss of plant resources.

Table 1. Effect of residue management and row spraying winter plant population and tiller length of Gulf annual ryegrass, March, 1997.

Treatment	Plant population	Mean tiller length
Residue	(no./sq. ft.)	(cm)
Flail full straw load	488	12.2
Bale + flail stubble	782	13.2
Row spray (% stand remaining)		
3 inch rows (25%)	370 c*	7.7 c
6 inch rows (50%)	428 bc	11.3 bc
9 inch rows (75%)	717 ab	13.8 b
Solid stand (100%)	1025 a	18.1 a

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

Table 2. Effect of residue management and row spaying on spring tiller production in Gulf annual ryegrass, June 1997.

	Fertile tiller		
	Density	Specific weight	Spike length
	(no./sq. ft.)	(mg/tiller)	(cm)
Residue			
Flail full straw load	310	237	21.4
Bale + flail stubble	329	218	21.1
Row spray (% stand remaining)			
3 inch rows (25%)	245	254 (ab)*	23.7 a
6 inch rows (50%)	293	284 (a)	21.4 b
9 inch rows (75%)	347	200 (bc)	20.1 b
Solid stand (100%)	323	173 (c)	19.8 b

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values P=0.05, (P=0.10)

Table 3. Harvest characteristics of Gulf annual ryegrass established at residue and row spray treatments, 1997.

	Above ground biomass	Seed yield	1000 seed weight
	(ton/a)	(lb/a)	(g)
Residue			
Flail full straw load	3.1	1842	2.95
Bale + flail stubble	3.0	1733	2.89
Row spray (% stand remaining)			
3 inch rows (25%)	2.9 b*	1903 (a)	2.95
6 inch rows (50%)	3.5 a	1885 (a)	2.84
9 inch rows (75%)	2.9 b	1750 (ab)	2.96
Solid stand (100%)	2.7 b	1614 (b)	2.92

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values P=0.05, (P=0.10)

This two-year study has indicated that volunteer stands can negatively impact seed yield. Optimum tiller populations for high seed yield are much less than what usually occurs in solid, volunteer established stands. Band-spraying herbicides to create rows in solid stands appears to be an effective and economical way to reduce the tiller populations and increase seed yield potential.

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HERBICIDE OPTIONS FOR ESTABLISHING ROWS IN VOLUNTEER ANNUAL RYEGRASS SEED

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Introduction

Volunteer cropping is not without problems. Recent on-farm trials have documented reductions in seed yield of 19 to 22 percent when volunteer established plots were compared with conventionally drilled plots seeded into plowed ground. These data have confirmed growers' perception that volunteered stands produce lower seed yields than drilled stands. Further studies on stand density effects of annual ryegrass seed crops have shown yield reduction can result at high plant density (See Department of Crop and Soil Science Ext/CrS 106, 3/96 and 110, 4/97). In addition, preliminary data have shown that using herbicides on a staggered spacing to make "rows" by spraying out inter-row regions can significantly improve seed yield. In these reports, a 68 percent increase in seed yield occurred when 75 percent of the stand was eliminated by banding herbicide.

However, little information is available regarding the optimum timing or herbicide possibilities for row-spraying. The timing of defoliation by row spraying or by grazing may have significant implications for tiller development, weed control, and seed yield in annual ryegrass. Thus, a study was established at OSU's Hyslop Crop Science Field Laboratory on a volunteer established annual ryegrass seed field to investigate herbicide options (contact, systemic and residual) and timing for optimum use of row-spraying to reduce stand density.

Procedure

A 2.5 acre field located at the OSU Hyslop Research Farm was seeded in September 1994 for a stand density study. Following plot harvest in 1995, a volunteer seedling stand was managed for a second trial, "Establishment of Rows in Volunteer Annual Ryegrass Seed Crops Using a Shielded Sprayer" (See Department of Crop and Soil Science Ext/CrS 110, 4/97). Following the above study, this trial was started using a second-year volunteer established crop. All crop residue from the previous crop was flail chopped and left on the soil surface, and a volunteer crop was allowed to germinate. Three herbicide row-spray treatments were applied at three dates in a completely random design with an unsprayed check plot. Herbicide treatments were:

1) Gramoxone (2 pt/a)
2) Roundup (1 qt/a)
3) Roundup (1 qt/a) + Diuron (1.6 lb a.i./a)

Surfactant was added according to label recommendations.

All plots were replicated three times. Application dates were December 19, 1996, January 10, 1997 and February 5 1997. Herbicides were sprayed using a shielded row sprayer set to spray a six inch band on 12 inch centers (50% of the stand sprayed out) at 55 gal/a in the band. Plots were 15 x 135 ft. and were swathed and combined using commercial-size harvesting equipment and a weigh wagon for yield measurements. Fertile and vegetative tiller numbers produced by all management systems were determined from 12-inch sections of crop row removed from each plot near peak anthesis. The total biomass present at harvest was also determined. A fall application of 200 lb/a of 16-20-0-14(S) was broadcast applied on October 11. Spring fertilizer applications were 68 lb/a N (as urea) on March 26, and 85 lb/a N (as urea) on April 8, 1997.

The stand was evaluated on June 5 (near peak anthesis) by sampling a 12 x 12 inch area from which fertile and vegetative tiller numbers, and total biomass were determined. In addition, subsamples of fertile tillers were taken to determine spikelet and floret number per inflorescence. Yield assessment was determined from a 14 ft swath cut through the center of each 135 ft plot. Plots were swathed June 23 and combine harvested July 15, 1997. Both operations were conducted using grower equipment. A weigh wagon was used to determine the bulk seed weight harvested from each plot. Clean seed yield was calculated from percent cleanout values in subsamples obtained during harvest.

Results

Seed yield from this trial was not affected by either time of application or the type of herbicide used. Initial seedling populations prior to spraying were sufficient to provide dense stands. Untreated plots had 929 tillers per square foot when sampled in early March. The Roundup treated plots had 624, 419, and 259 tillers per square foot for treatment dates 1, 2, 3 (respectively). Final seed yield was much lower than anticipated (Table 1). Spike length and specific fertile tiller weight were both improved by the row spraying, but this did not impact seed yield.

A second year trial is currently in progress to be harvested in 1998. The second trial was adjusted to spray out 75% of the stand as compared to the 50% in this trial.

Table 1. Effects of herbicide type and timing on harvest components in Gulf annual ryegrass, June 1997.

Treatment	Seed yield	Fertile Density	Fertile Specific weight	Spikelets per spike	Spike length
	(lb/a)	(no./sq. ft.)	(mg/tiller)	(no.)	(%)
Date 1 (Dec. 19)					
Gramoxone	1116	120	495 abcd[1]	22.7	27.1
Roundup	1067	157	376 ab	21.7	24.0
Roundup + diuron	1027	118	540 bcde	24.0	26.6
Date 2 (Jan. 10)					
Gramoxone	1120	117	708 e	22.4	27.6
Roundup	1061	108	619 de	21.9	26.0
Roundup + diuron	993	119	581 cde	22.0	26.0
Date 3 (Feb. 5)					
Gramoxone	1006	110	625 de	21.1	25.9
Roundup	915	135	406 abc	20.9	24.4
Roundup + diuron	1091	137	519 bcd	21.1	26.4
Untreated check	1061	182	320 a	20.4	21.6

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

THE ANNUAL BLUEGRASS CHALLENGE TO PERENNIAL RYEGRASS SEED PRODUCTION

G.W. Mueller-Warrant

Although annual bluegrass (*Poa annua*) is a relatively weak competitor in the field, it is a serious weed contaminant in harvested turfgrass seed, and an unmistakable indicator of management problems. Because annual bluegrass is primarily an opportunistic weed, its presence indicates that perennial ryegrass failed to occupy all available niches throughout the growing season. The list of reasons for this failure can be quite lengthy, including (1) wide row spacings relative to the ability of ryegrass plants to expand by tillering, (2) crop injury during fall and winter from many of the herbicide treatments applied to control weeds, and (3) poor regrowth in late summer and early fall due to shortage of soil moisture, limited perenniality in this species, and biotic factors such as pathogens and parasites. The development of resistance by annual bluegrass to herbicides such as Diuron allows this weed to successfully occupy those niches available in perennial ryegrass seed crops, and poses serious questions to growers, researchers, consultants, and regulatory agencies. Perhaps the most important of these is recognizing when a weed control practice has become counterproductive. For herbicides like Diuron, to which annual bluegrass populations are already resistant, any rate higher than that safely tolerated by the crop is clearly counterproductive. Sequential applications of Diuron are also likely to be counterproductive because any susceptible bluegrass plants were probably killed by the first application, and the surviving weeds are more tolerant to this herbicide than the crop. However, the continued existence of a Diuron-susceptible fraction of the total bluegrass population may mean that there still is some useful rate of Diuron that would not be counterproductive. Suitable rates and application sequence schemes for other herbicides will depend on the relative tolerance/susceptibility to the herbicide treatment in the crop and the weed. Substantial crop injury can be accepted if a treatment both controls existing weeds and provides residual control of any seedlings germinating before a full crop canopy is reestablished.

An interesting question is posed by the reaction of weeds such as annual bluegrass to full straw load chop (FSLC) versus residue removed management [bale, bale/flail chop, bale/flail chop/rake, bale/vacuum sweep (VS)]. Flail chopping the full straw load inhibits the germination of species with strong requirements for light, such as annual bluegrass, while allowing volunteer perennial ryegrass to germinate promptly with the first fall rains. These volunteer ryegrass seedlings, if not controlled by herbicides, can then suppress the germination and growth of annual bluegrass later in the growing season when the straw has matted down and partially decayed, allowing more light to reach the soil surface. Should we adjust our herbicide treatments to allow some volunteer crop seedlings to survive so that they can compete with later germinating annual bluegrass? If so, how many should we let survive? While average yield loss to dense stands of volunteer perennial ryegrass is about 9%, survival of a more modest number of volunteer seedlings has "thickened up" old stands and increased yield in subsequent years. Many herbicides behave quite differently in full straw versus residue removed environments. Prowl (pendimethanlin) (which may finally be registered in 1998 after a long series of regulatory delays) is extremely effective when applied preemergence to weeds on bare soil. Performance of Prowl in full straw conditions is much poorer, probably because it is adsorbed by the straw and cannot reach the germinating seedlings until they are too large to be controlled by it. Other herbicides have less of a tendency to "tie up" on straw; hence, Dual (metolachlor), Goal (oxyfluorfen), Diuron, and metribuzin (Sencor or Lexone) all show less difference in behavior in full straw versus residue removed conditions than Prowl.

The performance of 28 herbicide treatments was evaluated against Diuron-resistant annual bluegrass in an established perennial ryegrass stand near Tangent, Oregon. Six treatments were applied in both VS and FSLC residue management, and another 16 only in the full straw load. Some of these treatments were applied to the same plots for two consecutive years, while others were new treatments replacing the less satisfactory treatments of the 1995-96 growing season. In order to help separate the effects of crop injury and weed competition, perennial ryegrass yield was plotted against percent annual bluegrass ground cover. In the 1995-96 growing season (Fig. 1), 15 treatments appeared to show mainly effects of annual bluegrass on the crop (either competition or crop injury followed by expansion of the weed to fill the niches created by the injury). For these 15 treatments, yield was regressed against annual bluegrass ground cover, predicting a loss of 4.84 pounds of seed per acre for each 1% increase in annual bluegrass ground cover. The other 13 treatments fell well below the regression line, indicating that there were other factors contributing to reduced crop yield in these plots. These factors probably included further injury from the herbicide treatments and competition from volunteer perennial ryegrass. When yields were adjusted by covariance to remove the apparent competitive effects of annual bluegrass, the 13 treatments with additional problems shifted even further away from the others, implying that the 13 treatments had indeed been counterproductive.

In the 1996-97 growing season, 23 of the treatments primarily showed the effects of annual bluegrass competition with the crop (or expansion to fill niches created by herbicide damage to the crop), with only five treatments showing additional crop injury or competition from volunteer perennial ryegrass (Fig. 2). Based on these 23 treatments, yield loss was 4.88 pounds of seed per acre for each 1% increase in annual bluegrass ground cover. The relatively weak competitiveness of annual bluegrass against perennial ryegrass can be seen from the regression equation, which only predicts a loss of 488 lb/a (44% of the weed-free yield of 1105 lb/a) even at 100% annual bluegrass ground cover between the rows. In contrast, Kentucky bluegrass yield loss to downy brome has sometimes reached 100% in plots with extremely high weed densities.

The lowest yielding treatment was row spray Roundup (glyphosate) + Goal (661 lb/a seed yield), clearly suffering from herbicide injury (Table 1). The highest yielding treatments were FSLC Prowl at 3 lb/a applied through the flail (1038 lb/a), FSLC Goal + Prowl at 0.25+2 lb a.i./a surface applied at the 1-leaf stage followed by Goal + Diuron at 0.12+1.2 lb a.i./a applied at the 4-leaf stage (1026 lb/a), and VS Goal + FOE-5043 followed by Goal + Diuron (1028 lb/a). Volunteer perennial ryegrass seedlings in the untreated FSLC check competed well with annual bluegrass, resulting in annual bluegrass ground cover (14.3%) that was lower than for <u>any</u> of the other treatments. Yield for the untreated FSLC check was 974 lb/a, numerically higher than for 21 of the 27 other treatments, although only statistically higher than four of them. Reducing volunteer ryegrass cover without the use of herbicides, either by rotary hoeing in FSLC or by vacuum sweeping, increased the annual bluegrass cover by almost as much as the ryegrass cover was reduced. Several herbicide treatments had the dubious distinction of achieving nearly complete conversion from volunteer perennial ryegrass to annual bluegrass dominated weed populations, including DPX-R6447 at 0.25 lb a.i./a and Goal + Diuron at 0.25+1.6 lb a.i./a.

Relative to these two treatments (avg. 66% annual bluegrass ground cover), the best herbicide treatment (VS Goal + FOE-5043 followed by Goal + Diuron) achieved 71% control of the potential annual bluegrass problem, along with nearly total control of volunteer perennial ryegrass. This herbicide is being tested in the 1997-98 growing season as a 4:1 package-mix with metribuzin under the trade-name of Axiom.

Annual bluegrass seed yield averaged 353 lb/a in the harvested seed, with additional amounts shattering to the soil surface. Lowest annual bluegrass seed yield (198 lb/a) occurred in plots treated with Goal+FOE-5043 followed by Goal+Diuron, while the highest annual bluegrass seed production (530 lb/a) occurred with DPX-R6447 followed by Goal+Diuron. The most promising treatment containing Prowl was VS Prowl at 3.0 lb/a followed by Goal+Diuron at 0.12+1.2 lb a.i./a, which controlled 66% of the potential annual bluegrass. However, perennial ryegrass yield for this treatment was lower than yield for FSLC Prowl at 3 lb a.i./a applied through the flail, possibly indicating that vacuum sweeping either was too aggressive or was conducted too late in the summer, or that the Goal+Diuron application injured the crop in the VS environment. The current 'standard' treatment, Goal+Dual followed by Goal+Diuron, performed quite poorly against this population of annual bluegrass, and must be grouped into the long list of counterproductive treatments. Based on our limited success in controlling annual bluegrass in this two-year study, treatments were modified for the 1997-98 growing season, and are now focused on preemergence Axiom and high rates of Prowl in FSLC and VS, and late winter applications of low rates of Rely (glufosinate).

Table 1. Annual bluegrass and volunteer perennial ryegrass ground cover, March 1997, and perennial ryegrass seed yield, July 1997, Tangent, Oregon.

Treatments and application dates, 1996-97 growing season†		Annual bluegrass	Perennial ryegrass: Volunteer seedlings	Perennial ryegrass: Seed yield
-------------------- (herbicide rates in lb a.i./acre) --------------------		-----(% ground cover) ---		(lb/a)
FSLC	Untreated check	14.3	63.7	974
VS	Untreated check	45.4	17.3	927
FSLC	2 Prowl:flail 9-19 *	29.3	49.2	805
FSLC	3 Prowl:flail 9-19	28.3	44.7	1038
VS	3 Prowl 9-19	50.5	6.3	926
FSLC	4 Prowl:flail 9-19	30.3	36.0	964
FSLC	2 Prowl:flail 9-19 / rotary hoe 10-1	23.0	19.9	998
FSLC	3 Prowl:flail 9-19 / rotary hoe 10-1	24.8	11.4	974
FSLC	2 Prowl:flail 9-19 / 0.12 Goal+1.2 diuron 10-24	39.4	19.5	860
FSLC	3 Prowl:flail 9-19 / 0.12 Goal+1.2 diuron 10-24	39.3	23.2	930
VS	3 Prowl 9-19 / 0.12 Goal+1.2 diuron 10-24 *	22.3	1.6	849
FSLC	2 Prowl:flail 9-19 / 0.25 Goal+1.6 diuron 10-24	42.2	16.1	810
FSLC	3 Prowl:flail 9-19 / 0.25 Goal+1.6 diuron 10-24	59.1	21.4	851
FSLC	0.25 Goal+2 Prowl 9-26 / 0.12 Goal+1.2 diuron 10-24	48.6	22.8	1026
VS	0.25 Goal+2 Prowl 9-26 / 0.12 Goal+1.2 diuron 10-24	34.5	0.9	852
FSLC	0.12 DPX-R6447 9-23	54.8	29.2	751
VS	0.12 DPX-R6447 9-23	36.9	2.7	943
FSLC	0.25 DPX-R6447 9-23	66.4	7.9	712
FSLC	0.12 DPX-R6447 9-23 / 0.12 Goal+1.2 diuron 10-24	57.5	15.5	811
FSLC	0.25 Goal+0.45 FOE-5043 9-26 *	28.4	23.9	839
FSLC	0.25 Goal+0.45 FOE-5043 9-26 / 0.12 Goal+1.2 diuron 10-24	26.5	9.6	982
VS	0.25 Goal+0.45 FOE-5043 9-26 / 0.12 Goal+1.2 diuron 10-24	19.0	0.4	1028
FSLC	0.25 Goal+1.5 Dual 9-26	46.4	32.3	915
FSLC	0.25 Goal+1.5 Dual 9-26 / 0.12 Goal+1.2 diuron 10-24	45.5	12.1	860
FSLC	0.25 Goal+1.6 Diuron 9-26	45.2	31.6	909
FSLC	0.25 Goal+1.6 diuron 10-24	65.9	13.5	767
FSLC	Flail-only 9-19 / rotary hoe 10-1	34.7	37.6	814
FSLC	0.75 Roundup+0.03 Goal row spray 12-18 *	36.2	14.2	661
LSD(0.05)		17.6	10.1	186

†VS=Vacuum sweep Aug. 23, 1996. All other treatments were full straw load chop (FSLC) on Aug. 23, 1996.
Plots receiving Prowl through boom under baffles of Rear's flail were tedded Sept. 18 to dry out the straw.
All other herbicides were surface-applied using a normal plot sprayer.
* Treatments with yield apparently reduced by other effects in addition to annual bluegrass competition.

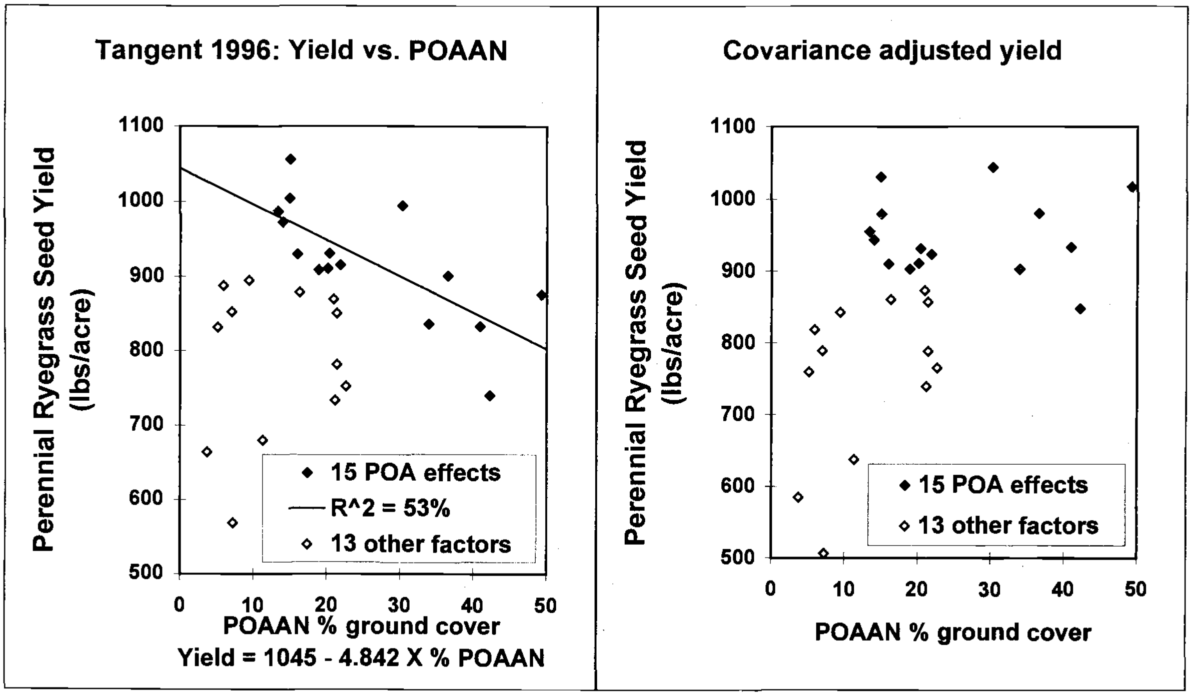

Figure 1. Relationship between perennial ryegrass seed yield and annual bluegrass ground cover in 1995-96 growing season at Tangent. Yield = 1045 - 4.842 X percent ground cover, R^2=53%. Regression based on 15 treatments (closed squares) primarily impacted by annual bluegrass density. Covariance adjusted yield removes the effects of annual bluegrass competition, leaving only residual effects of other factors such as crop injury and volunteer ryegrass competition.

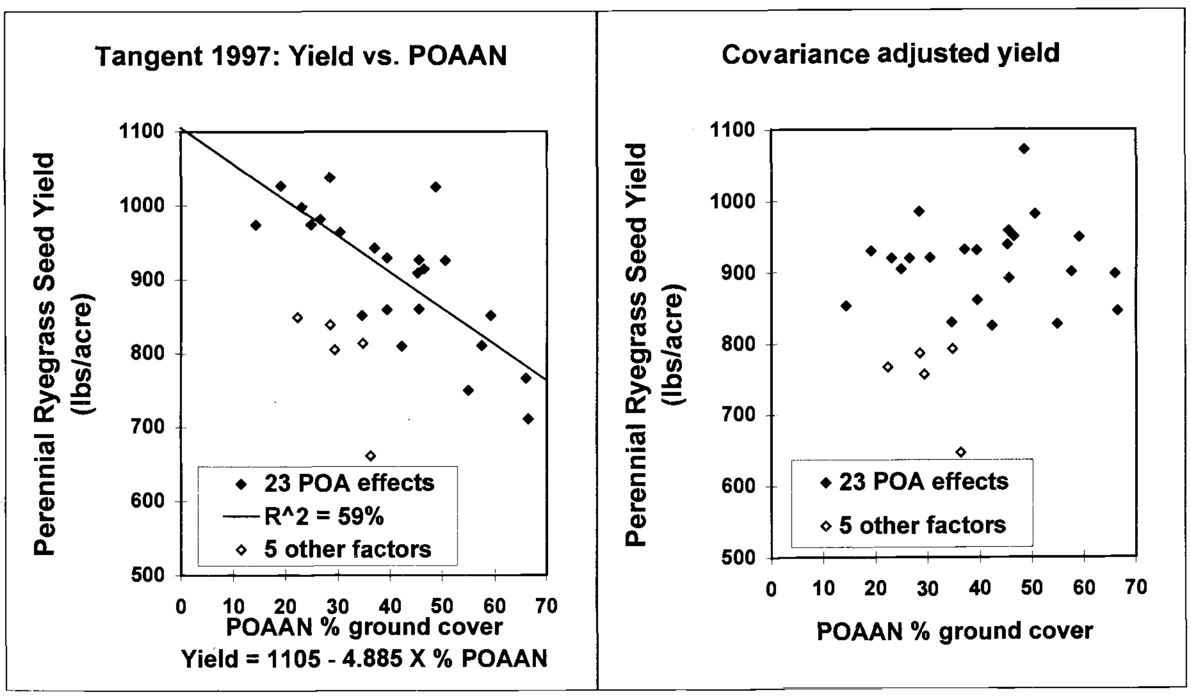

Figure 2. Relationship between perennial ryegrass seed yield and annual bluegrass ground cover in 1996-97 growing season at Tangent. Yield = 1105 - 4.885 X percent ground cover, R^2=59%. Regression based on 23 treatments (closed squares) primarily impacted by annual bluegrass density. Covariance adjusted yield removes the effects of annual bluegrass competition, leaving only residual effects of other factors such as crop injury and volunteer ryegrass competition.

CONTROLLING DIURON-RESISTANT ANNUAL BLUEGRASS IN THE SPRING IN TALL FESCUE AND PERENNIAL RYEGRASS

G.W. Mueller-Warrant

Attempts by growers and researchers to control diuron-resistant annual bluegrass in non-burned stands of perennial ryegrass and tall fescue grown for seed have often met with failure. Herbicides such as Dual (metolachlor) applied near germination and Goal (oxyfluorfen) plus diuron or metribuzin applied postemergence to this weed often cause more injury to the crop than to the weed. Even when these treatments do succeed in killing annual bluegrass plants present in the fall, excessive crop damage may leave stands thin and open to invasion by later emerging annual bluegrass. Because of poor margins of crop safety with these herbicides and because of slow recovery of the crop during the winter, we decided to look into the selectivity of spring applications of other herbicides. Rapid crop growth during the spring might allow us to achieve selectivity even with relatively non-selective herbicides if the perennial crop recovered quickly while the annual weeds died or were severely stunted. Of course, destruction of crop leaf tissue during the spring might also reduce seed yield, and such an effect would need to be weighed against the benefits of controlling annual bluegrass.

Tests conducted by Mallory-Smith and Brewster in 1996 indicated that Rely (glufosinate) and Avenge (difenzoquat) might be useful herbicides for postemergence control of annual bluegrass, with Avenge possessing greater crop safety while Rely possessed better efficacy on large weeds. In these initial tests, it was unclear whether Avenge would be as effective on herbicide-resistant annual bluegrass biotypes as it had been on the susceptible type found at the OSU research farm. It was also unclear what effects the injury from these herbicides might have on seed yield. The most immediate questions to answer were: (1) how much of each herbicide would it take to control annual bluegrass, (2) what would those rates do to perennial ryegrass and tall fescue seed yield, and (3) when should these treatments be applied. Recognizing that not all treatments of interest could be tested in a single year, we limited our treatments to spring applications, comparing several rates of Rely and Avenge, and several tank-mixes of these herbicides. Treatments were applied to an established stand of tall fescue on March 3 and April 3, and on May 12 to perennial ryegrass seeded the previous fall. The lateness of application to perennial ryegrass probably increased the impact on seed yield, as the crop had only two months to recover before harvest. However, the perennial ryegrass stand was thin and slow to establish, and earlier application might well have killed more of the crop plants.

Visual injury symptoms of Avenge were almost undetectable, while effects of Rely were quite severe. In tall fescue, Rely damage was sufficient to actually destroy many of the largest, most well developed tillers as well as much of the leaf tissue. Tall fescue recovery was based primarily on growth and development of smaller tillers to replace the ones damaged by Rely. Plots treated with Rely were therefore slightly delayed in maturity compared to the untreated checks. Effects on yield were much less obvious than the early visual symptoms, and were surprisingly small (Table 1). However, variability in seed yield was unusually large, probably due to uneven maturity between plots brought on by the herbicide treatments. This large variability in yield made it difficult to measure how much the herbicide injury actually reduced yield. Two of the three treatments involving 0.25 lb a.i./a Rely were lower yielding than the untreated check at the 10% probability level, while the third treatment yielded nearly the same as the check. Two treatments with 0.125 lb a.i./a Rely outyielded the check, although not significantly. The lowest yielding treatment in the study was the split application of Avenge at 1 lb/A on March 3 followed by 1 lb a.i./a on April 3. The highest yielding treatment was 2 lb a.i./a Avenge on March 3, which outyielded 2 lb a.i./a Avenge on April 3 by 536 lb a.i./a. Tall fescue yield was clearly sensitive to damage from these herbicides, but this vigorous stand also possessed substantial ability to recover and compensate for damaged tillers, and yield losses were far less than would have been expected based on the extent of foliar damage one to two weeks after application.

Avenge applied on March 3, at the higher rate on April 3, or split-applied on both dates slightly reduced the proportion of annual bluegrass that was flowering in late April, stunting the weed but not actually killing it. Rely was only applied on March 3. All treatments with Rely decreased the proportion of annual bluegrass that was flowering, and increased the proportions that were dead or were alive but non-flowering. The higher rate was more effective than the lower rate, and sequential application with Avenge was more effective than tank-mixing. The rate response in tall fescue yield between 0.125 and 0.25 lb a.i./a Rely suggests that higher rates are probably a bad idea, despite the fact that they would improve the control of annual bluegrass.

Perennial ryegrass seed yield was reduced by all rates of Rely greater than 0.175 lb a.i./a, and indeed, the reduction exceeded 70% at the highest rate tested, 0.375 lb a.i./a (Table 2). The effects would probably be less severe in a well established stand treated several months earlier. They were quite dramatic in this test where Rely was applied May 12, nine weeks before harvest. The proportion of annual bluegrass killed increased with Rely rate up to 76% at 0.30 lb a.i./a, but did not improve beyond that. Avenge at 1 lb/a only killed 20% of the annual bluegrass. Tank-mixes of Avenge plus Rely improved annual bluegrass kill slightly over that from Rely alone, and 0.125 lb a.i./a Rely plus 2 lb a.i./a Avenge was the most effective treatment not reducing perennial ryegrass seed yield. However, high rates of Rely (0.30 to 0.375 lb a.i./a) killed nearly twice as much annual bluegrass as this Rely plus Avenge tank-mix, and would be the treatments of choice if crop yield was not reduced. One approach to minimizing yield loss from Rely would be to apply it earlier, giving the crop more time to recover before harvest. That option is under study in the 1997-98 growing season. However, injury from Rely clearly has the potential to reduce perennial ryegrass seed yield, and no more than 0.125 lb a.i./a Rely should be applied within nine weeks of harvest.

The cooler, cloudier weather of February and March compared with that of April and May may alter the efficacy of Rely on annual bluegrass, possibly requiring more than the 0.30 lb a.i./a optimal for control in this test. Both weather conditions at application and the duration from application to harvest may alter the tolerance of perennial ryegrass to Rely, hopefully increasing it from the 0.125 to 0.175 lb a.i./a range in which yield was unaffected in this test. Low rates of Roundup severely reduced crop yield without killing annual bluegrass, and will not be included in future studies.

Table 1. Tall fescue and annual bluegrass (POANN) response to Rely and Avenge, 1997.

Treatment†	Crop yield	POAAN classification Apr. 22, 1997‡ Dead	Alive but non-flowering	Flowering
(lb a.i./a and date)	(lb a.i./a)	(%)		
Untreated	1672 abc	0.7 e	38 b	62 a
1 Avenge Mar. 3	1750 abc	2.1 de	50 ab	48 b
2 Avenge Mar. 3	1884 a	2.0 de	55 a	43 bc
1 Avenge Apr. 3	1523 bcd	0.6 e	33 b	66 a
2 Avenge Apr. 3	1348 d	1.7 de	56 a	42 bc
1 Avenge Mar. 3 / 1 Avenge Apr. 3	1298 d	1.4 de	53 a	46 b
0.25 Rely Mar. 3	1447 cd	15.2 b	61 a	24 de
0.25 Rely Mar. 3 / 1 Avenge Apr. 3	1667 abc	29.2 a	59 a	10 e
0.125 Rely + 0.5 Avenge Mar. 3	1757 ab	4.2 cd	65 a	30 cd
0.25 Rely + 1 Avenge Mar. 3	1442 cd	16.4 b	60 a	24 de
0.125 Rely + 1 Avenge Mar. 3	1741 abc	5.6 c	56 a	38 bcd

† 0.25% R-11 added to all treatment containing Avenge.
‡ Average annual bluegrass density totaled for all classes was 8.8 plants/ft.^{2}

Table 2. Perennial ryegrass and annual bluegrass (POANN) response to Rely, Avenge, and Roundup, 1997.

Treatment applied May 12, 1997†	Crop yield	POAAN classification June 9, 1997‡ Dead	Senescent¶	Healthy
(lb a.i./a)	(lb a.i./a)	(%)		
Untreated	290 a	6 fg	74 a	20 a-d
0.125 Rely	292 a	15 fg	51 bcd	34 a
0.175 Rely	209 ab	25 fg	66 abc	10 c-f
0.225 Rely	152 bcd	36 de	57 a-d	8 def
0.25 Rely	112 bcd	58 bc	40 de	2 ef
0.275 Rely	110 bcd	59 bc	39 def	2 ef
0.30 Rely	133 bcd	76 ab	24 ef	0 f
0.325 Rely	77 cd	76 ab	24 ef	0 f
0.35 Rely	74 cd	82 a	18 f	0 f
0.375 Rely	84 cd	75 ab	25 ef	0 f
0.156 Rely + 0.156 Roundup	91 cd	17 fg	72 ab	11 c-f
0.312 Rely + 0.156 Roundup	47 d	60 bc	40 def	0 f
0.125 Roundup	88 d	3 g	74 a	24 abc
0.125 Rely + 1 Avenge	153 bcd	24 ef	54 a-d	22 a-d
0.25 Rely + 1 Avenge	124 bcd	76 ab	23 ef	1 ef
1 Avenge	191 abc	20 efg	48 cd	32 ab
0.125 Rely + 2 Avenge	284 a	44 cd	39 def	17 b-e

† 0.25% R-11 added to all treatment containing Avenge.
‡ Average annual bluegrass density totaled for all classes was 0.66 plants/ft^2.
¶ Seed was produced on both senescent and healthy annual bluegrass, with healthy plants defined as those still possessing green leaves, and senescent as those entirely lacking green leaves.

SUMMER DROUGHT: CAUSE OF DIEBACK IN PERENNIAL RYEGRASS SEED FIELDS?

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Introduction

The cause of dieback, a form of premature stand loss in perennial ryegrass seed fields, has eluded researchers for nearly a decade. Seed growers have most often characterized this disorder as a failure of portions of the crop stand to regrow after harvest. In other words, the perennial ryegrass plants affected by this disorder cease to be a perennial and instead act like an annual grass.

Dieback generally occurs in the third or fourth year of production, but in several instances has appeared as early as the second year. This loss in stand has been estimated to cost seed growers approximately $10 million annually, with the economic shortfall resulting from the early plowdown of fields and reported reductions in seed yield.

Several potential causes of dieback have been investigated, such as plant diseases, pests, soil fertility, and others. None of these candidates was successfully linked to the dieback problem in perennial ryegrass.

An important clue to the appearance of dieback in seed fields is that the disorder seems to be more prevalent in years with dry conditions in late summer that extend well into autumn. We wanted to find out whether drought-induced stress, during the late summer and early autumn regrowth period, was responsible for dieback in perennial ryegrass seed fields, or at least played a role in the development of this disorder.

Approach

We conducted a three-year study (1995-1998) to determine whether water stress after harvest was associated with premature stand loss in perennial ryegrass seed fields. Field experiments were conducted at the Oregon State University's Hyslop Research Farm. A rainfall simulator and rainout shelters were used to control rainfall during

August and September in Affinity and Buccaneer perennial ryegrass. Rainout shelters were used to exclude natural rainfall during August and September in each year of the study.

The rainfall simulator was used to simulate a one-inch rainfall during the following times: mid-August, mid-September, and rainfall during both mid-August and mid-September. Rainfall was simulated by using a drip emitter system specifically designed for small plot irrigation. Simulated rainfall increased the soil water potential from about -0.4 MPa to approximately -0.1 MPa. The simulated rainfall treatments were compared to no rainfall and natural rainfall during August and September.

Weekly monitoring of canopy temperature and volumetric soil moisture content was achieved by using infrared thermometry and time-domain reflectometry, respectively. Wave guides were buried horizontally in the center of each plot to determine average soil volumetric water content at 6-inch and 12-inch depths in the root zone.

Tiller number, height, dry weight, basal diameter and number of leaves of two cultivars of perennial ryegrass were measured prior to and after a simulated rainfall treatments in late-summer and early-fall.

Fertile and spring vegetative tiller numbers were measured prior to peak anthesis and their combined weights used as total biomass. Plots were harvested in July 1996 and 1997 with a small plot swather and dried in windrows to approximately 12% moisture content. Windrows were combined with a small plot combine. Seeds were cleaned with a laboratory size Clipper M2-B air-screen cleaner before weighing.

Mid-morning collecting of plant samples was done to ascertain soluble sugars present in plants during regrowth. Samples were refrigerated, cleaned, oven-dried, ground to a fine powder then again refrigerated until ready for use. Total soluble carbohydrates were determined by the phenol-sulfuric acid colorimetric method. Absorbance of samples were read at 490 nm using a double-beamed UV-VIS scanning spectrophotometer.

Findings

Tiller production was progressively decreased as the stand aged, with the greatest decrease observed with reduced rainfall in August and September (Table 1). Losses in tiller production were proportional to the amount of rainfall received in August and September. Cool conditions during regrowth in 1996 reduced tiller production even at higher rainfall levels.

The two cultivars responded differently to water stress. However, no rainfall generally produced less regrowth in form of tillers than other rainfall treatments. At the last sampling date in each year, total tiller number was greater at the highest rainfall levels and lowest with the least rainfall. Since rainfall during the study period was much greater than normal in 1995 and in 1997, and normal in 1996, tiller production was either equivalent to or greater than artificial rainfall applied in both August and September. In some instances, rainfall in August produced greater tiller numbers than September rainfall at the last sampling date, but this effect was not consistent. There were no differences in tiller number at the first sampling date as these dates immediately preceded the rainfall treatments.

Climatological data for Corvallis indicate that the average rainfall for August and September is 2.38 inches (Fig.1). However, our research indicates that about 4 inches of rainfall during August and September may be necessary for optimum tiller production. Rainfall amounts that reach or exceed 4 inches are relatively rare in August and September. Our combined August and September treatment delivered a total of 2 inches whereas August and September treatments received 1 inch each. Rainfall during this period is 2 inches or less in nearly half of the years. Moreover, the extremely dry conditions simulated by the no rainfall or 1 inch in August or September treatments are more common than one might think. Less than 1 inch of rainfall can be expected during August and September in nearly one-third of the years.

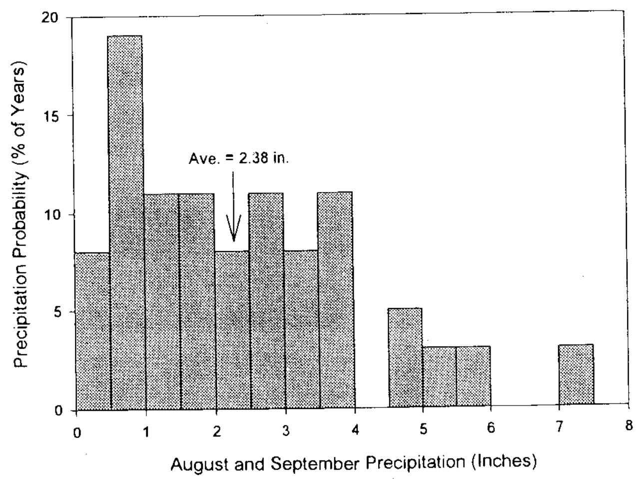

Figure 1. Probability of August and September rainfall at Corvallis. Average rainfall for August and September is 2.38 inches.

Therefore, perennial ryegrass seed crops may be under moderate to severe moisture stress during the early regrowth period in most years. This stress may have had detrimental effects on the ability of plants to recover and produce the tillers necessary for stand persistence.

Although there were differences in the rate of tiller production between Affinity and Buccaneer, the final tiller counts were equivalent at the same amount of rainfall. When final autumn tiller counts from both cultivars are plotted against rainfall during August and September, stand age effects are clearly evident (Fig. 2). Tiller production at the same rainfall level in first-year stands was greater than in second- or third-year stands. In other words, crops were less responsive to rainfall in older stands than in young stands. This supports the contention that as plants become older they are increasingly more susceptible to stress conditions. Therefore, the ability to replace the older tillers as they die is markedly reduced. Continual summer and early-fall water stress may be a major contributing factor to the onset of dieback.

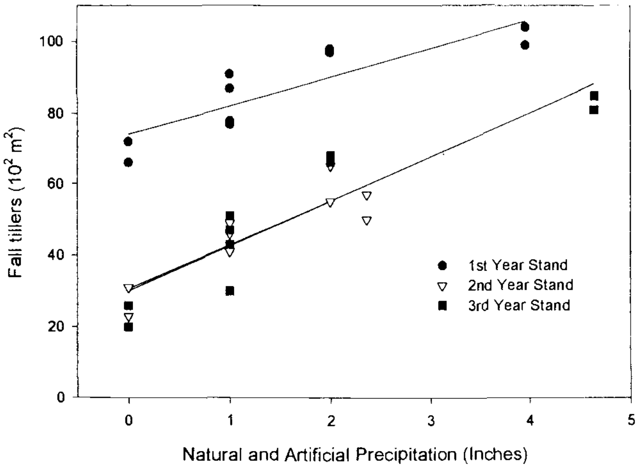

Figure 2. Influence of August and September rainfall on total tiller production in Affinity and Buccaneer perennial ryegrass.

Once growth conditions are favorable in the late-summer early-fall period of regrowth plants will produce as many tillers as light, nutrient and water resources will allow. However, self thinning in perennial ryegrass plants is a natural process that regulates tiller production to match available resources.

Stand cover was clearly affected by the water stress in August and September (Fig. 3 and 4). Loss of stand cover as the stand aged was less in Affinity (Fig. 3) than in Buccaneer (Fig. 4). No rain in August and September produced the lowest amounts of plant cover in each year, and contributed most to the decline of the stand. Higher rainfall treatments produced more stand cover, but stand loss was evident with increasing age across all rainfall treatments. Even in the low water stress environment created by the natural rainfall treatment, which averaged 3.65 inches (154% of average), stand loss was not prevented. Other factors, some natural and some related to management of the seed crop, may make additional contributions to the loss in stand over time.

Stand cover in October was not related to seed yield in the following year, but it is a factor important influencing competition of the crop with weeds. More openings in the stand result in an increase in the sites available for weed plant establishment.

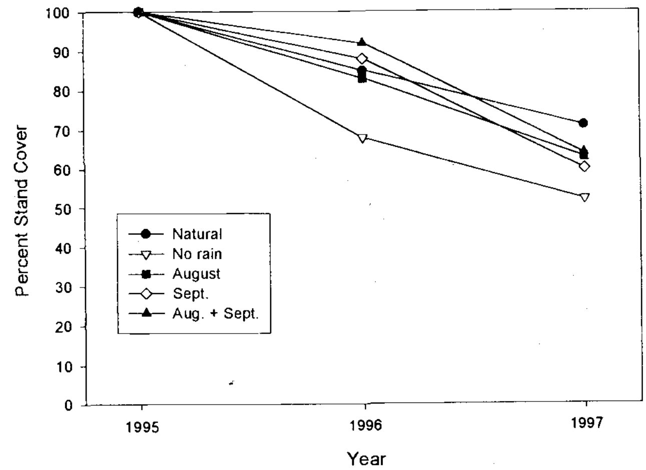

Figure 3. Effect of August and September rainfall on percent stand cover at the end of regrowth in Affinity perennial ryegrass.

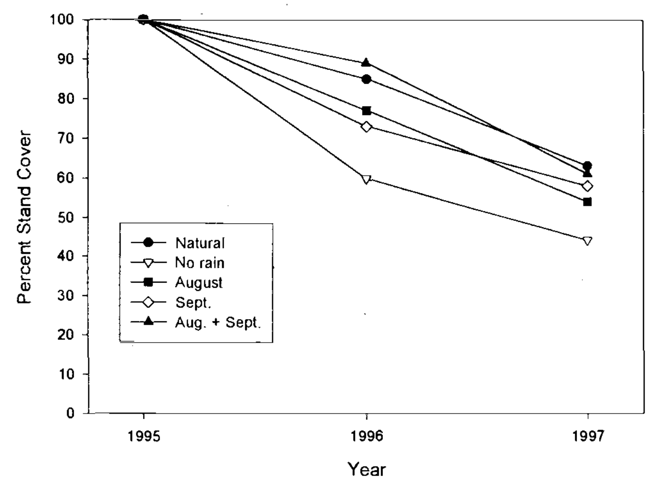

Figure 4. Effect of August and September rainfall on percent stand cover at the end of regrowth in Buccaneer perennial ryegrass.

Basal tiller number made up an increasing proportion of the total tiller number present as the stands aged (Table 2). Basal tillers were the key component involved in determining the tillering response of the crop to summer drought conditions.

Aerial tiller production was dramatically reduced as the perennial ryegrass stands aged (Table 3). Aerial tillers usually remain vegetative (if they survive at all) and they tend to behave as annual tillers and die before seed harvest. Basal tillers on the other hand were more likely to persist from autumn until spring than were aerial tillers, and so were had a greater opportunity to be induced to flower. Most of the loss in total tiller production (Table 1) due to increasing stand age resulted from reduced aerial tiller numbers. Unlike basal tillers, summer drought did not appear to have major effects on aerial tiller production.

Carbohydrate reserves in form of total soluble sugars were measured in mid-October (Table 4). These reserves are vital for initiation of new fall growth and initiation of regrowth following residue removal. There were no differences in carbohydrate levels between treatments for both cultivars in 1995 and in Buccaneer in 1997.

The 1996 data revealed that the concentration of sugars tended to be greater than in 1995. This may be caused by a concentration effect since there were fewer tillers in 1996 than in 1995. More sugars accumulate when fewer tillers are present because less sugar is required for tiller growth. This is evident in Affinity where the no rain treatment produced the highest concentration of sugars in 1996 and in 1997. But in Buccaneer, no rain produced lower levels of total soluble sugars in 1996. Natural rainfall produced high numbers of tillers causing soluble sugar levels to be low in all years. September rainfall caused low soluble sugar concentrations to be present in mid-October. These sugars are in demand by the plant at this time to support the regrowth stimulated by the rainfall three weeks earlier. August rainfall stimulated growth much earlier so that the plants had adequate time to replenish sugar reserves by mid-October.

Flowering and seed yield were not reduced in drought-affected stands in first- (1996) and second-year (1997) crops (Table 5). Although stand loss and reduction in crop regrowth were substantial under conditions of post-harvest summer drought stress, fertile tiller production in the following spring was unaffected. Plants growing in the drought-thinned stands produced more fertile tillers per plant than those receiving adequate rainfall after harvest, accounting for the lack of differences in fertile tiller production at the various rainfall levels. There is a threshold fertile tiller population density below which seed yields will be significantly lower because the seed crop can no longer compensate for losses in stand density. When that fertile tiller population is reached, seed yield will decline.

Only in Affinity were seed yields reduced by summer drought as observed in the 1996 season when an August rainfall treatment in the previous year apparently caused lower yields (Table 5). The innate ability of perennial ryegrass to compensate for great losses in stand is evident in these results. However, our results also point out the possibility that yield losses attributable to summer drought may arise in the latter part of the stand's life. Seed growers have noted that the majority of losses in stand and seed yield are observed in the third or fourth crop year. We will harvest the final seed crop this season to determine whether yields will continue to be maintained in drought-affected third-year stands.

Recommendations

Irrigation, where it is available, would clearly increase the long-term persistence of perennial ryegrass stands. Our results indicate that only a small amount of water is required to alleviate water stress during the late summer and early fall regrowth period.

Since there were different responses among the varieties that we have tested, it might be possible to use varieties of perennial ryegrass that exhibit greater drought tolerance in dryland production. We encourage the seed industry to develop new perennial ryegrass varieties with improved drought tolerance for cultivation under dryland seed production conditions.

Table 1. Water stress impacts on total tiller number at various times during autumn regrowth in two cultivars of perennial seed crops.

Rainfall treatment	Affinity 7 Aug	Affinity 8 Sept	Affinity 13 Oct	Buccaneer 7 Aug	Buccaneer 8 Sept	Buccaneer 13 Oct
	($10^2 m^{-2}$)					
1995						
Natural	14 a†	64 a	99 a	18 a	70 a	104 a
No rain	17 a	41 b	72 a	22 a	40 a	66 c
August	16 a	53 ab	87 a	15 a	51 a	91 ab
September	17 a	40 b	77 a	14 a	55 a	78 bc
August + September	12 a	60 a	97 a	18 a	49 a	98 ab
	18 Aug	11 Sept	11 Oct	18 Aug	11 Sept	11 Oct
1996						
Natural	11 a	29 bc	57 a	8 a	20 bc	50 a
No rain	12 a	20 c	31 a	11 a	13 c	23 b
August	10 a	44 ab	46 a	9 a	30 ab	41 a
September	11 a	25 c	49 a	10 a	13 c	46 a
August + September	11 a	49 a	65 a	7 a	33 a	55 a
	21 Aug	11 Sept	7 Oct	21 Aug	11 Sept	7 Oct
1997						
Natural	15 a	43 a	85 d	11 a	50 b	81 c
No rain	13 a	30 a	20 a	14 a	24 a	26 a
August	13 a	48 a	43 b	26 a	40 a	51 b
September	14 a	19 a	47 bc	11 a	19 a	30 a
August + September	14 a	39 a	66 c	8 a	42 b	68 bc

†Means within columns not followed by the same letters are significantly different according to Fisher's Protected LSD ($P = 0.05$) values.

Table 2. Water stress impacts on number of basal tillers at various times during autumn regrowth in two cultivars of perennial ryegrass seed crops.

Rainfall treatment	Affinity			Buccaneer		
		8 Sept	13 Oct		8 Sept	13 Oct
	($10^2 m^{-2}$)					
1995						
Natural		17 a†	36 a		14 a	56 a
No rain		11 a	36 a		8 a	37 a
August		16 a	37 a		16 a	48 a
September		15 a	34 a		13 a	45 a
August + September		20 a	34 a		14 a	62 a
	18 Aug	11 Sept	11 Oct	18 Aug	11 Sept	11 Oct
1996						
Natural	9 a	16 b	49 a	8 a	12 bc	37 ab
No rain	10 a	16 b	24 a	9 a	9 c	17 c
August	9 a	26 ab	31 a	8 a	18 ab	31 b
September	9 a	16 b	35 a	8 a	10 bc	37 ab
August + September	9 a	34 a	48 a	6 a	23 a	44 a
	21 Aug	11 Sept	7 Oct	21 Aug	11 Sept	7 Oct
1997						
Natural	11 a	31 a	69 c	8 a	39 c	73 c
No rain	11 a	23 a	17 a	12 a	20 ab	22 a
August	9 a	33 a	38 a	18 a	33 bc	40 b
September	9 a	12 a	40 b	10 a	14 a	26 ab
August + September	10 a	31 a	60 c	7 a	35 c	63 a

†Means within columns not followed by the same letters are significantly different according to Fisher's Protected LSD ($P = 0.05$) values.

Table 3. Water stress impacts on number of aerial tillers at various times during autumn regrowth in two cultivars of perennial ryegrass seed crops.

Rainfall treatment	Affinity			Buccaneer		
		8 Sept	13 Oct		8 Sept	13 Oct
	($10^2 m^{-2}$)					
1995						
Natural		46 a†	64 a		53 a	48 a
No rain		30 bc	36 a		31 a	29 a
August		37 ab	50 a		35 a	43 a
September		24 c	43 a		42 a	33 a
August + September		39 ab	63 a		35 a	36 a
	18 Aug	11 Sept	11 Oct	18 Aug	11 Sept	11 Oct
1996						
Natural	2 a	13 a	8 a	1 a	8 a	13 a
No rain	3 a	4 a	8 a	1 a	5 a	6 a
August	2 a	18 a	15 a	1 a	12 a	10 a
September	2 a	9 a	14 a	2 a	4 a	9 a
August + September	2 a	14 a	17 a	1 a	9 a	12 a
	21 Aug	11 Sept	7 Oct	21 Aug	11 Sept	7 Oct
1997						
Natural	5 a	11 a	17 b	3 a	11 a	8 ab‡
No rain	2 a	7 a	3 a	2 a	4 a	5 a
August	3 a	15 a	5 a	8 a	7 a	11 b
September	5 a	7 a	7 a	1 a	4 a	4 a
August + September	3 a	7 a	5 a	2 a	8 a	5 a

†Means within columns not followed by the same letters are significantly different according to Fisher's Protected LSD ($P = 0.05$) values.
‡Means within columns not followed by the same letters are significantly different according to Fisher's Protected LSD ($P = 0.10$) values.

Table 4. Water stress impacts on total soluble sugars at the end of the autumn regrowth period in two cultivars of perennial ryegrass seed crops.

Rainfall treatment	Affinity 1995	Affinity 1996	Affinity 1997	Buccaneer 1995	Buccaneer 1996	Buccaneer 1997
	($mg\ g^{-1}$ dry wt.)					
Natural	29.87 a†	33.68 b	23.11 a	30.87 a	26.97 cd	22.87 a
No rain	30.57 a	41.62 a	34.52 c	32.46 a	34.97 b	30.12 a
August	24.55 a	35.80 b	29.68 b	30.18 a	54.25 a	29.96 a
September	31.06 a	28.70 c	23.69 a	30.78 a	25.53 d	23.57 a
August + September	29.63 a	40.82 a	24.21 a	28.49 a	32.40 bc	26.00 a

Table 5. Water stress impacts on spring tiller number and seed yield in two cultivars of perennial ryegrass seed crops.

	Affinity			Buccaneer		
Rainfall treatment	Vegetative tillers	Fertile tillers	Seed yield	Vegetative tillers	Fertile tillers	Seed yield
	------------($10^2 m^{-2}$) --------		(lb/a)	------------($10^2 m^{-2}$) --------		(lb/a)
1996						
Natural	37 a†	24 a	1194 a	39 a	25 a	1088 a
No rain	35 a	22 a	1160 a	34 a	23 a	1039 a
August	36 a	23 a	924 b	34 a	21 a	1032 a
September	38 a	24 a	1221 a	30 a	21 a	1085 a
August + September	41 a	25 a	1156 a	32 a	22 a	1103 a
1997						
Natural	29 a	29 a	1195 a	31 a	24 ab	1275 a
No rain	24 a	31 a	1127 a	23 a	20 b	1200 a
August	24 a	31 a	1154 a	30 a	24 ab	1235 a
September	24 a	32 a	1062 a	34 a	29 a	1210 a
August + September	26 a	37 a	1115 a	25 a	29 a	1226 a

†Means within columns not followed by the same letters are significantly different according to Fisher's Protected LSD ($P = 0.05$) values.

SPRING-PLANTED NO-TILL CEREALS: A POSSIBLE ROTATION OPTION FOR PERENNIAL RYEGRASS SEED PRODUCTION

J.J. Steiner and R.S. Karow

Rotation crop options have been limited for many fields where perennial ryegrass seed is grown in the south Willamette Valley due to poor drainage conditions. Since the phase down of open-field burning and the implementation of maximal residue utilization, little is known about the impact of residue amount on subsequent rotation crop production. The purpose of this experiment was to determine the effect of maximal and minimal perennial ryegrass residue from three years of seed production on the yield of five wheat and oat cultivars that were spring-planted using no-till establishment. The experiment was conducted at the USDA-ARS Sustainable Grass Seed Production Research Project site located in Linn County. This site has an untiled, poorly drained, and low pH Dayton soil that is intermittently flooded during much of the winter and early spring. There is little deep water percolation, with most water moving laterally through the shallow soil horizon or by overland flow.

Straw from the three years of perennial ryegrass seed production was chopped twice for the maximal residue plots, and once for the minimal residue plots following straw removal. The plots were winter-fallowed with glyphosate applied 7 October 1996 and 24 March 1997 at three and two quarts per acre, respectively to control winter weeds. The wheat and oat varieties were planted 1 inch deep in 7 inch rows on 4 April 1997 by no-till using conventional John Deere double disk openers. Seeding rate of the cereal cultivars was 40 seeds/ft of row. Two subplots 10-rows wide of each cultivar were planted in each of the four replicate blocks. One-hundred-twenty-five pounds per acre of 16-16-16-4 fertilizer was also shanked into the soil at the time of planting. An additional 173 lb. per acre of fertilizer (46-0-0-0) was broadcasted on 27 April. The wheat plots received 2.5 pints per acre of Hoelon herbicide to control volunteer grass seedlings. No registered herbicides are available to control volunteer grass seedlings in oats. The wheat and oat plots were harvested on 7 and 8 August 1997, respectively.

All wheat and oat cultivars yielded more grain when planted into maximal perennial ryegrass residue plots compared to minimal residue plots (Table 1). 'Treasure' wheat yielded more than the cultivars Alpowa, Whitebird, Pennawawa, and WB936R. The oat cultivars Monida, Cayuse, and Ajay yielded more than 'Ogle' and 'Montezuma'. The yield potential for Montezuma was not realized because its larger seed size made planting difficult which resulted in a sub-optimal final plant stand.

Table 1. The grain yields of five wheat and five oat cultivars that were 1997 spring-planted using no-till establishment and following three years of perennial ryegrass seed production that used minimal or maximal post-harvest residue management on a poorly drained and undrained field in Linn County.

Cereal cultivar effects			
Wheat		Oats	
Cultivar	Bushels per acre	Cultivar	Tons per acre
Treasure	92.4 a	Monida	1.91 a
Alpowa	84.9 b	Cayuse	1.78 a
Whitebird	84.3 b	Ajay	1.76 a
Pennawawa	81.2 b	Ogle	1.28 b
WB936R	81.0 b	Montezuma	1.03 b
Perennial ryegrass residue effects			
Wheat		Oats	
Low residue	79.5 b	Low residue	1.50 b
High residue	87.3 a	High residue	1.61 a

Fall-planted cereals are not an option for the soil conditions similar to this location. An earlier fall-seeded experiment using 'Yamhill' wheat that was planted 17 December 1993 produced grain yields ranging among 17.7, 38.5, 44.4, and 94.1 bushels per acre, depending upon how well the soils were drained for each individual block of the experiment (poorly drained plots yielded less than better-drained plots). The winter 1993/94 was not exceptionally wet, and even poorer yield results could be expected under higher precipitation conditions. This single year study suggests that a spring planting strategy may ensure more stable and greater grain yields across variable drainage conditions than fall planting.

No-till management of these soils may be a viable option. When the soils are left undisturbed in the fall, spring planting can be done with conventional seed drill equipment with greatly reduced compaction than when the soils are disturbed in the autumn. In addition to spring-planted cereals, we have also successfully no-till planted perennial ryegrass and meadowfoam in the fall, and white clover for seed in the spring. Meadowfoam root and plant growth are enhanced when planted no-till in the autumn, compared to autumn-tilled conventional planting. Our research continues to determine the success of charcoal banding used in no-till planted perennial ryegrass in the fall, and between-the-row directed spray diuron for spring-planted white and red clover, and mustard seed crop seed establishment.

For more information about grass seed cropping systems research or spring-planted cereals, contact: Jeff Steiner, National Forage Seed Production Research Center, USDA-ARS, 3450 SW Campus Way, Corvallis, OR 97331; or Russ Karow, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331; or access the web site at: http://pwa.ars.usda.gov/nfsprc/steiner/steinersustain.htm for more information.

SEASONAL POPULATIONS OF GRAY GARDEN SLUG IN FOUR SPECIES OF GRASS

G.C. Fisher, J.T. DeFrancesco and R.N. Horton

Different species of grasses grown for seed appear to vary according to slug populations and/or damage sustained. Quantifying and comparing slug populations are a basis for understanding why these differences occur and for using this knowledge in a management strategy.

Table 1. Effects of grass species on slug population, OSU Hyslop Research Farm.

	Average number slugs per bait station	
Grass species and cultivar	1996-97[1]	1997-98[1]
Chewings fescue		
SR 5100	5.1	3.6
Jamestown II	3.5	2.0
Creeping red fescue		
Shademaster	6.2	1.2
Seabreeze	6.3	2.8
Perennial ryegrass		
Affinity	11.2	10.4
Buccaneer	8.0	5.2
Tall fescue		
Fawn	10.7	2.5
Rebel II	13.4	5.2

[1] Averaged across 12 dates

Four established grass species, two cultivars each, were monitored for gray garden slug activity from mid-October through mid-February in both 1996-97 and 1997-98. Plots were 115 x 150 feet and located at the OSU Hyslop Research Farm. They were grown in the same block in similar soil type and environmental conditions. Open stations baited with three metaldehyde bran pellets (Deadline Bullets®, 4% metaldehyde) in the late afternoon were inspected for slugs early the next morning.

Results and Discussion:
Slug populations varied according to grass species and cultivar. It is believed that part of the differences in slug populations among grass types are due to environmental conditions rather than to any inherent characteristics of the grass species themselves. Obvious differences in soil drainage led to areas of prolonged saturation and standing water. Slugs perish or migrate under these conditions.

'Rebel II' tall fescue had the greatest number of slugs in 1996-97 with almost four times as many slugs that were observed in 'Jamestown' Chewings fescue (Table 1). We attribute this to its lush, early-season growth which is desirable habitat and food source for slugs. Slug populations in 1996-97 for all grass species and cultivars remained fairly constant throughout the evaluation period, with low counts seen only during cold weather or saturated soil conditions (Figure 1).

In 1997-98, 'Affinity' perennial ryegrass, another species that grows early and lush, had the largest slug population, ranging from two to more than eight times as many slugs as any of the other grass species or cultivars (Table 1). However, the high seasonal average for 'Affinity' can be attributed to an unusually high number of slugs observed at the first evaluation date in October; without this anomaly, 'Affinity' would probably still have had the largest slug population, but not by such a large margin. In general, all grass species and cultivars had the largest slug populations in mid-October of 1997-98, as compared to the remainder of the evaluation period (Figure 2). In 1997-98, slug populations, in general, were greatest at the first evaluation date in mid-October when compared to the other evaluations dates.

Populations of slugs displayed similar trends between cultivars within a given grass species. Thus, the cultivar that had the fewest number of slugs in 1996/1997 also had the fewest number in 1997-98. The gray garden slug was the predominant slug species found in all plots in both years.

All the cultivars experienced population reductions, from nearly one quarter to almost four-fold, in the second year of evaluations. The reason for this is uncertain however, it may be due to saturated soil conditions more prevalent during 1997-98 or possibly because the intense regime of weekly baiting reduced the overall slug population over a two year period.

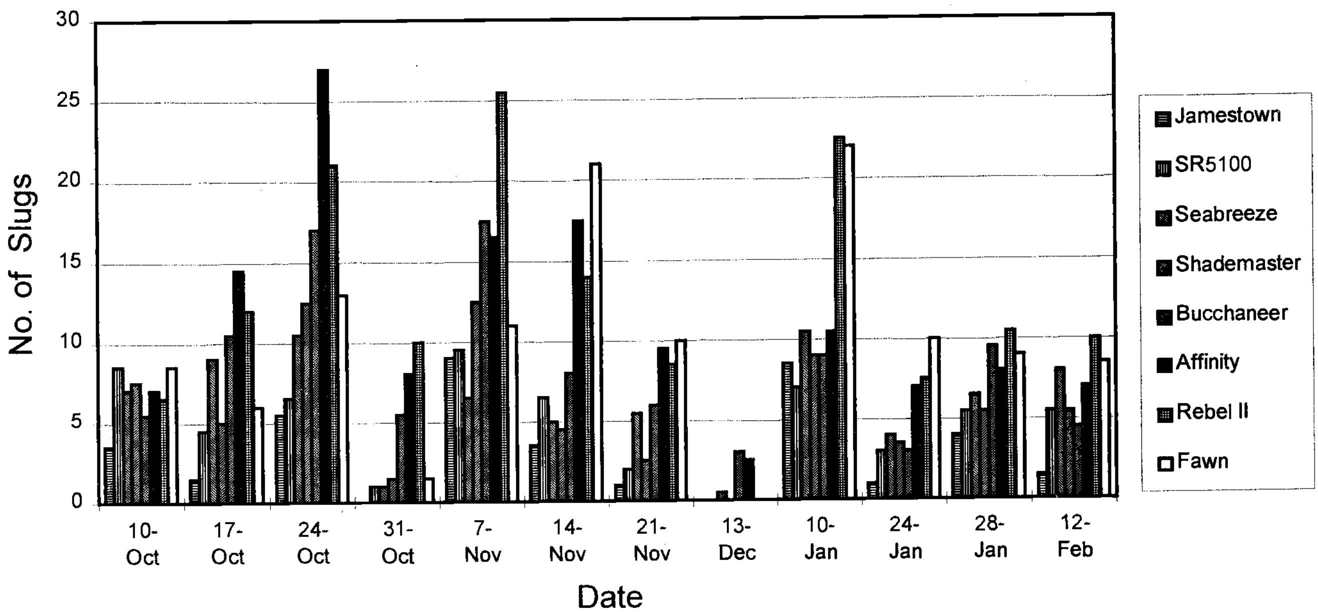

Figure 1. Effects of grass species and cultivar on slug population, OSU Hyslop Research Farm, 1996-97.

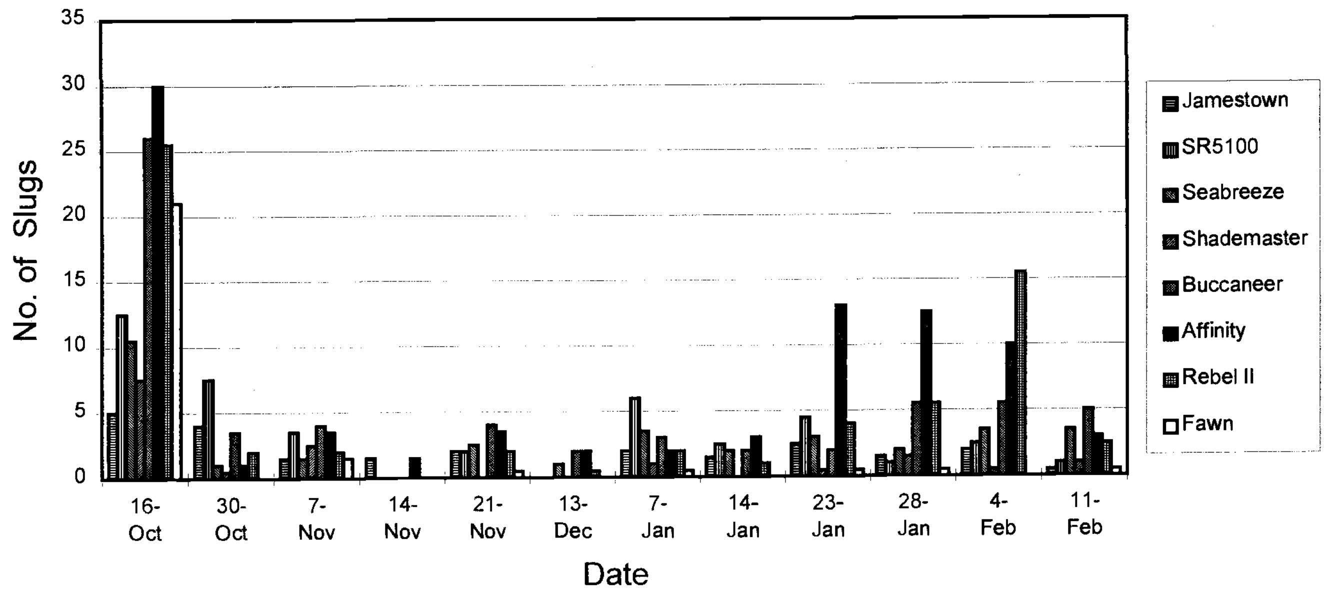

Figure 2. Effects of grass species and cultivar on slug population, OSU Hyslop Research Farm, 1997-98.

SOIL AND PERENNIAL RYEGRASS SEED CROP N STATUS AND N MANAGEMENT CONSIDERATIONS FOR WESTERN OREGON

S.M. Griffith, T.W. Thomson and J.S. Owen

Perennial ryegrass (*Lolium perenne* L.) has evolved highly efficient mechanisms for N acquisition from soil. Their shallow spreading root system and the ability to use both ammonium-N and nitrate-N allows for rapid N uptake and assimilation, even at low temperature. Although not native to western Oregon, perennial ryegrass is well adapted to the climate, soil, and other environmental conditions that exist there. Considerable perennial ryegrass seed crop acreage in western Oregon is found on land less suited for most traditional crops. These areas are poorly drained and thus have soil regimes common to temperate wetland environments; low oxygen levels, high ammonium to nitrate ratios, acid pH, and low redox potential. In order to optimize crop N acquisition for maximum economic return, with minimal environmental impact, it is critical to have knowledge of soil N cycling processes, crop N acquisition and assimilation, and the fate of excess N in these agricultural systems.

The research reported here are second-year findings of a study that was first reported by Griffith and Thomson (1997). The objectives of the first-year study were: 1) to determine the interaction of N rate and time of application to perennial ryegrass growth and seed yield; and 2) to determine the relationship between shoot tissue N concentration with final seed yield as functions of N rate and N timing based on an accumulated growing degree day (GDD; C°) scale (Griffith and Thomson, 1997). In the second study-year, research objectives were modified from the first year's objectives, in that all fertilizer was applied at only one time, approximately 600 GDD (618 GDD; 4 April 1997), and at N rates ranging from 0 to 200 lb N/a/yr. The N fertilizer source was urea ammonium sulfate. Previous reports had shown that perennial ryegrass seed yield was not affected by N timing when applied between 400 and 800 GDD. Also, in the second study-year measurements of relative leaf chlorophyll content were taken and compared to tissue N concentrations. This was done mainly to determine if a hand held chlorophyll meter could, through an instantaneous field measurement, estimate crop N status. Within each treatment plot, chlorophyll meter (Minolta SPAD-502) readings were made from the newest most fully expanded leaf from 20 different plants and averaged. The instrument was placed directly over the leaf blade's longitudinal mid-point. Soil and plant samples in 1997 were collected at 618 (4 April), 716 (15 April), 962 (6 May), 1136 (16 May), 1403 (2 June), and 1874 GDD (2 July). The crop was at the 4^{th}-leaf stage at 618 GDD, 4^{th} to 5^{th}-leaf /stem elongation stage at 716 GDD, boot emergence-post boot stage at 1136 GDD, mid-anthesis stage at 1403 GDD, and seed harvested at 1874 GDD. For a complete description of all methods, site description, and experimental design, see Griffith and Thomson (1997).

Maximum second-year seed yield of perennial ryegrass (cv. Broadwalk) was reached at fertilizer N rates of 100 lb

N/a/yr and above when applied at 618 GDD (Table 1). This was achieved at a lower N rate than that required for the first seed-year and consistent with past first seed-year results (Griffith, unpublished). Often the first seed-year can require more N than subsequent grass seed-years of the same stand. Seed yield remained constant at N rates between 100 to 200 lb N/a/yr. Final fertile tiller number was not affected by N rate, nor was final shoot biomass accumulation at rates above 50 lb N/a/yr. It should be noted that at the time N was applied to the plots at 618 GDD the crop was nutrient stressed in that leaves appeared slightly chlorotic (yellow) and had a reddish hue. Within days following the N application the crop returned to a healthy green appearance.

The grower applied approximately 180 lb N/a/yr on the same second-year grass seed stand outside of the research plot area. This was done in several split applications, 40 lb N/a at 238 GDD (15 Feb), 50 lb N/a at 598 GDD (1 April), and 90 lb N/a at 831 GDD (25 April). The grower's final seed yield was 1157 lb/a (using a different seed cleaning method, the grower estimated his seed yield at 1300 lb/a) and 4.92 ton/a in final shoot biomass. Seed yield and final shoot biomass of the grower's crop were not significantly different from research plots receiving N rates greater than 100 lb N/a/yr applied in one application at 618 GDD. The grower's N management method maintained a nearly constant 2 to 2.5% shoot N concentration from 600 to 1400 GDD and had greater shoot dry mass accumulation earlier in the season compared to the N study plots for the same period.

In the second seed-year, as with the first, there was a high correlation (r^2 values ranged between 0.85 and 0.98) between shoot N concentration and final seed yield (Fig.1). We also determined that leaf chlorophyll level was highly correlated to leaf N content (Fig. 2) and final seed yield (Fig. 3) as predicted. The highest correlation between shoot N concentration or leaf chlorophyll to final seed yield was found using a second-order polynomial function. These data indicate that tissue N or chlorophyll determinations could be used to manage grass seed crop N for maximum economic yields. It is not known if different grass varieties would give consistent results, so a study is underway to determine this. One approach to managing crop N for optimum economic yield would be to apply a conservative N rate initially in the spring (based on recommended rates, crop N status, and mineralization inputs), then follow by monitoring crop N status with a chlorophyll meter or tissue N analysis and make a later adjustment with a liquid application. This is being field-tested.

It has been consistently observed that soil inorganic N is not a good indicator of grass seed crop N status in western Oregon grass seed crops. The reason for this is that soil inorganic N is rapidly depleted by the grass seed crop following N fertilizer application (Fig. 4). This is also reflected in the rapid rise of tissue N concentration following N application (Fig. 5) that increases with increasing fertilizer N rate. When fertilizer N rates exceed optimum N levels necessary for maximum seed yield, crop tissue N continues to increase in shoot tissue, due to greater N uptake from soil, but this additional plant N does not always support higher seed production. This partially explains why crop N utilization efficiency declines with increasing N fertilizer rates (Fig. 6). Another example of perennial ryegrass uptake efficiency was demonstrated in the level of total shoot N accumulation as a function of applied fertilizer N (Fig. 7). We estimate that natural mineralization (inorganic-N release from organic-N) contributes about 75 lb N/a/yr. Because some mineralization occurs when the crop is biologically inactive, inorganic-N released from soil organic matter may not be captured by plants and thus, in part, leached below the root system. Residue mineralized-N in the root zone is captured in the fall by the grass crop coming out of summer dormancy. There appears to be sufficient fall mineralized-N in the soil to met the demands of fall and early-winter crop growth without adding fall N. It is hypothesized that the source of shallow ground water ($\leq$ 6 ft.) nitrate beneath grass seed crops is from mineralized-N and not directly from fertilizer-N (Griffith, unpublished).

The notion that multiple N fertilizer applications provides for maximum N use efficiency and maximum seed yield was not supported by this study nor in other known reports. In addition, the notion that applying all the N fertilizer in one application would contribute to lower N capture by the crop was not strongly supported by these data or of Griffith et al. (1997). Many factors should be considered when determining the most optimum N fertilizer timing and rate. Little is known of the impact of years of early season (late winter) N applications or multiple applications or both, on weed populations (e.g., *Poa annua*) and disease infestation (e.g., rust). Theoretically, both weed and disease infestations could dramatically increase by such N management strategies. Another factor to consider are the consequences of repeated passes of equipment on fields which could potentially increase soil compaction, enhance erosion, increase the spread of weeds and diseases, and increase energy and equipment use and maintenance costs. Research is underway addressing the impact of these N management strategies on grass seed cropping systems weed and disease dynamics. Another factor is associated fertilization costs. Table 2 shows a simplified budget for different fertilizer rates, resulting seed yields, and net profits. If a grower feels that higher N rates are needed based on seed yield increase, it may not always provide a greater net return when considering associated fertilizer and application costs not to mention environmental impact and resource conservation.

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Griffith, S.M. and T. Thomson. 1997. N Rate and Timing Relationships with Tissue N Concentration and Seed Yield in Perennial Ryegrass. In: *Seed Production Research*, W. Young, III (ed.), Oregon State University Extension and USDA-ARS, Corvallis, Oregon. pp. 41-42.

Table 1. Values represent means of perennial ryegrass (cv. Broadwalk) above ground biomass, fertile tiller number, and seed yield as a function of N fertilizer rate for the second seed year (1997). Data were collected on 2 July 1997. Means followed by the same letter were not significant at P < 0.05 by the Duncan's Multiple Comparison test.

Nitrogen fertilizer rate	Shoot biomass	Fertile tillers	Seed yield
(lb N/a)	(ton/a)	(# per meter)	(lb/a)
0	3.37 a	1532 a	536 a
50	4.50 ab	1220 a	926 b
100	4.75 ab	1436 a	1165 c
150	4.48 ab	958 a	1204 c
200	5.72 b	1434 a	1222 c

Table 2. A simplified cost analysis of perennial ryegrass seed production. Application and other costs were not included. This is based on a single N application. Multiple applications would further reduce net profits.

Nitrogen fertilizer rate	Seed yield	Price of seed ($0.55/lb)	Cost of fertilizer N ($0.35/lb)	Net profit
(lb N/acre)	(lb/acre)	(per acre)	(per acre)	(per acre)
0	536	$295	$ 0	$295
50	926	$509	$18	$491
100	1165	$641	$35	$606
150	1204	$662	$53	$609
200	1222	$672	$70	$602

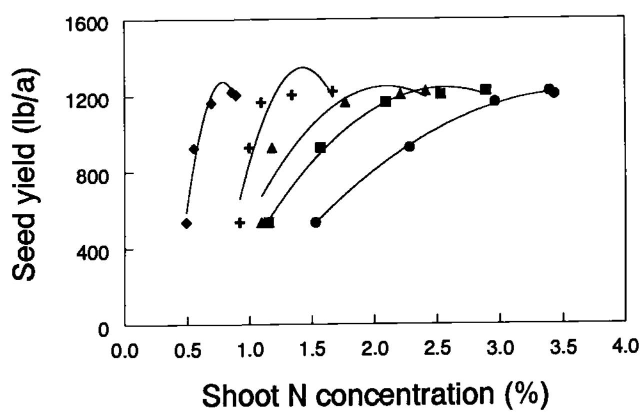

Figure 1. Final perennial ryegrass seed yield as a function of shoot N concentration. Shoot samples were taken on the following accumulated growing degree days (GDD), 716 (15 April) (circle), 962 (6 May) (square), 1136 (16 May) triangle, 1403 (2 June) (cross), and 1874 GDD (2 July) (diamond). The crop was at the 4th-leaf stage at 618 GDD, 4th to 5th-leaf/stem elongation stage at 716 GDD, boot emergence-post boot stage at 1136 GDD, mid-anthesis stage at 1403 GDD, and seed harvested at 1874 GDD.

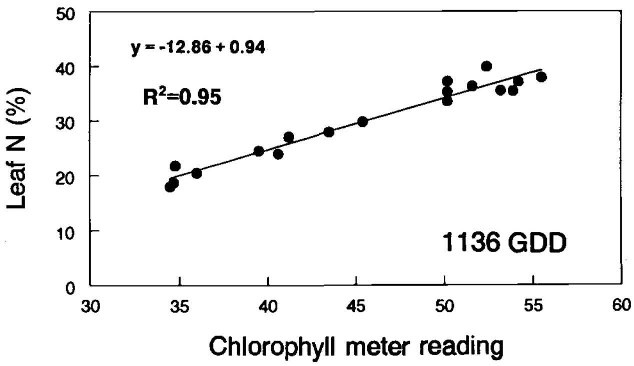

Figure 2. Relationship between perennial ryegrass leaf relative chlorophyll reading and shoot tissue N concentration.

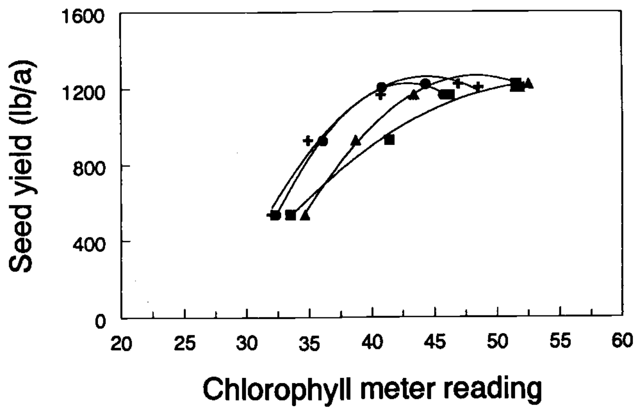

Figure 3. Final perennial ryegrass seed yield as a function of leaf chlorophyll meter reading (Minolta SPAD-502). Measurements were taken on the following accumulated growing degree days (GDD), 716 (15 April) (circle), 962 (6 May) (square), 1136 (16 May) (triangle), 1403 (2 June) (cross), and 1874 GDD (2 July) (diamond). The crop was at the 4th-leaf stage at 618 GDD, 4th to 5th-leaf/stem elongation stage at 716 GDD, boot emergence-post boot stage at 1136 GDD, mid-anthesis stage at 1403 GDD, and seed harvested at 1874 GDD.

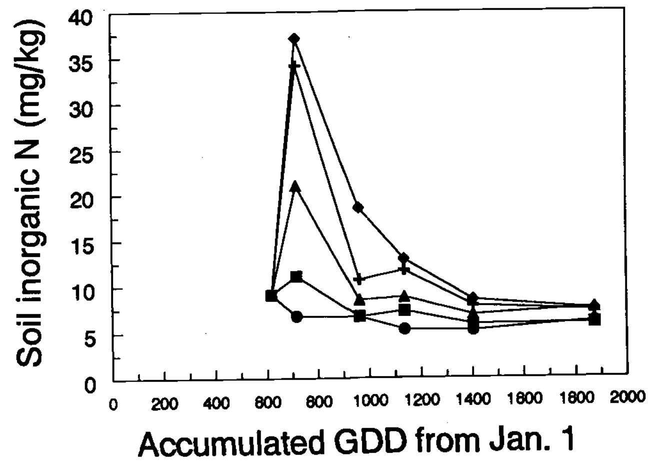

Figure 4. The temporal relationship of soil inorganic N (NH_4^+ and NO_3^-) concentration from plots receiving 0 (circle), 50 (square), 100 (triangle), 150 (cross), and 200 lb N/a (diamond) fertilizer rate and as a function of accumulated growing degree days (GDD). Data were collected in 1997 during the second perennial ryegrass seed-year.

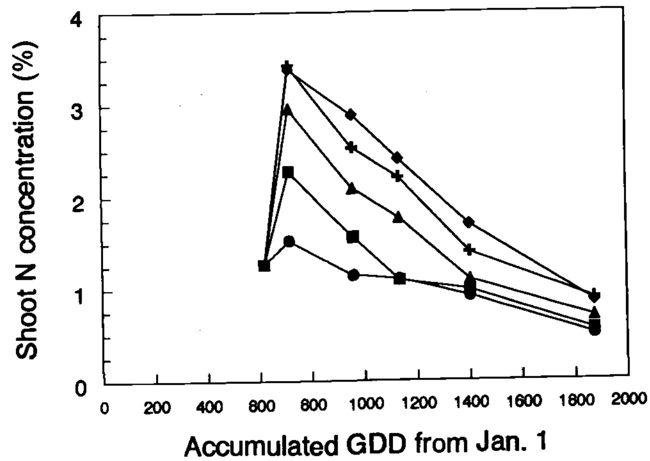

Figure 5. The temporal relationship of perennial ryegrass tissue N concentration from plots receiving either 0 (circle), 50 (square), 100 (triangle), 150 (cross), or 200 lb N/a (diamond) fertilizer rate and as a function of accumulated growing degree days (GDD). Data were collected in 1997 during the second perennial ryegrass seed-year.

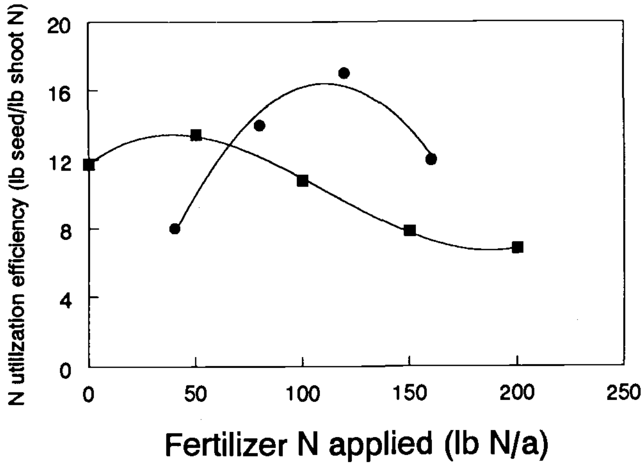

Figure 6. Nitrogen utilization efficiency of perennial ryegrass for the first (circle) and second (square) seed-years.

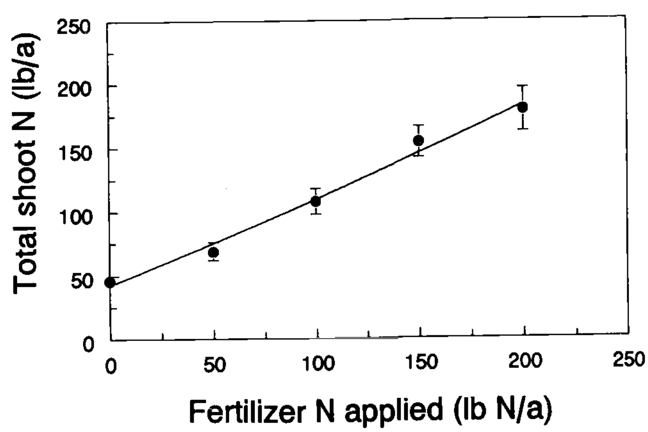

Figure 7. Maximum accumulated shoot N from perennial ryegrass seed crops receiving either 0 (circle), 50 (square), 100 (triangle), 150 (cross), or 200 lb N/a (diamond) fertilizer N. Data were collected at 1136 GDD (16 May 1997) during the second perennial ryegrass seed-year.

PERENNIAL RYEGRASS RESPONSE TO FOLIAR APPLICATION OF TRINEXAPAC-ETHYL PLANT GROWTH REGULATOR

T.B. Silberstein and W.C. Young III

Introduction

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

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

Procedure

An established stand (planted fall 1994) of 'Affinity' perennial ryegrass at Hyslop Crop Science Research Farm was used for the trial. The experiment was treated with 1.6 lb ai/a diuron in the fall as well as 250 lb/a 16-20-0 fertilizer. Spring N was applied March 12 at 80 lb N/a and April 10 at 40 lb N/a. The experimental design was a randomized complete block replicated four times. PGR treatments were applied at walking speed using a bicycle type 6-foot boom sprayer with nozzles at 18 inch spacing. The sprayer operated at 20 psi with XR TEEJET 8003VS nozzles (approx. 30 gal/a water). Seven treatments were as follows: an untreated check and three rates of Trinexapac-ethyl (500, 1000, and 1500 g a.i./ha) applied at one of two dates (April 9 and May 2, 1997). Plot size was 6 ft x 25 ft. Application was made prior to any active internode elongation but during rapid leaf development (April 9), and at the onset of rapid internode elongation (May 2). Elongation was assessed using a weighted average of tiller size and internode expansion from plant samples taken the day of or day prior to treatments.

Plots were sampled (9-inch row samples) at early bloom for fertile tiller counts, length measurements, and above ground biomass weights. Ten inflorescences were also randomly sampled for yield component analysis and spike length measurements. Harvesting was done using a 5 ft wide swather for windrowing and a Wintersteiger small plot combine for harvest. Combined seed samples were cleaned using an M2-B clipper cleaner for final cleanout; subsamples of clean seed were taken for 1000 seed weights.

Results

The highest yields were derived from the lowest rate of the late applied treatment, and the middle rate of the early treatment; both gave yield increases of 34% (Table 1). At the higher rates used in this study some phytotoxicity occurred to the fully expanded leaves in the form of discoloration and senescence. The highest, late rate (1500 g a.i./ha) had the greatest phytotoxic effect on leaves that were emerged during treatment, but had little effect on seed yield when compared to the untreated check. This indicates a good margin of safety for the crop, and suggests the expected maximum rate should be around 500-600 g a.i./ha.

Specifically what component(s) of harvest improved seed yield was not apparent. Floret numbers and spikelet numbers were not affected (data not presented). However, the effect on crop lodging was dramatic in relation to the check. Even as the check was fully lodged at harvest, there was almost no lodging in all but the lowest treatments up until harvest, when all but the highest rate started to lean over. This upright stature allowed easy windrowing and combining.

Cleanout was significantly reduced in the treated plots. The overall high cleanouts are expected from the type of combine used, also we set the air and sieves to prevent light seed from getting separated out. Improved cleanout may be attributed to less total dry matter running through the combine as well as the makeup of the windrow. In the untreated plots there was a lot of leaf and stem material, and in the treated plots the swaths were much smaller and had less plant material.

In addition to improved cleanout, the increase in harvest index indicates better seed set in the crop. The overall tiller length and the spike length was reduced an average of 30% across all treatments (Table 1). This along with reductions in lodging may have improved conditions for seed set as well as seed recovery during harvest. This experiment will be repeated for the 1998 season and is being expanded to include another PGR on perennial ryegrass and tall fescue.

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

Table 1. Effects of foliar applied Trinexapac-ethyl on seed yield, harvest components, and tiller length in Affinity perennial ryegrass, 1997.

Treatment	Seed Yield	Seed Yield	Straw yield	Clean-out	Harvest index	Culm reduction
(g a.i./ha)	(lb/a)	(% of Check)	(ton/a)	(%)	(%)	(%)
Untreated check	1382 c*	100	6.6[1]	43 a	10 c	0 d
Early (April 19)						
500	1664 ab	120	4.8	33 bc	15 ab	18 c
1000	1855 a	134	4.4	31 bc	17 a	22 c
1500	1526 bc	110	4.9	34 bc	14 abc	34 ab
Late (May 2)						
500	1852 a	134	4.5	28 c	17 a	27 bc
1000	1582 bc	114	5.8	33 bc	12 bc	38 a
1500	1384 c	100	5.4	40 ab	12 bc	40 a

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values at P=0.05
[1]Contrast of treated vs untreated significant P=0.05

LIMING WITH RECYCLED PAPER RESIDUE (RPR)

M.H. Fitzgerald, M.E. Mellbye and D.M. Sullivan

Recycled Paper Residue (RPR) is a byproduct of the towel and tissue paper-making process. RPR is mixture primary and secondary solids that are recovered from wastewater treatment system. It contains approximately 22% organic carbon and has a calcium carbonate equivalent of 25%. Potential agronomic benefits of using RPR as a soil amendment include: soil liming potential, increased soil organic matter and improved soil tilth. Wastewater treatment solids such as RPR, have high C to N and N to S ratios. In the soil, microbes that decompose the C provided by the RPR can compete with a ryegrass crop for available N and S.

This study was conducted to assess second year effect of RPR on ryegrass yield, soil pH, and soil organic matter content. During the first year, seed yield was 12% lower with RPR (not significant at P=0.10) and soil pH increased from 4.7 to 6.5 (Mellbye,1996)

Materials and Methods

The field site for this study is located on Malpass Farms near Harrisburg, OR on a poorly-drained Dayton silty clay loam soil. Treatments consisted of application of 35 dry ton/acre of RPR in September 1995, compared to no RPR application. This was a typical application rate for RPR applied to fields in the area. No treatment was made to a 400 by 100ft block about 200 feet from the edge of the field.

The remainder of the field received RPR application. After application with a manure spreader, the RPR was incorporated to a depth of six to eight inches by disking.

This report covers only the second year after RPR application (1996-97). On September 15 1997, *Froghair*, a variety of intermediate ryegrass was seeded at a rate of 10 lb/acre. Fertilizer (100 lb of 10-20-20)was also banded with the seed. Another application of 350 lb/acre 38-0-0-8 was broadcast on April 15, 1997. Soil samples were taken on April 21 and June 24. Whole plant samples (three subsamples 9 ft^2 each) were taken on June 24 to measure biomass production and plant nutrient status. Soil and plant samples were analyzed by the OSU Central Analytical Laboratory. Seed harvest of the RPR and no RPR blocks occurred on July 14, 1997. We harvested six combine strips from the RPR and no RPR areas (approx. 1/8 acre each). A sample collected at harvest was used to determine clean seed yield.

Results

Seed yield for the second year after the RPR application was similar with and without RPR (P=0.10, Table 1). Although not statistically significant, lower measured seed yields were obtained with RPR application (1675 lb/acre with RPR, 1824 lb/acre without RPR). The concentration of N, K, S and Ca in the whole plant samples was significantly higher with RPR application (Table 1).

Table 1. Clean seed yield, whole plant yield, and whole plant nutrient content. Malpass Farms 1997

RPR	Whole plant yield	Clean seed Yield	Whole plant nutrient content N	P	K	S	Ca	Mg
---(ton/a)---		(lb/a)	----------------(%)----------------					
0	4.5	1824	1.56	0.17	0.36	0.22	0.29	0.09
35	5.0	1675	1.74	0.16	0.47	0.25	0.63	0.15
	NS	NS	*	NS	**	**	***	**

NS = Not significant
* = Statistically significant at the 10% probability level
** = Statistically significant at the 5% probability level
***= Statistically significant at the 1% probability level

Soil pH and organic matter were increased with RPR (Table 2). With RPR, the soil pH was 6.3 in June and 7.1 in April. The application of RPR also increased exchangeable Ca.

With RPR, exchangeable bases were approximately equal to soil cation exchange capacity (CEC), indicating that no further liming benefit would be obtained with increased rates of RPR. Soil organic matter also showed an increase from 4.4% with no RPR to 4.8% with RPR.

Discussion

There was a non-significant trend for lower seed yield with RPR application for both the 1996 and 1997 growing seasons. An apparent yield decline of 270 lb/acre from the treated plots was observed in 1996, and an apparent yield decline of 150 lb/acre was observed in 1997. In contrast, whole plant yield and nutrient uptake were increased by RPR (Table 1). For example, N uptake increased from 124 lb/acre in the untreated plots to 156 lb/acre with RPR. This suggests that nutrient deficiencies are not the cause of reduced seed yields. The higher nutrient uptake with RPR is probably due to increased microbial activity in the soil and mineralization of nutrients from soil organic matter.

Increased soil pH, exchangeable Ca, and SMP buffer values all demonstrate the liming value of RPR (Table 2). The increase in exchangeable soil Ca with RPR, about 12 meq/100g, is approximately equal to 6 tons per acre of 100-score lime. The change in SMP buffer values suggests that the RPR application rate of 35 dry ton/acre provided at least 7 tons of 100 score lime per acre. To calculate an appropriate rate of RPR we suggest using the OSU Guide for Fertilizer and Liming Material (FG-52) with a liming material fineness factor of 1.0.

The pH levels attained with RPR in this study are greater than needed for annual ryegrass. The acceptable pH level for ryegrass production is 5.5 or higher. To reach this level on a Dayton soil with an initial pH of 4.6, the addition of 2 to 3 ton/acre of 100 score lime is required (Peterson, 1972).

The liming benefits of the RPR are expected to last for a number of years. Previous research on Willamette Valley soils has demonstrated that a limed soils pH will drop 0.05 to 0.1 pH units per year over a ten year period (Doerge,1985).

Conclusion

The application of RPR supplied readily available Ca, increased pH, soil organic matter, and nutrient uptake of the plants. The application rate of 35 dry ton/acre supplied the equivalent of 6 to 7 tons 100 score lime, based on soil test Ca values and soil test SMP buffer pH. Since ryegrass yields are not responsive to pH adjustments above 5.5, we recommend lower RPR application rates.

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Table 2. Soil test values (0-6 in.) for ryegrass field, Malpass Farms. Sampled June 24 1997.

RPR	pH buffer	SMP	P	K	B	Ca	Mg	Na	CEC	SOM[a]
(ton/acre)	---- (ppm) ----		-----(meq/100g)-----							(%)
0	4.8	5.5	13.7	57.3	0.2	8.3	3.0	0.1	23.5	4.4
35	6.3	6.8	10.3	62.7	0.4	20.2	2.4	0.1	23.9	4.8
	***	***	NS	NS	NS	**	**	NS	NS	

[a] = Soil Organic Matter
NS = Not significant
** = Statistically significant at the 5% probability level
*** = Statistically significant at the 1% probability level

CONTRIBUTION OF HIDDEN FLUORESCENCE IN SEEDLING ROOT FLUORESCENCE TESTS OF RYEGRASS

R.E. Barker, S.K. Davidson, R.L. Cook, J.B. Burr, L.A. Brilman, M.J. McCarthy, A.E. Garay and W.D. Brown

Introduction

Seedling root fluorescence has been used as a separator of kind almost since its discovery (Gentner, 1929). Generally, seedling roots of annual or Italian ryegrass (*Lolium multiflorum* Lam.) fluoresce when placed under ultraviolet light and those of perennial ryegrass (*L. perenne* L.) do not. Application of the test, however, has had difficulties associated with variability since its inception. Because of the variability, early researchers suggested that the test could be used as an indicator of kind, but should not be used as a rigid discriminator (Rampton, 1938).

One source of variation associated with the test is that some fluorescence is not readily visible (hidden) while the seedling root is still on the filter paper. For many years, roots with this light intensity were ignored when standard or production tests were conducted. In 1990 the Federal Seed Act rules for testing seeds were amended to allow the seedling root test to be used as a variety descriptor in the ryegrasses (AOSA rules, 1994). This change led to the realization that the test should have been completed by removing all seedlings from the filter paper (Colbry, 1963). While lifting seedlings does reduce some human judgement errors in making decisions about intensity, removal of seedlings in production laboratories is time consuming.

Objectives

This study was conducted as a survey to determine the amount of hidden fluorescence in ryegrass seed test lots and to ascertain if lifting could be eliminated without appreciably affecting detection of annual ryegrass contamination in perennial ryegrass seed lots. This was not a study to incorporate interpretation of fluorescence intensity, with its associated subjectivity, into testing procedures.

Eleven cultivars that were tested to describe varietal fluorescence level were used in the study. In each cultivar description, seedlings with hidden fluorescence were separated from seedlings where fluorescence was readily observable without lifting the seedling from the filter paper. Breeders of the cultivars maintained records of grow out results on each seedling. Grow out tests were conducted either in the greenhouse, or in the field, and plants were grown until an annual ryegrass check cultivar had flowered.

Results and Discussion

Of 970 seedling roots with fluorescence, 898 survived through the full grow out tests (Table 1). Variety fluorescent descriptions (VFL) calculated as:

$$\text{VFL (\%)} \quad \frac{\text{Normal Fl seedlings} - \text{Annuals}}{\text{Total normal germinated seedlings}} \quad \text{x } 100$$

ranged from 0.42 To 4.83%. Only one plant out of 418 with hidden fluorescence flowered by the end of the grow out tests. This one seedling would have impacted the VFL by changing the value from 0.42% to 0.44%. There is far more variation in the fluorescence test because of other factors than that expressed in this study impacted by the small contribution of not lifting roots with hidden fluorescence (R.E. Barker, et al., 1998, unpublished data). Of greater concern, however, is the inflation of VFL caused by overestimating fluorescence level by counting the roots with hidden fluorescence. Adjusted VFL values, not considering hidden fluorescence, would range from 0.16 to 1.92%.

Garbacik and Grabe (1992) conducted grow out tests on OSU Seed Lab samples consisting of 255 samples from 45 cultivars in one study, and 1203 seedlings with hidden fluorescence from 75 cultivars in another study. Combining the results, they reported that there was only a 0.02% contribution to annual ryegrass classification based on hidden fluorescent seedling roots. During the 1997-98 seed season in Oregon, leaf vernation grow out tests were conducted on 54 foundation class seed lots of 36 cultivars (A.E. Garay and W.D. Brown, 1998, personal communication). Seedlings with hidden fluorescence were kept separate from those with visible fluorescence. Of 275 seedlings (110 visible, 165 hidden), none showed rolled-type vernation typical of annual ryegrass.

Based on the results from these three studies, it appears unwarranted on the basis of delays to the test to continue to lift seedlings. Not only is it more labor intensive to lift the seedlings, but there are few, if any, seedlings with hidden fluorescence that are actually annual ryegrass types. The numbers of seedlings added to the total fluorescent count from hidden fluorescence adds further variability to the final results.

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Table 1. Seed test results from eleven cultivars of perennial ryegrass showing numbers of seedling roots with fluorescence detected either as visible (without lifting the seedling) or as hidden (only detectable by lifting the root from the filter paper).

Cultivar	No. of lots	No. of certification classes	No. of years represented	Seeds tested	Seeds germinated	Fluorescent seedlings returned	Surviving plants Visible	Surviving plants Hidden	Annual (flowering) Visible	Annual (flowering) Hidden
Majesty	5	3	3	5,000	4,525	73	28	28	0	0
Calypso II	5	3	3	6,000	5,559	31	17	9	0	0
Calypso	6	2	3	7,800	7,399	88	49	27	1	0
Accolade	3	3	3	3,000	2,629	128	50	78	1	0
Divine	5	3	2	6,000	5,563	171	41	127	0	0
Omni	5	3	2	6,000	5,492	37	14	15	1	0
SR 4010	5	3	2	2,000	1,887	13	3	10	1	0
SR 4100	6	4	5	7,200	6,770	36	16	20	1	0
SR 4200	6	3	4	7,200	6,392	28	12	16	0	1
Line Drive	6	3	3	7,200	6,738	183	127	54	0	0
Pennant II	10	3	3	12,000	11,042	182	123	34	2	0
Totals				69,400	63,996	970	480	418	7	1

DEVELOPMENT OF MOLECULAR TESTS TO DIFFERENTIATE PERENNIAL FROM ANNUAL RYEGRASS

S.E. Warnke and R.E. Barker

Two important grass species grown in the Pacific Northwest are annual (Lolium multiflorum) and perennial (L. perenne) ryegrass. These two cool-season outcrossing grasses are marketed as synthetic varieties. Annual and perennial ryegrass are capable of freely interbreeding, and the hybrid (L. X hybridium) is marketed as intermediate ryegrass. The differentiation of annual and perennial ryegrass can be easily done at the adult plant stage using several morphological characteristics, however, interbreeding between the species has created a situation in which individuals ranging from completely annual to strongly perennial can be isolated.

This absence of a strong species boundary between annual and perennial ryegrass creates a problem for seed certification agencies because the contamination of perennial ryegrass seed by annual ryegrass creates an undesirable turf product. For the last sixty years, seedling root fluorescence has been used as a method to assess the level of annual ryegrass contamination in perennial ryegrass seed lots. The fluorescence test, however, has become inaccurate and can lead to the labeling of perennial ryegrass seed lots as annual ryegrass, resulting in a considerable monetary loss. One solution to this problem is to develop a new test to identify plants with annual characteristics in perennial ryegrass seed lots. The test must be fast, accurate, and inexpensive.

The problem with using morphological characteristics to discriminate these two species is the length of time required to grow plants to a size suitable for evaluation. One way to bypass this time delay is through the use of a DNA test that would allow the prediction of adult plant phenotype based on the genetics of a seed or small seedling. Two methods can be used to locate markers that identify plants with annual growth characteristics. The first method is a correlation study in which a group of annual plants and a group of perennial plants are created and differences between the two groups DNA are evaluated to identify a discriminating

DNA marker. The advantage of this method is that it can be done very rapidly, however, it can be very difficult to find one marker that accurately discriminates the two species. Additionally, a single marker of this type would have the same disadvantages as the fluorescence test because, over time, introgression of genes between the two ryegrass types will reduce accuracy.

The second method involves a through genetic study of each of the characteristics that are important in discriminating these two species. The genetic method is more difficult, but will result in a test that is much more accurate, and flexible. The genetic approach requires research to identify which genetic differences between annual and perennial ryegrass are important to include in a discriminatory test. There are several key morphological characteristics that are used to differentiate these species (Table 1). A few of these characteristics such a leaf width, color, and growth habit are of primary importance in seed certification, because it is a combination of these characteristics that result in the "big ugly" phenotype that negatively impacts turfgrass quality.

Table 1. Taxonomic characteristics discriminating annual and perennial ryegrass.

Taxonomic descriptors	Perennial ryegrass	Annual ryegrass
Spikelet flower number	Low	High
Awn	Typically absent	Typically present
Plant height	Short	Tall
Longevity	Perennial	Annual or Perennial
Leaf blade width	Narrow	Wide
Leaf blade length	Short	Long
Leaf vernation	Folded	Rolled
Root fluorescence	Typically nonfluorescent	Typically fluorescent
Vernalization	Required	Generally not required

Very few studies have investigated the inheritance of taxonomic characters that discriminate annual and perennial ryegrass. In order to investigate these characters we have developed several annual by perennial ryegrass populations as well as backcross populations to both the annual and perennial parents. The backcross populations are segregating for a number of characters that discriminate between these two species. We have focused our initial efforts on first year flowering or flowering without vernalization. In three backcross populations this character segregated in a 1:1 ratio and Randomly Amplified Polymorphic DNA (RAPD) markers that co-segregate with this character have been isolated (Figure 1). The marker bands isolated in the initial phase of this study are being sequenced so that site specific primers can be developed. The sequence characterized regions (SCARs) will be utilized in a test that can screen for a number of discriminating characters simultaneously. This method will ultimately provide a very rapid, and accurate test for annual ryegrass contamination in perennial ryegrass seed lots. Additionally, this test will provide valuable information on the feasibility of marker assisted selection in outcrossing cool-season grass species. We are working to simplify the technique so that it can be easily and quickly used in a seed testing laboratory.

Gel A

Gel B

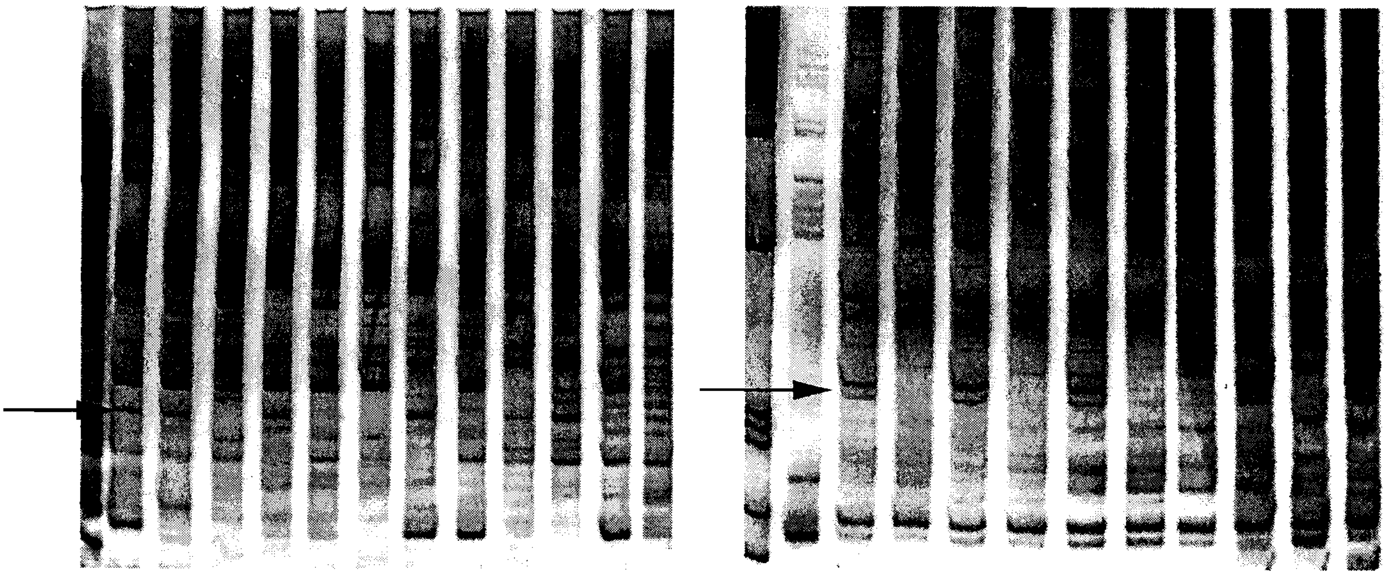

Figure 1. Gel A the amplification of DNA from twelve ryegrass individuals using the primer E9. The arrow points to a 500 bp fragment present in plants that flowered without vernalization and absent in plants requiring vernalization. The band is approximately 6 centimorgans from the first year flowering locus. Gel B the amplification of DNA from twelve ryegrass individuals using primers UBC 201 and 207. The arrow points to a 500 BP fragment present in plants that flowered without vernalization and absent in plants requiring vernalization. The band is approximately 8 centimorgans from the first year flowering locus.

CHOKE DISEASE OF ORCHARDGRASS IN OREGON

W.F. Pfender and S.C. Alderman

Choke disease of orchardgrass is characterized by a grayish-white to orange-colored fungal growth ('stroma') that develops on the flag leaf sheath as the head is about to emerge from the boot. The stroma covers the sheath completely, is about ¼ inch wide and 2 to 5 inches long, and has a slightly rough texture. The stroma physically prevents the flower head from emerging, thus 'choking' the stem and preventing seed production on the affected tiller. The disease is caused by an endophytic fungus named *Epichloe typhina*. Until 1996, orchardgrass choke was not known to occur in Oregon, but it has been common in certain grass-seed producing areas of Europe, principally France, for many years. In France, choke is a major constraint on stand longevity in orchardgrass, and commonly causes fields to become unprofitable after as few as 3 years of production.

In 1996 an infected tiller was collected from an orchardgrass field in Linn County, but the field had been harvested before the disease was identified and no survey was possible. In 1997, the disease was observed in four fields near Halsey and in one near Lebanon. All infected fields observed in 1997 were planted to the same experimental cultivar. Surveys taken in the affected fields showed that the disease was evenly distributed in several of them, with about 3% of the tillers choked. One field that had been planted more recently than the others showed a lower proportion of tillers affected, with the disease occurring in patches. This pattern, of increasing prevalence as the stand gets older, is consistent with observations of choke development in France. We do not yet know how widespread the disease is among cultivars and locations in the Willamette Valley. A survey is planned for the 1998 season to address this question.

The pathogen spreads from one plant to another by spores (ascospores) produced in and ejected from the orange fungal stroma that chokes the seed head. The spores infect other plants at harvest time, by entering into the cut ends of the stubble and growing down into the crown area. No disease symptoms are produced on the newly-infected plants at this time. The next spring, the fungus grows inside the plant as it elongates. No symptoms are produced until shortly before flowering, when the choking stroma of the fungus appears on the tiller. This fungus growth is white at first, then matures to produce the characteristic bright orange color. Because it can spread within a field on a yearly cycle, the disease is likely to become progressively more serious within a field from one year to the next. Research on choke, conducted in Europe, indicated that the pathogen is not seed-borne. However, recent correspondence with French researchers, and the pattern of occurrence of the disease here, suggest that it may be seed-borne at very low frequency.

Presently, there are no good controls for the disease. Genetic resistance is probably not available in our commonly-grown varieties. Several Oregon-grown cultivars were tested in France in 1993-94, and none was resistant. It is unknown whether the choke fungus now in Oregon is the same as the pathogen in France with regard to its ability to attack various orchardgrass cultivars, but this seems likely. There are no effective fungicides known for controlling this disease, and it would be difficult for a fungicide to reach the fungus (inside the plant) at concentrations sufficient to control it. Management practices that prevent establishment of the pathogen in the freshly-cut stubble could slow the spread of the disease in a field. European research suggests that it is best to harvest infected fields and areas first, allowing the spore-producing stroma to dry out and die before exposing the cut culms in healthy areas or fields to spores that would come from active stroma. The possibility that these and/or other management approaches would be helpful in Oregon needs to be addressed. In addition to surveys to determine the extent of choke in the Willamette Valley, we will begin field experiments to evaluate disease management practices under Oregon conditions.

STEM RUST CONTROL IN PERENNIAL RYEGRASS: COMPARISON OF FUNGICIDES, RATES AND INITIAL SPRAY DATES

W.F. Pfender and R.J. Burr

The current best control method for stem rust is the use of fungicides (often 3 applications per season on perennial ryegrass), and one fungicide (propiconazole) is used almost exclusively for this purpose in Oregon. The research reported here was undertaken to test several different fungicides for ability to control stem rust, and to test the possibility of saving money by reducing the number of fungicide sprays per season.

Experiments were conducted in a perennial ryegrass field 5 mi. south of Corvallis, on the Venell farm. The field was planted September 18, 1996, with carbon-banding and preemergence herbicide. In one experiment, fungicides were applied at heading (May 9) and two additional times (May 29 and June 18). In the other experiment, located immediately adjacent to the first, the initial fungicide application was delayed until May 29, at which time rust severity (modified Cobb scale) was approximately 10%; one additional fungicide application was made on June 18 in this experiment. In each experiment, plots were 8 X 25 ft and were replicated 4 times in a randomized complete-block design. Fungicides were applied using a backpack sprayer with an 8-ft boom and XR8003 flat fan nozzles in 20 gal/a carrier at 30 psi.

Disease severity and incidence were evaluated for 50 tillers per plot on three dates: June 15, June 26 and July 5. Plots were harvested on July 10 using a small-plot harvester to cut a strip 3.12 ft X 18.4 ft from the center of each plot. The cut grass was dried outdoors in burlap bags for 3 weeks, and threshed on a belt thresher with 8/64 round-hole top screen and 6 X 32 woven-wire bottom screen. Seed was cleaned first on an M2B seed cleaner with 7/64 round-hole top screen and 6 X 30 woven-wire bottom screen and no air, then with a Westrup air/screen machine using a 7/64 round-hole top screen, a 4 X 28 woven-wire bottom screen and forced air. Final cleaning was done in an air-column separator for 15 seconds. Yield of cleaned seed from the 57.4 ft^2 harvested area was converted to lb/a, and weight of 1000 seeds determined.

Although initial stem rust development was later in 1997 than in some other years, it was adequate for a good test. The disease was first observed on April 10, and reached a severity (modified Cobb scale on stem above flag leaf) of 70% in check plots by June 26 (Table 1). Yield improvement was statistically significant with fungicide treatment in the two-application as well as the three-application programs (Table 2). In both programs, propiconazole produced similar yield improvements (approximately 45%). Note that yield in the non-treated (check) plots of the three-application experiment appears to be lower than that of the two-application experiment, although this difference cannot be tested statistically.

In the three-application program, the disease rating was significantly less in fungicide-treated plots than in unprotected plots, all fungicides improved seed weights, and Quadris at 9.2 fl. oz./a produced a higher 1000-seed weight than other treatments. In the two-application program, disease rating was significantly less in treatments with Quadris (alone or in combination with other fungicides) than in unprotected plots; disease was not significantly less for the sterol-inhibiting fungicides used alone than for unprotected plots. However, there were no significant differences among fungicides in yield (lb/a) response: all improved yield compared to unprotected plants. The 1000-seed weight did not differ among fungicide treatments in the two-application program (all were higher than the check). Overall, there was a curvilinear decrease in yield with increasing rust severity (Figure 1), and 1000-seed weight decreased directly with increasing rust severity (Figure 2).

Several fungicides, including one (Quadris) that is relatively new and in the process of being labeled for grass seed crops, controlled the disease at least as well as Tilt did. Quadris improved the seed quality (1000-seed weight) slightly more than the standard treatment. By using two fungicide applications, the disease was not controlled as well as it was with three applications (plants had more infections), but the yield (expressed as % of the relevant check treatment) was almost as high as it was with three applications. In each experiment, there were no statistically significant differences in yield among the different fungicides and rates. Because the yield effects of different fungicide programs will depend on the particular year's epidemic characteristics (how early and how quickly rust develops, with respect to the crop development that year), additional field trials are needed before we can assume that a two-application program will necessarily give a similar yield benefit as a three-application program in perennial ryegrass. Additional data of this type will allow an assessment of the trade-off between the benefits of frequent fungicide applications (better disease control and yield) and the costs (environmental and economic costs of repeated applications). Also, the results with the strobilurin-type fungicide (Quadris) are promising. It will be useful to have more than one fungicide effective against stem rust, because the repeated use of a single fungicide could allow fungicide resistance to develop in the rust pathogen population.

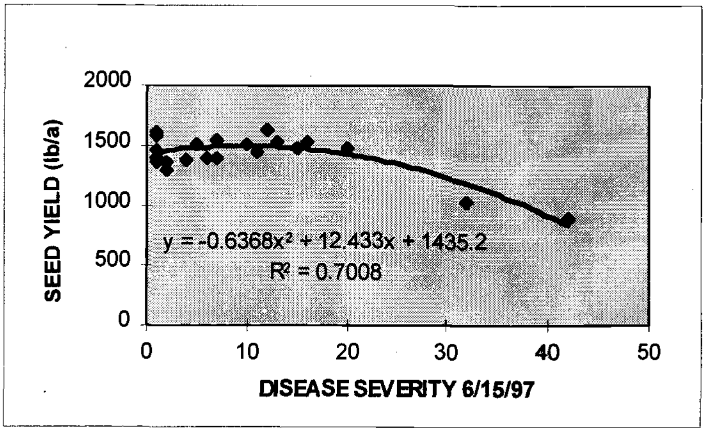

Figure 1. Effect of stem rust severity on seed yield in perennial ryegrass, 1997, at one location.

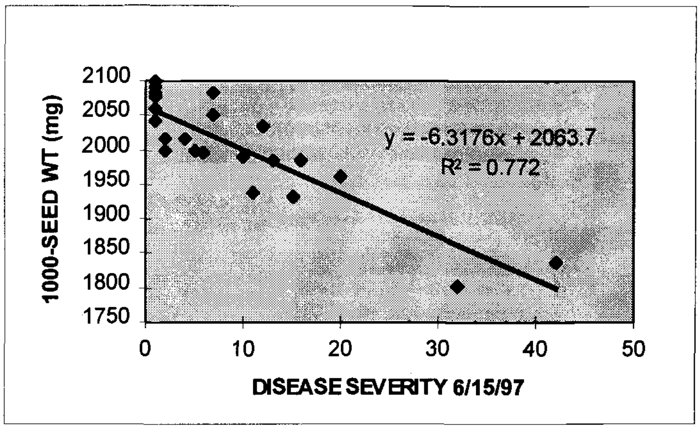

Figure 2. Effect of stem rust severity on 1000-seed weight of perennial ryegrass, 1997 at one location.

Table 1. Rust severity in perennial ryegrass at three dates during the 1997 season, as affected by fungicide and application program.

Fungicide	Rust Severity on indicated dates in the 2-Application Program			Rust Severity on indicated dates in the 3-Application Program		
	June 15	June 26	July 5	June 15	June 26	July 5
None (check)	32	72	61	42	71	70
Folicur 6oz	15	30	21	2	6	6
Tilt 6 oz	20	33	22	2	6	5
Folicur (4oz) + Echo (1.5 p)	16	20	32	4	1	1
Tilt (4 oz) + Echo (1.5 p)	11	29	19	1	2	1
Quadris 6oz	12	5	2	1	1	1
Quadris(6oz) + Folicur (4oz)	13	3	2	1	1	1
Quadris (6oz) + Echo (1.5 pt)	10	5	8	1	0	1
Quadris (6oz) + Tilt (4oz)	5	2	3	7	1	1
Quadris 9oz	6	3	1	1	1	1
Quadris 12oz	7	4	1	1	1	1

Table 2. Effect of fungicide and application program on final disease and yield in perennial ryegrass.

Fungicide[1] (and rate/acre)	2-Application Program[2]				3-Application Program[3]			
		Yield				Yield		
	Rusted tillers[4]	Seed yield	Yield increase[5]	1000-seed weight	Rusted tillers[4]	Seed yield	Yield increase[5]	1000 seed weight
	(%)	(lb/a)	(%)	(oz.)	(%)	(lb/a)	(%)	(oz)
None (check)	99 a[6]	1029 a	-	0.064 a	99 a	894 a	-	0.065 a
Folicur 6oz	82 ab	1472 b	43	0.068 b	34 b	1359 b	52	0.071 b
Tilt 6 oz	78 ab	1480 b	44	0.069 b	28 b	1299 b	45	0.070 b
Folicur (4oz) + Echo (1.5 p)	81 ab	1532 b	49	0.070 b	9 c	1374 b	54	0.071 b
Tilt (4 oz) + Echo (1.5 p)	69 ab	1449 b	41	0.070 b	10 c	1397 b	56	0.073 bc
Quadris 6oz	18 d	1630 b	58	0.072 b	7 c	1585 b	77	0.073 bc
Quadris(6oz) + Folicur (4oz)	22 cd	1530 b	49	0.071 b	9 c	1583 b	77	0.075 c
Quadris (6oz) + Echo (1.5 pt)	39 c	1510 b	47	0.070 b	1 c	1367 b	53	0.073 bc
Quadris (6oz) + Tilt (4oz)	16 d	1508 b	47	0.070 b	4 c	1397 b	56	0.073 bc
Quadris 9oz	14 d	1389 b	35	0.070 b	4 c	1607 b	80	0.075 c
Quadris 12oz	12 d	1540 b	50	0.072 b	7 c	1457 b	63	0.073 bc

[1]All treatments were applied with crop oil concentrate (Agridex) at 0.8 qt/a
[2]Application dates May 29 and June 18, 1997
[3]Application dates May 9, May 29 and June 18, 1997
[4]Disease incidence (% tillers with rust pustules) on July 5, 1997
[5]% increase in seed yield, compared to check (no fungicide) treatment in the respective experiment
[6]All values are averages of 4 replicate plots. Values within a column followed by the same letter do not differ ($P<0.05$) by Student-Newman-Keuls' procedure

EVALUATION OF FUNGICIDES FOR CONTROL OF BLIND SEED IN TALL FESCUE

S.C. Alderman, M.E. Mellbye and R.L. Spinney

During the past few years high levels of blind seed have occurred in several fields of tall fescue. Although most fields of tall fescue and perennial ryegrass have little to no blind seed, the threat of increasing blind seed disease in the absence of field burning remains. In the absence of field burning, fungicides may provide an alternative disease control option.

During 1997, a fungicide trial was established in a commercial field of 'Fawn' tall fescue near Tangent, OR. Blind seed occurred in the field during 1996. Field plots were 10 x 24 feet with 10-foot borders surrounding each plot. Plots were arranged in a randomized complete block design with four replications per treatment. Fungicides were applied at 35 psi with a CO_2 powered backpack sprayer with 8004 twin-jet nozzles. Fungicides were applied at the beginning of flowering (16 May) and about 6 weeks later (30 June). When mature, 400 seed heads were collected by hand at random from each plot and threshed in a laboratory scale thresher. Blind seed level was determined based on a count of conidia of *Gloeotinia* washed from seed. A 10 g seed sample from each plot was soaked in water for 15 minutes. The water was transferred to test tubes, agitated with a vortex mixer to suspend conidia, then samples were drawn for counting. Conidia were counted using a hemacytometer under 200X magnification.

Conditions during early to mid-flowering were dry and generally unfavorable for blind seed development. A low level of blind seed (2-4% infected seed) developed in the field. This level was too low to detect significant differences among treatments, based on percent infected seed. However significant differences among treatments were apparent when the data, based on number of conidia washed from seeds, were analyzed by one-way ANOVA. Conidia of the blind seed fungus are fungal spores that develop during infection and are responsible for rapid spread of the disease within a field during favorable (i.e. wet) conditions. No significant reduction in blind seed conidia, compared with the control plots, occurred in plots treated with Quadris (azoxystrobin) (Table 1). The level of blind seed from plots treated with Tilt (propiconazole) sprayed twice, or once at the rate of 8 oz, did induce a significant reduction in conidia. Folicur (tebuconazole), 8 oz, dual application, also significantly reduced the level of blind seed.

Table 1. Efficacy of fungicides for control of blind seed disease in tall fescue during 1997.

Treatment and rate/acre	Application dates	Log conidia/ 10 g seed*	
Control		3.38	a**
Quadris 2.08 F, 4 oz	16-May	3.45	a
Quadris 2.08 F, 4 oz	30-June	3.27	ab
Quadris 2.08 F, 4 oz	16-May, 30-June	3.36	a
Quadris 2.08 F, 8 oz	16-May	3.27	ab
Quadris 2.08 F, 8 oz	30-June	3.26	ab
Quadris 2.08 F, 8 oz	16-May, 30-June	3.33	ab
Tilt 428 GS, 4 oz	16-May	3.81	abcd
Tilt 428 GS, 4 oz	30-June	2.97	abc
Tilt 428 GS, 4 oz	16-May, 30-June	2.35	d
Tilt 428 GS, 8 oz	16-May	2.69	bcd
Tilt 428 GS, 8 oz	30-June	2.71	bcd
Tilt 428 GS, 8 oz	16-May, 30-June	2.89	cd
Folicur 3.6 F, 8 oz	16-May, 30-June	2.68	bcd

*Means of four replications

**Means in a column followed by the same letter are not significantly different (S-N-K test, P=0.05).

Fungicides such as Tilt or Folicur may provide a means of reducing the level of blind seed, although additional testing in years of high disease pressure will be required to evaluate effectiveness of fungicides for blind seed control. In management of blind seed in the absence of field burning, fungicides may compliment but should not substitute for cultural management approaches for blind seed control. The blind seed fungus overwinters in infected seed and the greater the number of infected seeds left in the field, the greater the potential inoculum during the following spring. Removing as many seeds as possible from the field during or following harvest reduces the inoculum carry-over. Timely harvest to limit excess seed shatter and adjustment of combines to remove lightweight seeds are recommended. Avoid precleaning in the field since this returns many lightweight, and potentially infected, seeds to the field. In addition, maintaining a healthy, vigorous stand, will also help reduce blind seed severity.

EVALUATION OF FUNGICIDES FOR CONTROL OF ERGOT IN KENTUCKY BLUEGRASS, 1997

M.D. Butler, S.C. Alderman and F.J. Crowe

Ergot, caused by the fungus *Claviceps purpurea*, is an important flower-infecting pathogen in grass seed production regions of the Pacific Northwest. Of the grass species grown for seed in Oregon, Kentucky bluegrass is particularly affected by ergot. Traditional control has been through open field burning, which has partially suppressed the disease.

Previous fungicide evaluations in central Oregon during 1992 to 1996 indicate excellent ergot control with Punch (fusilazole), for which there are no plans for registration in the United States. Suppression of ergot has been provided by Tilt (propiconazole) and Folicur (tebuconazole). As a result of this research, and similar fungicide evaluations by William Johnston at Washington State University, ergot suppression was added to the Tilt label in 1995 through a 24(c) special local need registration. Folicur was also recently registered for use on grass seed.

During the 1997 season fungicides evaluated for control of ergot were conducted in a commercial field of 'Georgetown' Kentucky bluegrass at Trail Crossing, and in a 'Coventry' Kentucky bluegrass plot at the Central Oregon Agricultural Research Center, Powell Butte location. The Powell Butte location was infested with ergot at 1 sclerotia/ft^2 on December 20, 1996. Tilt, Folicur, Quadris (azoxystrobin), and Orthorix (calcium polysulfides) were evaluated during the 1997 season. Surfactants Penaturf, Sylgard 309, and crop oil concentration were also evaluated in combination with fungicide treatments.

Plots 10 ft x 20 ft were replicated four times in a randomized complete block design.

Materials were applied using a 9-foot CO_2 pressurized boom sprayer with 8003 TwinJet nozzles at 40 psi and 30 gal/a water. Sylgard 309 at 16 fl oz/100 gal and R-56 at 1 pt/100 gal were applied with in combination with all fungicides, but not when Penaturf, Sylgard 309, or Orthorix were applied alone. Crop oil concentrate (COC) was applied at 1 percent volume per volume with single and double applications of Quadris, and a double application of Tilt. Treatments were applied at Trail Crossing on June 2 and June 13, and at the Powell Butte site on May 30 and June 9, 1997. The first treatments were applied at the initiation of anthesis at both locations. Plots in the commercial field at Trail Crossing were covered with 4 mil polyethylene to prevent contamination during aerial application of Tilt on June 6 and June 20, 1997.

One hundred panicle samples were randomly collected from each plot on July 3 at Trail Crossing and July 11 at Powell Butte. Number of panicles with sclerotia, total sclerotia per sample, panicles with honeydew, and seed weight were determined per sample for each plot.

The level of ergot infection at the Trail Crossing location was extremely low, with only one sclerotia found in a total of 400 panicles from the untreated plots. Counting sclerotia in the treated plots was discontinued, but seed cleaning and seed weight were determined.

At the Powell Butte location which was infested with ergot sclerotia, disease levels averaged 741 sclerotia per 100 panicle samples in the untreated plots (Table 1). All fungicide treatments significantly reduced sclerotia per sample, with the best treatment being two applications of Tilt at 8 oz/a. Penaturf, Orthorix and crop oil concentrate in combination with the 8 oz/a Tilt treatments did not significantly alter fungicide performance.

Tilt applied as a single 8 oz/a application or a double 4 oz/a application were not significantly different, but the trend was for slightly better control with the double application. The trend also indicates that Tilt at 8 oz/a followed by a Penaturf treatment provided better control than Tilt followed by Sylgard 309, which was better than Tilt applied alone. The performance of the new fungicide Quadris at 12 oz/a was similar to Folicur at 8 oz/a when applied as a double treatment. The presence of honeydew followed a similar trend to the number of sclerotia per sample. When evaluating weight per sample and 1000 seed weight, there does not appear to be any consistent treatment effect across both locations.

Table 1. Evaluation of fungicides applied for ergot control to 'Coventry' Kentucky bluegrass at the COARC Powell Butte site in central Oregon on May 30 and June 9, 1997.

Fungicide Treatment	Rate May 30	Rate June 9	Panicles with sclerotia	Total sclerotia per sample	Total honeydew per sample	Weight per sample	1000 seed weight
	(fl oz/a)		(%)	(no.)	(no.)	(g)	(g)
Tilt	8		71 ab	303 bc	99 a	3.65	0.39 abc
Folicur	8		73 ab	228 bc	79 a	4.15	0.40 a
Quadris (coc)	12		78 ab	374 b	96 a	3.78	0.40 a
Tilt + Tilt	4	4	68 bc	234 bc	93 a	3.5	0.39 abc
Folicur + Folicur	4	4	65 bc	194 bc	92 a	3.38	0.39 ab
Tilt + Tilt	8	8	21 e	35 c	6 d	3.45	0.37 bc
Folicur + Folicur	8	8	46 cd	108 bc	11 d	3.3	0.40 a
Tilt (coc) + Tilt (coc)	8	8	33 de	87 c	7 d	3.23	0.39 ab
Quadris (coc) + Quadris (coc)	12	12	46 cd	108 bc	23 cd	3.75	0.40 a
Tilt + Penaturf	8	48	63 bc	234 bc	38 bc	3.2	0.38 abc
Tilt + Sylgard 309	8	32	53 bcd	181 bc	23 cd	3.25	0.39 ab
Tilt/Penaturf+Tilt Penaturf	8/48	8/48	33 de	105 bc	4 d	3.6	0.39 ab
Tilt/Orthorix +Tilt/Orthorix	8/64	8/64	26 de	76 c	8 d	3.63	0.39 abc
Untreated	---	---	92 a	741 a	99 a	4.3	0.39 ab

[1] Sylgard 309 at 16 fl oz/100 gal and R-56 at 1 pt/100 gal applied with all treatments except when surfactants were applied alone.
[2] fl oz/100 gals
[3] crop oil concentrate (COC) applied at 1% in combination with fungicides
Mean in the same column with different letters are significantly different at P≤ 0.05

ERGOT LEVEL EFFECT OF SEED STOCK ON DISEASE INCIDENCE

M.D. Butler, S.C. Alderman and F.J. Crowe

Ergot (*Claviceps purpurea*) is an important flower-infecting pathogen which is particularly damaging to Kentucky bluegrass seed production. The disease not only replaced the seed with ergot sclerotia, but also produces honeydew which makes harvest difficult.

The objective of this study was to determine if there is a direct correlation between the number of sclerotia present in seed at planting and incidence of the disease in following years. This is the third and final year of the project.

'Coventry' Kentucky bluegrass seed was infested with 0, 0.1, 0.5, 1, 2, and 3 percent ergot sclerotia by weight. This seed was planted August 29, 1996 in 14 ft x 14 ft plots replicated 4 times at the Central Oregon Agricultural Research Center, Madras location. Plots were separated by 10 foot borders planted with 'Stevens' wheat to provide isolation and prevent movement of secondary spores by wind and insects between plots.

One hundred panicle samples were harvested from each plot on July 8, 1997. Samples were evaluated for percent panicles with honeydew, and total sclerotia per 100 panicle sample.

There were no differences in the number of sclerotia present at harvest between the different levels of ergot-infested seed at planting (Table 1). These results are similar to the first two years of the project conducted in Powell Butte during the 1994-1995 season and at the Madras location during the 1995-1996 season. It is not clear if no treatment effect is due to a lack of correlation with the level of sclerotia in the seed at planting, or experimental design. Explanations would include the possibility that the 10 foot borders of wheat may not have been sufficient to prevent cross contamination between plots, or alternately, spores could have come from outside the trial area.

Table 1. Effect of sowing various levels of ergot-infested seed on incidence of the disease at the Central Oregon Agricultural Research Center, Madras location, during 1996-1997.

Percent infested of sown seed by weight	Sclerotia per sample	Panicles per sample with honeydew
(%)	(number)	(%)
0	2.6	1.8
0.1	1.0	0.8
0.5	2.6	1.0
1.0	1.6	0.6
2.0	0.8	0.4
3.0	3.8	1.4
LSD 0.05	NS	NS

During the 1994-1995 season plots in Powell Butte were sprinkler-irrigated twice a week prior to harvest, and it appeared that a moist, high-humidity microclimate developed in the protected pockets of grass surrounded by the three-foot high wheat. This would have provided near optimum conditions for ergot infection during flowering. However, during the 1995-1996 season, plots were irrigated once a week, with the plots remaining relatively dry. Despite the dryer conditions, a moderate level of ergot developed in the plots, but was not significantly correlated with the level of inoculum at planting. During the 1996-1997 season plots received a moderate amount of water, with no differences between inoculum levels were observed.

EVALUATION OF HERBICIDES FOR CONTROL OF ROUGHSTALK BLUEGRASS AND INJURY TO KENTUCKY BLUEGRASS, 1996-1997

M.D. Butler

Research to evaluate herbicides for control of roughstalk bluegrass in Kentucky bluegrass was initiated in 1993. A wide variety of herbicide combinations were screened during the 1994-1995 season. In subsequent years, the objective has been to evaluate treatments with the most promise, and fine-tune application rates and timings of the most effective herbicide combinations. In addition, several new herbicides have been evaluated as they have become available.

To date, the most effective treatment for control of roughstalk bluegrass while minimizing injury to Kentucky bluegrass appears to be Sinbar (terbacil) at 0.5 lb/a plus Karmex (diuron) at 2 lb/a applied in early November, followed by Beacon (primisulfuron) at 0.76 oz/a plus Diuron at 1 lb/a applied in mid April.

During the 1996-1997 season the focus was on combining a fall application of Sinbar plus Diuron with a spring application of Beacon plus Diuron. Spring applications included both April and May application dates to determine proper timing. A mid-winter application of Horizon (fenoxaprop) and fall application of Rely (glufosinate), alone and in combination with Goal (oxyfluorfen), were also evaluated.

Plots were place in three commercial grass seed fields to evaluate crop reduction and yield reduction of 'Cypress' and 'Saber II' roughstalk bluegrass, and 'Crest' Kentucky bluegrass. Evaluations included a November 2, 1996 application of Sinbar at 0.5 lb/a plus Diuron at 2 lb/a alone, or in combination with a spring application of Beacon at 0.76 oz/a plus Diuron at 1 lb/a applied either April 23 or May 16, 1997. A single November 2 application of Beacon at 0.76 oz/a plus Diuron at 2 lb/a was evaluated, along with a double application of Beacon at 0.38 oz/a plus Diuron at 2 lb/a applied November 2, and May 16.

New product evaluations included a November 2 application of Rely at 4 pt/a alone, and in combination with Goal at 0.5 pt/a. Horizon at 1.6 pt/a was evaluated as a single January 20 application, and following a November 2 application of Sinbar at 0.5 lb/a plus Diuron at 2 lb/a.

Treatments were applied with a CO_2 pressurized, hand-held, boom sprayer at 40 psi and 20 gal/a water. Plots 10 ft x 20 ft were replicated three times in a randomized complete block design. A nonionic surfactant was applied at 1 qt/100 gal in combination with all herbicides. Visual evaluations for percent reduction in biomass to established plants were conducted December 6, 1996, and pre-harvest evaluations of percent reduction in seed set were conducted June 19, 1996.

Results for Cypress roughstalk bluegrass are provided in Table 1. Yield reduction with fall application of Sinbar plus Diuron alone (70%), or followed by spring applications of Beacon plus Diuron (93-99%), were more effective than Beacon plus Diuron alone (43%), or applied both fall and spring (60%). Sinbar plus Diuron followed by Beacon plus Diuron applied in April performed better (99%) than when the Beacon plus Diuron was applied in May (93%). Horizon applied in January reduced yield about 7 percent when either applied alone or following Sinbar plus Diuron. Rely alone, or in combination with Goal, resulted in serious crop reduction (85, 93%), but relatively light yield reduction (12, 20%).

Results for Saber II are provided in Table 2. Treatments generally had less effect on Saber II than Cypress, but followed the same trends observed on Cypress. Sinbar plus Diuron followed by Beacon plus Diuron applied in April resulted in the greatest yield reduction (92%), followed by Beacon plus Diuron applied in May (63%). Fall applications of either Sinbar plus Diuron or Beacon plus Diuron did not perform as well alone as when followed by a spring application of Beacon plus Diuron.

Results for Crest Kentucky bluegrass are provided in Table 3. Sinbar plus Diuron had no effect on yield whether applied alone or followed by Beacon plus Diuron in April. There were slight yield reductions (7-10%) with Beacon plus Diuron, whether applied in the fall or in May. Rely alone, or in combination with Goal, seriously reduced both crop (90-95%) and yields (70-77%). Horizon applied in January had little effect on crop or yields.

Table 1. Effect of fall-applied herbicide applications November 2, 1996 alone or in combination with additional applications as indicated below on Cypress roughstalk bluegrass at S & L Farms near Madras, Oregon.

Treatments	Rate	Crop reduction[1] December 6, 1997	Yield reduction[2] June 19, 1997
	(product/a)	--------------(percent)--------------	
1. Sinbar + Diuron	0.5 lb + 2.0 lb	22 c[3]	70 ab
2. Beacon + Diuron	0.76 oz + 2.0 lb	5 d	43 c
3. Sinbar + Diuron	0.5 lb + 2.0 lb	17 c	99 a
Beacon + Diuron (Apr 23)	0.76 oz + 1.0 lb		
4. Sinbar + Diuron	0.5 lb + 2.0 lb	17 c	93 a
Beacon + Diuron (May 16)	0.76 oz + 1.0 lb		
5. Beacon + Diuron	0.38 oz + 2.0 lb	3 d	60 bc
Beacon + Diuron (May 16)	0.38 oz + 1.0 lb		
6. Sinbar + Diuron	0.5 lb + 2.0 lb	13 c	77 ab
Horizon	1.6 pt		
7. Rely + Goal	4.0 pt + 0.5 pt	93 a	12 d
8. Rely	4.0 pt	85 b	20 d
9. Horizon (Jan 18)	1.6 pt	5 d	7 d
10. Untreated	---	0 d	0 d

[1]Data based on visual evaluation of reduction in biomass.
[2]Data based on visual evaluation of reduction in seed set.
[3]Mean separation with Student-Newman-Keuls.

Table 2. Effect of fall-applied herbicide applications, alone or in combination with additional applications as indicated below. November 2, 1996 on Saber II roughstalk bluegrass at Bob Houts Farms near Madras, Oregon.

Treatments	Rate	Crop reduction[1] December 6, 1997	Yield reduction[2] June 19, 1997
	(product/a)	-------------(percent)-------------	
1. Sinbar + Diuron	0.5 lb + 2.0 lb	7 c[3]	10 cd
2. Beacon + Diuron	0.76 oz + 2.0 lb	5 c	17 cd
3. Sinbar + Diuron	0.5 lb + 2.0 lb	7 c	92 a
Beacon + Diuron (Apr 23)	0.76 oz + 1.0 lb		
4. Sinbar + Diuron	0.5 lb + 2.0 lb	7 c	63 b
Beacon + Diuron (May 16)	0.76 oz + 1.0 lb		
5. Beacon + Diuron	0.38 oz + 2.0 lb	3 c	40 bc
Beacon + Diuron (May 16)	0.38 oz + 1.0 lb		
6. Sinbar + Diuron	0.5 lb + 2.0 lb	5 c	17 cd
Horizon	1.6 pt		
7. Rely + Goal	4.0 pt + 0.5 pt	95 a	27 cd
8. Rely	4.0 pt	88 b	17 cd
9. Horizon (Jan 18)	1.6 pt	2 c	5 cd
10. Untreated	---	0 c	0 d

[1]Data based on visual evaluation of reduction in biomass.
[2]Data based on visual evaluation of reduction in seed set.
[3]Mean separation with Student-Newman-Keuls.

Table 3. Effect of fall-applied herbicide applications November 2, 1996, alone or in combination with additional applications as indicated below, on Crest Kentucky bluegrass at Boyle Farms near Madras, Oregon.

Treatments	Rate	Crop reduction[1] December 6, 1997	Yield reduction[2] June 19, 1997
	(product/a)	-------------(percent)-------------	
1. Sinbar + Diuron	0.5 lb + 2.0 lb	7 c[3]	0 b
2. Beacon + Diuron	0.76 oz + 2.0 lb	3 c	7 b
3. Sinbar + Diuron	0.5 lb + 2.0 lb	7 c	0 b
Beacon + Diuron (Apr 23)	0.76 oz + 1.0 lb		
4. Sinbar + Diuron	0.5 lb + 2.0 lb	7 c	10 b
Beacon + Diuron (May 16)	0.76 oz + 1.0 lb		
5. Beacon + Diuron	0.38 oz + 2.0 lb	3 c	10 b
Beacon + Diuron (May 16)	0.38 oz + 1.0 lb		
6. Sinbar + Diuron	0.5 lb + 2.0 lb	7 c	0 b
Horizon	1.6 pt		
7. Rely + Goal	4.0 pt + 0.5 pt	95 a	77 a
8. Rely	4.0 pt	90 b	70 a
9. Horizon (Jan 18)	1.6 pt	0 c	5 b
10. Untreated	---	0 c	0 b

[1]Data based on visual evaluation of reduction in biomass.
[2]Data based on visual evaluation of reduction in seed set.
[3]Mean separation with Student-Newman-Keuls.

KENTUCKY BLUEGRASS VARIETY TOLERANCE TO PRIMISULFURON

G.W. Mueller-Warrant, D.S. Culver, S.C. Rosato and F.J. Crowe

Twelve popular varieties of Kentucky bluegrass were seeded Sept. 4-5, 1997, at the Central Oregon Agricultural Research Center in Madras to confirm findings from the 1996-97 growing season of varietal differences in tolerance to Beacon (primisulfuron). Beacon plus 1% crop oil concentrate was applied Nov. 3 at full (0.75 oz product/acre) and half rates, Dec. 11 at full rate, and split-applied at half rate on both dates. The full rate was also applied April 6, 1998, to plots that had served as extra untreated checks until that time. Downy brome populations were light and variable, while volunteer barley populations were moderate. Variety mainplots were 16 feet wide by 200 feet long, with three replications, and herbicide treatment subplots were 8 feet wide by 50 feet long. Crop injury was evaluated April 6 by measuring plant diameter (row width) and height at six randomly chosen locations per plot. For each variety, plant size in Beacon-treated plots was expressed relative to size of the untreated checks.

Beacon stunted the growth of seedling Kentucky bluegrass, but caused less stand thinning than seen in the previous year, perhaps because the crop seedlings were older when first treated (EPOST applied at 6½ weeks after emergence in 1997 versus 4 weeks in 1996). Degree of stunting was affected by application date and rate (Table 1) and by variety (Table 2). Maximum injury occurred when the full rate was applied Nov. 3 or split-applied between Nov. 3 and Dec. 11. While Beacon provided good control of volunteer barley when applied EPOST (avg. 94% control), the best treatment (split-applied EPOST + MPOST) only controlled 60% of the downy brome. However, the downy brome populations were too low and too variable for an accurate measurement of the effect of Beacon. Control from similar treatments in other studies has been as high as 95%. The full rate applied Dec. 11 caused slightly less injury than when it was applied Nov. 3 or split-applied between both dates, and reductions in plant size from the Dec. 11 full rate treatment were non-significant compared to the untreated checks for five of the varieties. 'Baron,' 'Abbey,' 'Ascot,' and 'Merit' were the most tolerant varieties, showing only 6 to 14% reductions in plant size in response to the two most severe treatments. The eight remaining varieties showed 22 to 43% reductions in size from these treatments. Although 'Bartitia,' 'Viva,' and 'Georgetown' were the most sensitive varieties, treatment of these varieties at 8½ weeks after planting (6½ weeks after emergence) caused no reductions in stand.

Growers should be cautious when treating new Kentucky bluegrass stands with Beacon until they have had personal experience treating their own varieties on their own soils. All varieties appear to be stunted at least briefly by Beacon, and while they have the potential to recover well enough to produce full stands, heading during the first summer was substantially reduced in nearly all varieties. Seed cleaning for the 1997 harvest is still underway. Seed yield will also be measured for 1998 harvests of both the 1997 and the 1996 plantings (additional treatments were applied in the 1997-98 growing season to the 1996 plantings). Visual ratings of heading during pollination in June 1997 indicated that 'Monopoly' was the most tolerant variety, while Abbey, Ascot, Bartitia, and 'Wildwood' were the least tolerant. Reductions in heading (and probably seed yield) for each variety did not correspond all that well with reductions in vegetative growth. Instead, the reductions in heading were much more severe than the reductions in vegetative growth for most, but not all varieties. Beacon will be most useful for treating new seedings threatened by high populations of downy brome, populations high enough to prevent seedling establishment. In new seedings with lower populations of downy brome and other susceptible species (such as volunteer wheat or barley), reductions in seed yield caused by Beacon injury must be weighed against those caused by weed competition.

Table 1. Effect of Beacon application date and rate on Kentucky bluegrass seedling size, April 6, 1998, and on heading in the previous year's test, June 12, 1997.

Beacon application rate and date, 1997-98 growing season test	Treated seedling size spring 1998†	Visual rating of heading, 1997 harvest previous year's test) ‡
(1.0X = 0.0352 lb a.i./acre)	(% of untreated check)	
Untreated check	100.0	100.0
0.5X on Nov. 3 (EPOST)	83.0	55.3
1.0X on Nov. 3	76.4	40.2
0.5X on Nov. 3 / 0.5X on Dec. 11	73.8	39.4
1.0X on Dec. 11 (MPOST)	81.1	57.3
1.0X spring applied (LPOST)	----	63.6
LSD(0.05)	5.0	7.4

† Seedling size (row width) averaged over all 12 varieties.
‡ Heading relative to untreated checks averaged over all 12 varieties. Data from 1996-97 growing season test with EPOST Oct. 8, MPOST Dec. 3, and LPOST Mar. 24.

Table 2. Kentucky bluegrass variety response to the most damaging Beacon treatments.

Variety	Untreated seedling size	Treated seedling size, spring 1998†	Visual rating of heading, 1997 harvest, previous year's test‡
	(inches)	(% of untreated check)	
Merit	3.08	93.7 NS	47.5 **
Baron	3.00	88.2 *	43.3 **
Abbey	2.96	87.6 *	22.8 **
Ascot	2.72	85.5 **	27.5 **
Bristol	3.03	77.6 **	30.0 **
Midnight	3.39	75.4 **	55.5 **
Wildwood	2.57	73.8 **	25.5 **
Shamrock	3.12	70.0 **	33.2 **
Monopoly	3.57	69.6 **	78.3 *
Bartitia	2.42	66.1 **	24.5 **
Viva	4.00	57.1 **	39.7 **
Georgetown	4.04	56.7 **	50.3 **

† Seedling size (row width, April 6, 1998) averaged over the two most damaging treatments, full rate applied Nov. 3 and half rate split-applied Nov. 3 and Dec. 11, 1997. Full rate = 0.0352 lb a.i./acre.

‡ Visual rating of heading (June 12, 1997) relative to untreated checks for each variety, averaged over the two most damaging treatments, full rate applied Oct. 8 and half rate split-applied Oct. 8 and Dec. 3, 1996.

* and ** indicates size or heading reduced relative to untreated checks at the P=0.05 and 0.01 probability levels. NS indicates non-significance.

EVALUATION OF PRIMISULFURON FOR DOWNY BROME CONTROL IN EASTERN OREGON TALL FESCUE SEED PRODUCTION

D.A. Ball, D.L. Walenta and D. Singh

Downy brome is one of the major problem weeds in grass seed production systems of Eastern Oregon. Besides causing yield reductions in field, it's presence in harvested seed increases cleaning costs. Primisulfuron (Beacon®) has been identified as a potential herbicide for control of downy brome in seedling and established Kentucky bluegrass seed production fields. Further information is needed on the effectiveness of this material under eastern Oregon conditions on other grass seed crops. Two studies were initiated to evaluate the potential use of primisulfuron in tall fescue seed production. Studies were established in commercial tall fescue fields in the Lower Umatilla Basin to assess the tolerance of seedling and established tall fescue to primisulfuron applications.

The first study was established in a commercial field under center pivot irrigation, east of Boardman, OR on a seedling stand of tall fescue var. 'Barlexus' seeded August 20, 1995. EPOST treatments were made on October 13, 1995, (air temp. 63°F, sky clear, wind calm, relative humidity 60%, soil temp. at 2 inch 64°F) to 4 inch downy brome with many tillers, 6 inch and branching henbit, and seedling tall fescue at 4 to 6 inch height with many tillers and actively growing. MPOST treatments were made on November 1 (air temp. 41°F, sky clear, wind NE at 0 to 2 mph, relative humidity 76%, soil temp. at 2 inch 46°F) to downy brome with many tillers and partially dormant tall fescue 4 to 6 inch height. All treatments were made with a hand-held CO_2 sprayer delivering 15 gpa at 30 psi. LPOST treatments were made on February 16, 1996 (air temp. 49°F, sky cloudy, wind calm, relative humidity 80%, soil temp. at 2 inch 49°F) to fully tillered downy brome and tall fescue at 5 to 7 inches in height. Plots were 10 by 30 ft in size, in a randomized complete block design, with four replications. Soil at the site was a loamy sand with 87.0% sand, 7.6% silt, and 5.4% clay, 0.8% organic matter, 7.3 soil pH, and a CEC of 6.9 meq/100g.

The second study was initiated on a commercial field under center pivot irrigation, east of Boardman, OR on a second year, established stand of tall fescue var. 'Barlexus'. EPOST treatments were made on October 13, 1995 (air temp. 53°F, sky clear, wind W at 0 to 2 mph, relative humidity 74%, soil temp. at 2 inch 57°F) to 2 to 4 in tall fescue that had been grazed by sheep. No weeds were present at time of treatment. MPOST treatments were made on November 1 (air temp. 43°F, sky clear, wind N at 1 to 3 mph, relative humidity 77%, soil temp. 2 inch 45°F) to 2 to 4 inch established tall fescue with no weeds present. LPOST treatments were made on February 16, 1996 (air temp. 48°F, sky cloudy, wind calm, relative humidity 86%, soil temp. at 2 inch 43°F) to tall fescue with 4 to 6 inches of regrowth. All treatments were made with a hand held CO_2 sprayer delivering 15 gpa at 30 psi. Plots were 10 by 30 ft in size, in an RCB arrangement, with four replications. Soil at the site was a loamy sand with 84.0% sand, 9.6% silt, and 6.4% clay, 1.1% organic matter, 7.1 soil pH, and a CEC of 6.9 meq/100g.

Primisulfuron applied to seedling tall fescue produced substantial crop injury at all application timings (Table 1). The incidence of visual injury symptoms increased with increasing primisulfuron rate. Injury appeared as stunting and yellowing of seedling tall fescue. Primisulfuron treatments provided some early downy brome control, and very good early control of henbit in the seedling trial. However overall downy brome control was unacceptable, probably due to advanced developmental stage of downy brome at the time of herbicide applications.

Evaluation of early weed control was not possible at the established tall fescue site due to negligible weed populations. As was seen in the seedling tall fescue trials, primisulfuron applied to established tall fescue produced substantial crop injury (Table 2). Early injury from primisulfuron was more severe than that observed from the standard treatment of oxyfluorfen and metribuzin, and comparable to crop injury seen from the standard oxyfluorfen and terbacil treatment. Spring application and split application of primisulfuron caused significant reductions in seed yields.

The results from this study indicate low tolerance of tall fescue to primisulfuron, which caused substantial crop injury in eastern Oregon. Further testing of primisulfuron on tall fescue is not warranted based on these studies.

Table 1. Assessments of crop tolerance and weed control in seedling tall fescue, Boardman, OR 1996.

Treatment	Product rate	Timing	December 1, 995 Crop injury	Downy brome control	Henbit control	April 24, 1996 Crop injury	Downy brome control
	(oz/acre)		-(%)-			-(%)-	
Primisulfuron	0.375	EPOST	48	67	99	48	43
Primisulfuron	0.5	EPOST	55	73	100	45	20
Primisulfuron	0.75	EPOST	43	48	77	35	17
Primisulfuron	0.375	MPOST	22	43	52	37	40
Primisulfuron	0.5	MPOST	22	37	75	35	38
Primisulfuron	0.75	MPOST	32	50	79	53	40
Primisulfuron	0.375	LPOST	--	--	--	17	17
Primisulfuron	0.5	LPOST	--	--	--	37	27
Primisulfuron	0.75	LPOST	--	--	--	67	17
Primisulfuron + primisulfuron	0.375 + 0.375	EPOST + MPOST	52	65	100	86	57
Primisulfuron + primisulfuron	0.375 + 0.375	EPOST + LPOST	--	--	--	88	47
Oxyfluorfen + primisulfuron	6.0 + 0.375	EPOST	55	65	100	40	27
Glyphosate + AMS + R-11	4.0 + 1%	EPOST	78	99	99	58	88
Control			0	0	0	0	0
LSD (0.05)			22	29	35	23	34

Primisulfuron applied with Crop Oil concentrate at 1 qt/acre.
Glyphosate applied with non-ionic surfactant (R-11) at 0.25% v/v, and ammonium sulfate (AMS) at 8.5 lb/100 gal.
Primisulfuron applied as Beacon®, oxyfluorfen applied as Goal®, glyphosate applied as Roundup®.
EPOST – October 13, 1995; MPOST – November 1, 1995; LPOST – February 16, 1996.

Table 2. Assessment of crop tolerance in established tall fescue, Boardman, OR, 1996

Treatment	Product rate	Timing	Crop Injury 12/1/95	Crop Injury 4/24/96	Seed yield 7/17/96
	(oz/acre)		------------- (%)	--------------	(lb/a)
Primisulfuron	0.375	EPOST	45	17	1248
Primisulfuron	0.75	EPOST	54	14	1232
Primisulfuron	1.5	EPOST	66	35	866
Primisulfuron	0.75	MPOST	14	12	1530
Primisulfuron	0.75	LPOST	--	27	1841
Primisulfuron + primisulfuron	0.375 + 0.375	EPOST + MPOST	54	30	1225
Primisulfuron + primisulfuron	0.375 + 0.375	EPOST + LPOST	--	34	1427
Oxyfluorfen + primisulfuron	10.0 + 0.375	EPOST	34	7	1557
Oxyfluorfen + primisulfuron	10.0 + 0.375	EPOST	41	10	1577
Oxyfluorfen + metribuzin	10.0 + 5.3	EPOST	19	1	1742
Oxyfluorfen + terbacil	10.0 + 0.4	EPOST	43	15	1831
Control			0	0	1746
LSD (0.05)			10	12	345

Primisulfuron applied with Crop Oil concentrate at 1 qt/acre.
Metribuzin and terbacil applied with nonionic surfactant, R-11 at 0.25% v/v.
Primisulfuron applied as Beacon®, oxyfluorfen applied as Goal®, metribuzin applied as Lexone® DF, terbacil applied as Sinbar®.
EPOST – October 13, 1995; MPOST – November 1, 1995; LPOST – February 16, 1996.

CROP TOLERANCE OF SEEDLING AND ESTABLISHED CHEWINGS FESCUE TO PRIMISULFURON IN EASTERN OREGON

D. Singh and D.A. Ball

Primisulfuron (Beacon®) has been introduced in Oregon for control of downy brome in seedling Kentucky bluegrass. It can be effective on seedling Kentucky bluegrass stands where downy brome infestation is severe although crop injury is still an issue. Two studies were initiated to investigate the potential use of primisulfuron in chewings fescue (*Festuca rubra* subsp. commutata). A seedling chewings fescue study was established in a commercial field near Cove, OR in the Grande Rhone Valley to evaluate the crop tolerance of primisulfuron from applications at different timings. Another study on established chewings fescue was initiated in a commercial field near Echo, OR in the lower Umatilla Basin. Both studies were conducted under irrigated conditions typical for each location.

The seedling chewings fescue (var. 'Bargreen') study was seeded in first week on May, 1996. Early fall herbicide treatments (EPOST) were made on October 11, 1996 [air temp. 64°F, rel. hum. 60%, and soil temp. at 0 inch 63°F, 1 inch 64°F, 2 inch 61°F and at 4 inch 59°F] to 2 inch high chewings fescue. Late fall treatments (MPOST) were made on November 20, 1996 [air temp. 40°F, rel. hum. 85%, and soil temp. at 0 inch 52°F, 1 inch 42°F, 2 inch 38°F, and at 4 inch 37°F] and dormant chewings fescue. Spring treatments (LPOST) were made on April 7, 1997 [air temp. 52°F, rel. hum. 62%, and soil temp. at 0 and 1 inch 52°F, 2 inch 46°F, and at 4 inch 42°F]. The field was lightly infested with downy brome and nuttall alkaligrass. Soil at the site was silt loam with 33% sand, 52% silt, and 16% clay, 8.4 pH, 2.1% organic matter and a CEC of 21 meq/100 gm. Chewings fescue was swathed on July 8, 1997 with a plot swather and harvested on July 21, 1997 with a plot combine.

The established chewings fescue (var. 'Barnica') study was on a third year stand, seeded on August 17, 1993. Early fall herbicide treatments (EPOST) were made on October 8, 1996 [air temp. 56°F, rel. hum. 82%, and soil temp. at 0 inch 56°F, 1 and 2 inch 52°F, and at 4 inch 56°F] and with 5 inches of regrowth of chewings fescue. Late fall treatments (MPOST) were made on November 11, 1996 [air temp. 66°F, rel. hum. 82%, and soil temp. at 0 inch 64°F, 1 inch 58°F, 2 inch 50°F, and at 4 inch 46°F]. Spring treatments (LPOST) were made on February 20, 1997 [air temp. 42°F, rel. hum. 62% and soil temp. at 0 inch 42°F, and 1, 2, and 4 inch 40°F]. The field was essentially weed free. Soil at the site was sandy loam with 68% sand, 23% silt, 9% clay, 6.7 pH, 1.4% organic matter and a CEC of 10.7 meq/100g. Chewings fescue was swathed on June 13, 1997 with a plot swather and harvested on June 21, 1997 with a plot combine.

In both the studies, plots were 10 x 40 ft in a randomized complete block design with 4 replications. Herbicide treatments were applied with a hand-held CO_2 sprayer at 16 gpa at 30 psi. Harvested seed was preconditioned before cleaning by rethreshing through the combine after oven drying at 32°C for 24 hours. Seed was cleaned with a 3-sieve clipper cleaner before yield determination. Seed samples from the seedling chewings fescue trial were sent to OSU Seed Laboratory at Corvallis for purity and percent germination analysis.

In the seedling chewings fescue study at Cove, crop injury was evident from the primisulfuron at 1.5 oz/acre that resulted in reduction in yield compared to untreated check (Table 1). Split applications of primisulfuron also caused crop injury. However, downy brome control was very good from these treatments compared to untreated check. Early fall application of primisulfuron at 0.75 oz/acre provided good control of downy brome and did not cause significant crop injury. Early fall split application and fall applications at 0.75 oz/acre (EPOST and MPOST) were most effective in reducing contamination from downy brome seed (Table 2). Spring treatments with primisulfuron were not as effective in reducing downy brome contamination in harvested seed. Purity analysis of the chewings fescue seed indicated that primisulfuron was also effective in reducing the contamination from nuttall alkaligrass compared to the untreated check. Nuttall alkaligrass is a problem weed in fields with high pH and salinity in the Grande Rhone Valley. Early fall application at 0.75 oz/acre and split application resulted in more pure live seed (PLS) compared to other application timings and untreated check. Results from the seedling chewings fescue study indicate that primisulfuron may provide an effective tool in reducing weed contamination in chewings fescue seed.

In the established chewings fescue study at Echo, crop injury was evident at the early evaluation times from fall primisulfuron applications at higher rates and as split applications (Table 3). However, crop injury from these treatments did not result in significant reduction in chewings fescue seed yields compared to untreated check. Spring application of primisulfuron had no influence on the chewing fescue seed yields. Seed yield from primisulfuron application at 0.75 oz/acre in spring resulted in statistically higher seed yields compared to untreated check. Under the weed free conditions of this study, established chewings fescue was fairly tolerant to primisulfuron applications in fall and spring.

The potential for primisulfuron registration in Oregon on fine fescue has not been discussed to date. Further testing of primisulfuron on fine fescue is required to gain confidence about crop safety and weed control effectiveness under a range of conditions in Oregon and elsewhere.

Table 1. Crop injury and downy brome control from primisulfuron treatments in seedling chewings fescue. Cove, OR, 1996-97.

Treatment	Product rate	Timing	Crop injury 7 Apr 97	Crop injury 25 Apr 97	Crop injury 9 May 97	Control 25 Apr 97	Seed Yield
	(oz/acre)		(%)				(lb/acre)
Primisulfuron	0.375	EPOST	6	4	4	90	746
Primisulfuron	0.500	EPOST	4	5	1	71	803
Primisulfuron	0.750	EPOST	6	7	3	99	877
Primisulfuron	1.500	EPOST	22	26	17	98	634
Primisulfuron	0.750	MPOST	7	15	7	94	832
Primisulfuron	0.750	LPOST		5	5	45	836
Primisulfuron + primisulfuron	0.375 + 0.375	EPOST + MPOST	9	14	17	100	978
Primisulfuron + primisulfuron	0.375 + 0.375	EPOST + LPOST	3	6	9	95	816
Primisulfuron + primisulfuron	0.375 + 0.375	MPOST + LPOST	2	13	11	80	840
Primisulfuron + oxyfluorfen	0.375 + 10.0	EPOST	3	11	7	91	890
Primisulfuron + oxyfluorfen	0.750 + 10.0	EPOST	13	22	21	95	709
Untreated Check			0	0	0	0	736
LSD (0.05)			7	12	NS	22	NS

Primisulfuron (Beacon®) applied with 1 qt/acre crop oil concentrate (Mor Act®), oxyfluorfen applied as Goal®

Table 2. Purity analysis* of seed from the seedling chewings fescue study. Cove, OR, 1996-97.

Treatment	Product rate	Timing	Purity	Inert	Weed	Nuttail alkaligrass	Downy brome	Germination	PLS
	(oz/acre)		(%)				(no./lb)	(%)	
Primisulfuron	0.375	EPOST	82.8	6.4	10.7	8.4	4554	93	77
Primisulfuron	0.500	EPOST	79.5	6.5	14.0	11.0	5817	90	72
Primisulfuron	0.750	EPOST	91.3	5.6	3.1	2.1	1243	94	86
Primisulfuron	1.500	EPOST	83.3	8.9	7.8	5.9	1804	96	80
Primisulfuron	0.750	MPOST	89.3	8.9	1.8	< 1.0	1017	89	79
Primisulfuron	0.750	LPOST	90.1	5.6	4.4	1.9	5668	92	83
Primisulfuron + primisulfuron	0.375 + 0.375	EPOST + MPOST	90.6	8.0	1.4	0.0	752	95	86
Primisulfuron + primisulfuron	0.375 + 0.375	EPOST + LPOST	89.9	7.9	2.2	1.5	1901	93	84
Primisulfuron + primisulfuron	0.375 + 0.375	MPOST + LPOST	87.9	10.9	1.2	< 1.0	1117	94	83
Untreated Check			77.4	5.6	17.0	11.7	10513	90	70

* Data from a composite sample of four replications.
Primisulfuron (Beacon®) applied with 1 qt/acre crop oil concentrate (Mor Act®).
PLS = % pure live seed = (% purity x % germination) x 100.

Table 3. Crop injury and seed yields from Primisulfuron treatments in established chewings fescue. Echo, OR, 1996-97.

Treatment	Product rate	Timing	Crop injury 3 Dec 96	Crop injury 20 Feb 97	Crop injury 7 Mar 97	Crop injury 8 Apr 97	Seed Yield
	(oz/acre)		(%)				(lb/acre)
Primisulfuron	0.375	EPOST	7	15	10	0	1251
Primisulfuron	0.500	EPOST	5	7	8	0	1114
Primisulfuron	0.750	EPOST	8	13	14	0	1036
Primisulfuron	1.500	EPOST	11	21	16	0	1084
Primisulfuron	0.750	MPOST		6	13	0	1289
Primisulfuron	0.750	LPOST			18	0	1350
Primisulfuron + primisulfuron	0.375 + 0.375	EPOST + MPOST	11	12	12	1	1177
Primisulfuron + primisulfuron	0.375 + 0.375	EPOST + LPOST	8	10	9	0	1311
Primisulfuron + primisulfuron	0.375 + 0.375	MPOST + LPOST		8	20	0	1213
Primisulfuron + oxyfluorfen	0.375 + 10.0	EPOST	18	13	7	0	1247
Primisulfuron + oxyfluorfen	0.750 + 10.0	EPOST	23	9	2	0	1077
Oxyfluorfen + metribuzin	10.0 + 4.0	EPOST	41	14	3	0	1091
Untreated Check			0	0	0	0	1136
LSD (0.05)			11	NS	9	NS	175

Primisulfuron (Beacon®) applied with 1 qt/acre crop oil concentrate (Mor Act®), metribuzin applied as Lexone® DF, applied with 0.25% v/v nonionic surfactant (R-11), oxyfluorfen applied as Goal®.

NUTRIENT UPTAKE FOR ROUGHSTALK BLUEGRASS, 1997

M.D. Butler and J.M. Hart

Roughstalk bluegrass (*Poa trivialis*) was first grown in central Oregon in the mid-1970s. The crop consisted of the single variety, 'Saber,' with relatively few acres until the mid-1980s. Since then, new varieties, which include 'Laser,' 'Cypress' and 'Saber II' were introduced. Plantings steadily increased to approximately 4,400 acres in 1997. Cultural practices for roughstalk bluegrass are substantially different from Kentucky bluegrass and little is known about roughstalk bluegrass nutrient needs. This research project was initiated to determine the nutrient uptake for roughstalk bluegrass that would be used to assist growers in determining rate and timing of fertilizer applications to maximize their economic return.

The research was conducted on commercial fields at two locations north of Madras, Oregon. First year fields of the cultivars Cypress and Saber II were chosen for the study. The Cypress location was fairly sandy soil with sprinkler irrigation, while the Saber II location was on loamy soil using furrow irrigation. Row spacing at both locations was 15 inches apart.

First foot soil samples and biomass samples were collected biweekly from April 17 to June 18. Two feet of two adjacent rows from three predetermined locations per field were clipped, dried, and weighed. Sampling locations in the Saber II field were in an area of lush growth.

Roughstalk bluegrass is a shallow-rooted crop with a high water requirement. As harvest nears, growers maintain high moisture levels to cause the crop to lodge and keep the heads moist to reduce shatter and seed loss. Commercial production on the Cypress field was quite low and thought to be the result of sprinkler-irrigated, sandy soil where adequate moisture levels were not maintained. Biomass production and yield at the Saber II field were considered very high.

Above ground plant material or biomass and concentration of N, P, K, and S are presented in Table 1. The June 18 sampling was not made at the Cypress site. Even so, the difference in biomass is evident for the two cultivars and locations. These two sites probably represent extremes in production of biomass. Early to mid-May is a time of rapid biomass accumulation.

Table 1. Biomass accumulation and nutrient concentration for Cypress and Saber II roughstalk bluegrass.

Sampling Date	Biomass	N	P	K	S
	(lb/a)	----------------(%)----------------			
Cypress					
4/1	556	4.66	0.40	2.44	0.29
4/17	798	4.37	0.37	2.59	0.28
5/6	1052	4.88	0.51	3.95	0.29
5/22	4403	3.10	0.39	3.40	0.22
6/6	5539	2.89	0.34	2.59	0.17
Saber II					
4/1	1458	3.86	0.35	3.45	0.53
4/17	1713	4.12	0.37	3.19	0.37
5/22	6892	2.97	0.38	3.29	0.26
6/6	9032	2.16	0.34	2.31	0.21
6/18	16349	1.86	0.30	2.30	0.20

Nitrogen concentration in the tissue was high, about 4%, early in the season and decreased with growth. The decrease was expected and at a normal rate compared to other grass species. Horneck (1995) reported N concentration at harvest of 1 to 3% for tall fescue, perennial ryegrass, orchardgrass, fine fescue, and Kentucky bluegrass. The low final N concentration in the Saber II field is probably caused by dilution of the N in the extremely high amount of biomass produced at this site.

Phosphorus concentration also decreased as the crop matured and was above the harvest concentrations reported by Horneck except for fine fescue. The P concentration at the two sites was well above expected critical concentrations for other grasses.

Potassium concentration is a function of potassium supply and biomass as plants will take up K in excess of needs for growth and reproduction. The K concentrations at both sites were not excessive, or above 4% as reported in grass forage fields on many dairies. Potassium was adequate and similar to that reported in other grass species by Horneck (1995).

Sulfur concentration decreased with plant growth or maturity and reached approximately the same level in both cultivars. Sulfur loss through leaching is a concern in central Oregon, especially on shallow sandy soils. The concentration in both cultivars was adequate even in the conditions of high water application used to produce roughstalk bluegrass.

Comparisons of nutrient uptake between the two cultivars are difficult to make since the final sampling was not made in the Cypress field (Table 2). The nutrient uptake data show that N and K uptake were similar to each other at both sites, as were P and S uptake. Nutrient uptake from these two sites was similar to the amounts reported by Horneck (1995).

Table 2. Nutrient uptake for Cypress and Saber II roughstalk bluegrass.

Sampling Date	N	P	K	S
	--------------------(lb/a)--------------------			
Cypress				
4/1	26	2	14	2
4/17	35	3	21	2
5/6	52	5	42	3
5/22	136	17	150	10
6/6	160	19	144	10
Saber II				
4/1	56	5	51	7
4/17	69	6	56	6
5/22	205	26	226	18
6/6	195	30	208	19
6/18	302	49	371	32

The most telling data from this study was not the amount of nutrient taken up, but the marked increase in uptake in early May. Biomass increased rapidly in early to mid-May. At the site where Cypress was planted, N, P, K, and S uptake approximately tripled between the May 6 to the May 22nd sampling. A similar increase was seen at the Saber II site between the April 17 and May 22 sampling dates.

Comparison of biomass and nutrient accumulation can be made by dividing the amount at a sampling date by the amount at the final harvest. This calculation provides a percent of the total accumulation for any sampling date. At both sites, when 10 to 12 % of the biomass accumulated, more than twice or 25% of the N was already in the plant tissue. By the time 50 to 60% of the biomass accumulated, over 70% of the N was found in the plant. A similar pattern is found for the other nutrients. Accumulation of 60 to 70% of the N, P, K, and S occurs by June 1.

Nutrient uptake is in advance of biomass accumulation and nutrient supply to roughstalk bluegrass before the rapid growth and uptake of early May is essential. Roughstalk bluegrass will take up 200 to 300 lb N/a, 20 to 40 lb P/a, and 150 to 350 lb K/a in 4 to 8 ton/a of straw plus seed.

Uptake or accumulation by the crop does not mean all the nutrients in the crop must or should be supplied by fertilizer. For N, the rate of fertilizer applied should be less than found in the crop. Soil in other areas of Oregon routinely supplies crops with 100 to 150 lb N/a.

Reference

Horneck, Donald A. 1995. Nutrient Management and Cycling in Grass Seed Crops, Ph.D. dissertation, Oregon State University.

SELECTION OF WOVEN WIRE SCREENS FOR SEPARATING *POA TRIVIALIS* AND *POA PRATENSIS* SEED

D.B. Churchill, D.M. Bilsland and M.D. Butler

Seeds of Kentucky bluegrass (*Poa pratensis*) and rough bluegrass (*Poa trivalis*) are small and similar in size, roughly 2.54 mm long by 0.64 mm in width and thickness. However small differences exist in size between species. The objective of this research was to identify woven wire screens that would aid in producing seed lots with reduced levels of non-crop bluegrass.

Separation of seed lots based on differences in width is accomplished by screens with square or round openings. Separation based on differences in thickness is accomplished by screens with rectangular, oblong or slotted openings. Woven wire screens are designated in number of openings per inch in two directions. A 6x24 woven wire screen would have 6 openings per inch in the length direction and 24 openings per inch in the width direction.

Five cultivars of Kentucky bluegrass (Kbg) (Merit, Rugby, Geronimo, Georgetown, Gnome) and three cultivars of rough bluegrass (Rbg) (Laser, Sabre, Cypress) were acquired from growers in the region. These lots had undergone normal seed conditioning procedures including screening and debearding. Random samples of each cultivar were taken for microscopic width and thickness measurement.

Selection of woven wire screens for these separations included a range between those that would allow all seed to pass through openings or to be entirely held on the screen top surface. Woven wire screens with square opening widths ranging from 0.018 inch to 0.042 inch and screens with rectangular opening widths ranging from 0.015 inch to 0.035 inch, were selected. These included 11 screens with square openings (38, 36, 34, 32, 30, 28, 26, 24, 22, 20 and 18 openings per inch) and 13 screens with rectangular openings (6 openings per inch in the length direction and the following openings per inch in the width direction: 40, 38, 36, 34, 32, 30, 28, 26, 25, 24, 23, 22 and 20). Opening sizes of all woven wire screens used in this research were microscopically measured to the nearest 0.001 of an inch.

Random samples of approximately 70 g of each cultivar were taken using a Boerner divider. The samples were individually placed on each screen and shaken using a screen shaker for 1 minute at 10 hz and 8.26 mm amplitude. These settings were selected to simulate treatment in a commercial seed cleaner. The weights of the sample fraction held on the screen top surface and the fraction passing through each screen were recorded for each cultivar, and each screen opening type and size.

Based on tests of these screens for each of the eight cultivars, a 6x28 rectangular opening screen and 30x30 square opening screen were determined to be the optimum and were tested further.

To compare the predicted results to results that growers might expect, blends of two Kbg and two Rbg cultivars were created. A large-seeded Kbg, Gnome, was mixed with a large-seeded Rbg, Sabre, and with a small-seeded Rbg, Cypress. A small-seeded Kbg, Rugby, was mixed with a large-seeded Rbg, Sabre, and with a small-seeded Rbg, Cypress. In these four mixtures, Kbg was the intended crop, and comprised 99% of the mixtures by weight. For the second set of mixtures, a large-seeded Rbg, Sabre, was mixed with a large-seeded Kbg, Gnome, and with a small-seeded Kbg, Rugby. A small-seeded Rbg, Cypress, was mixed with a large-seeded Kbg, Gnome, and with a small-seeded Kbg, Rugby. In these four mixtures Rbg was the intended crop, and comprised 99% of the mixtures by weight. Three replicated separations of each of the eight mixtures were made using the 6x28 screen and the 30x30 screen resulting in a total of 48 tests. The resulting crop fractions was submitted for seed purity testing by a certified seed analyst.

Results and Discussion

Average width and thickness values from the microscopic measurements of each cultivar are shown (Fig. 1). Rough bluegrass cultivars are shown to be smaller than Kbg cultivars in width and thickness. Some size variation between cultivars also exists within each species. Table 1 shows results of microscopically measured rectangular and square opening widths compared to openings per inch. The woven wire screen with 30 rectangular openings per inch has smaller openings than one with 32 openings per inch.

If a seed lot must be completely free of non-crop, Kbg or Rbg, then a screen must be selected accordingly. For example, a rectangular 6x28 woven wire screen would pass nearly 100% of the Rbg from the Kbg cultivars. However, the amount of crop mixed with Rbg in the through screen fraction would vary somewhat for each Kbg cultivar.

Figure 2 shows the percentage of contamination remaining after screening eight mixtures of Kbg and Rbg. The percentage of contamination remaining is a measure of the difficulty of separation. As expected, for both screens Rugby, the small-seeded Kbg, was most difficult to separate from the rough bluegrasses while Gnome, the large-seeded Kbg, was most easily separated. Similarly, Cypress, the small seeded Rbg, was most easily separated from the Kentucky bluegrasses while Sabre, the large seeded Rbg, was most difficult to separate.

Overall, the more predictable results were achieved using the 6x28 screen, a thickness separator. This suggests that the thickness differences were greater between these two species than were the width differences. This screen reduced contamination from the original 1.00% to 0.00% in two of the eight cases. For all of the Kentucky bluegrasses tested, the 6x28 screen left an average of 0.02% Rbg, a 98% reduction, and saved an average of 78% of the crop. For all rough bluegrasses, the 6x28 screen left an average of 0.07% Kbg, a 93% reduction, and saved 94% of the crop. For all Kentucky bluegrasses, the 30x30 screen left an average of 0.10% Rbg, a 90% reduction, and saved 85% of the crop. For all rough bluegrasses, the 30x30 screen left an average of 0.09% Kbg, a 91% reduction, and saved 92% of the crop.

Summary and Conclusions

The Kbg and Rbg cultivars in this study can be effectively separated with rectangular- and square-opening woven wire screens. Best overall results may be obtained with either a 30x30 or a 6x28 woven wire screen.

Seed cleaner operators should be aware of both numbers of wire per inch and actual opening size since wire diameter is not always consistent. Microscopic measurement of woven wire screen opening size is one possible solution.

Table 1. Openings per inch compared to actual opening width in inches.

Openings per inch	Rectangular opening width (in)	Square opening width (in)
40	0.0150	N/A
38	0.0153	0.0183
36	0.0168	0.0198
34	0.0184	0.0214
32	0.0212	0.0223
30	0.0200	0.0253
28	0.0227	0.0257
26	0.0245	0.0275
25	0.0260	N/A
24	0.0277	0.0307
23	0.0295	N/A
22	0.0315	0.0335
20	0.0350	0.0370
18	N/A	0.0426

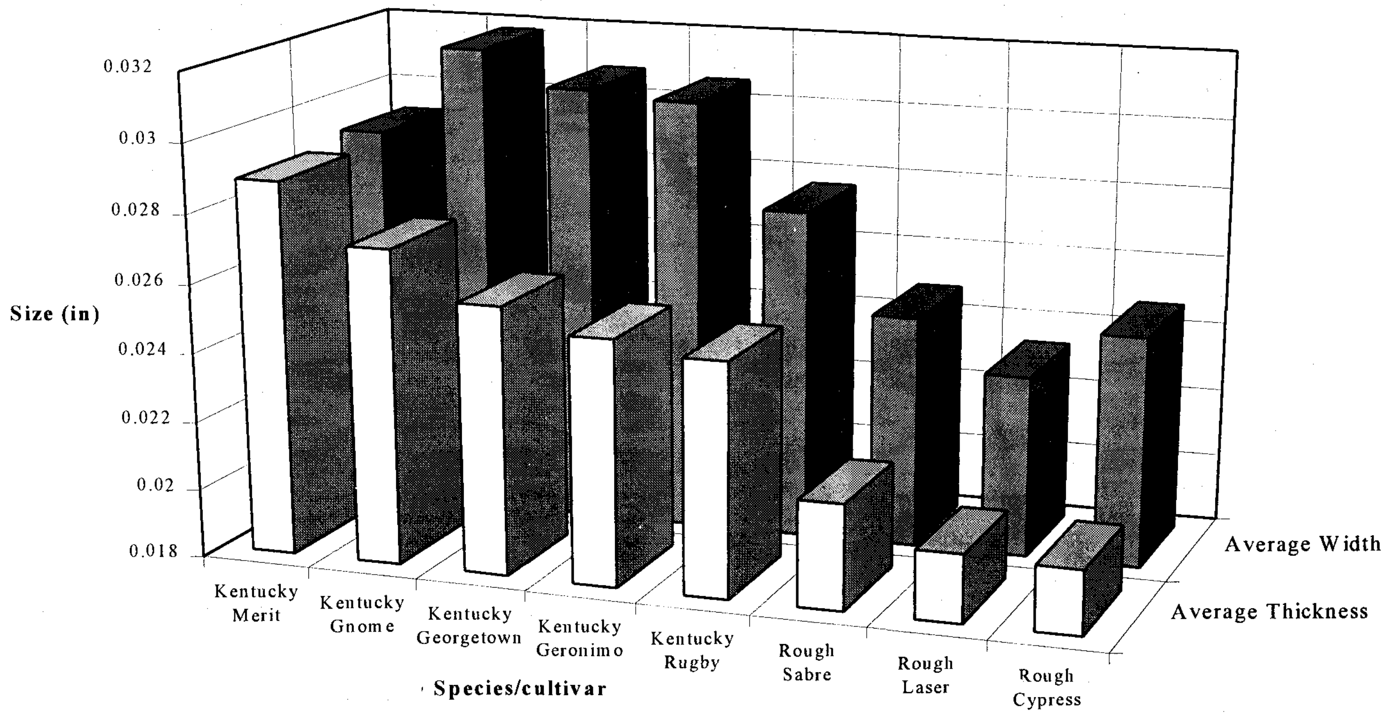

Figure 1. Average seed width and thickness of cultivars of Kentucky and rough bluegrass.

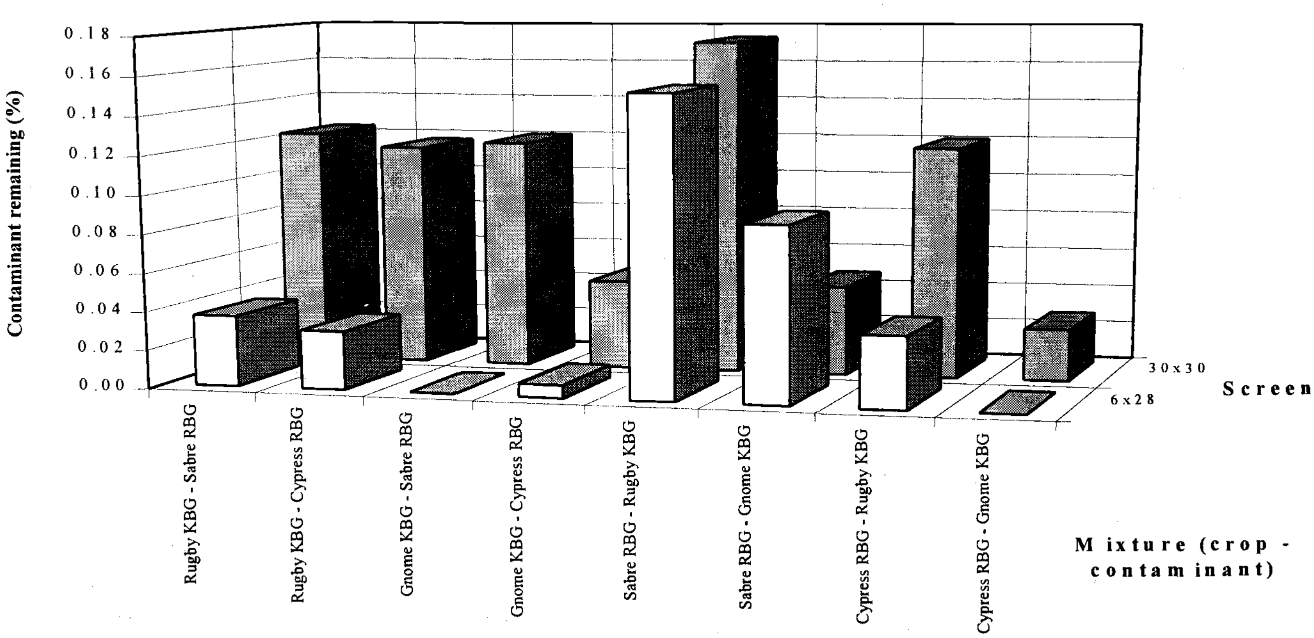

Figure 2. Average percentage of contamination remaining after screening mixtures of Kentucky and rough bluegrasses. The first cultivar listed is the crop.

EFFECT OF RED CLOVER CULTIVAR ROOT ROT RESISTANCE ON FORAGE AND SEED PRODUCTION SYSTEMS

J.J. Steiner, R.R. Smith and S.C. Alderman

Most red clover cultivars are bred for grazing or for frequently clipping for hay and silage. An important factor for successful red clover forage production and utilization is the ability of the plants to persist for more than one season. Improved cultivars such as Marathon are able to persist longer and yield more than common cultivars under disease pressure in forage growing states such as Wisconsin. This results in greater sustainable forage production. However, these superior yielding cultivars have a low seed yielding potential so many seed producers in Oregon prefer to grow the higher yielding common ecotypes that are not as good forage producers in the midwestern states.

Six improved cultivars and three regionally adapted ecotypes were grow in forage and seed yield trials under typical production system conditions, respectively. Seed yield was determined at two locations in Oregon and forage yield at one in Wisconsin. Roots were evaluated for disease incidence and the relationship of cultivar flowering capacity to seed yield determined.

This research showed that high forage producing cultivars are more root disease resistant than common ecotypes, but are poorer seed producers. It was also shown that selection for disease resistance in Wisconsin increased forage yield, but did not benefit seed production in Oregon because different root rot diseases exist in the two regions. It was found that the seed yielding capacity of the cultivars examined was highly correlated with the number of flowers produced by late-July. Flowers produced after that time do not produce mature seeds by the time of harvest in September. Using this finding, it was determined that the greatest improvement in seed yield capacity of high forage yielding, root rot resistant cultivars could be made by selecting for rapid flowering after spring forage removal. The improved cultivars had 72.1% fewer flowers than the three common ecotypes on 1 July. These findings are important because cultivars selected for root rot resistance in forage production regions produced an average of 3.2 tons per acre per year more forage, but 120 pounds per acre less seed per year over a two year period than the three common ecotypes and Kenland.

For a more detailed report of this research see: J.J. Steiner, R.R. Smith, and S.C. Alderman. Red Clover Seed Production: IV. Root Rot Resistance under Forage and Seed Production Systems. Crop Science 37:1278-1282.; or write to Jeffrey Steiner, National Forage Seed Production Research Center, USDA-ARS, 3450 SW Campus Way, Corvallis, OR 97331; or access the web site at: www.http://pwa.ars.usda.gov/nfsprc/steiner/steinerj.htm for more information about seed production research.

Table 1. Effect of red clover cultivar/ecotype on average forage yield in Wisconsin and seed yield in Oregon.

	Yearly average	
Cultivar/ecotype	Forage yield†	Seed yield‡
	(tons/acre)	(lb/acre)
Improved cultivars:		
C11	8.5 a§	366.2 def
Marathon	8.4 a	334.2 ef
Kenstar	7.0 b	364.0 cde
Arlington	8.1 a	405.4 bcd
Atlas	8.4 a	259.0 f
Regionally adapted ecotypes:		
Kenland	5.7 c	409.0 bcd
Wisconsin Common	5.5 c	420.1 bc
Oregon Common #1	5.3 c	495.7 ab
Oregon Common #2	6.1 c	538.5 a

† Average for two years of production from the same stand at one location.

‡ Average from two different-aged stands replicated at two locations.

§ Yields in columns followed by a different letter are significant at $P \leq 0.05$ according to Fisher's protected least significant difference.

CRIMSON CLOVER CULTIVAR UNIQUENESS

J.J. Steiner

Crimson clover is an erect-growing annual forage that is primarily grown in regions with Mediterranean-like climates for hay and grazing, and in the southeastern USA for overseeding with cool-season annual grasses in warm-season perennial grass pastures to reduce beef production costs and improve animal performance. The crimson clover cultivar Dixie has historically accounted for a major portion of the USA production as well as for international trade with Europe. However, under recently adopted rules for seed commerce in European Economic Community member countries, the importation of non-certified Dixie seed has slowly fallen since 1991 because it is not a certified cultivar and is not on the list of cultivars that can be imported. Dixie is not certified because breeder seed has not been available for decades.

With the decline in Dixie exports, there has been a concurrent increase in the amount of seed production of certified Europe cultivars to more than 25% of the present USA market. Little is known about the genetic background of most crimson clover cultivars and this has resulted in concern whether the expanding European market cultivars are unique or just releases of selections out of the old market standard, Dixie. At the request of the Oregon Clover Commission, a project was begun to measure the amount of genetic diversity among crimson clover cultivars and to determine whether new cultivars are utilizing all of the available genetic diversity found in present plant germplasm collections. This research was done in cooperation with Drs. Emanuele Piccioni and Mario Falcinelli who are scientists at the University of Perugia in Italy; and Aaron Liston with the Department of Botany and Plant Pathology, Oregon State University.

Thirty-six accessions of commercial cultivars and wild germplasm were obtained from the USDA-ARS National Plant Germplasm System (NPGS); the Istituto di Miglioramento Genetico Vegetale (IMGV) at the University of Perugia, Italy; state experiment stations; and private companies. The plants were grown in the greenhouse and observed for time of flowering and flower color. Leaf samples were taken and DNA extracted and examined by the polymerase chain reaction using 21 random amplified polymorphic DNA (RAPD) markers. The pedigrees of the crimson clover cultivars were determined by cultivar registration reports and personal communications with plant breeders in the USA, Italy, and New Zealand.

This research found two major genetic groups of crimson clover cultivars exist as well as a group of more genetically diverse sources (Fig. 1). By examining the pedigrees of most newer U.S. cultivars, we found that relatively few distinct genetic sources have been used in their development. The greatest percentage of named cultivars and germplasms are derived from Dixie, regardless of whether they were bred in Europe or the USA. European cultivars are generally no more similar to Dixie than newer USA cultivars. In fact, some of the European cultivars utilize more of the available genetic diversity than USA ones do. Both European and USA cultivars do not utilize the most-unique genetic sources as found in the NPGS and Italian germplasm collections. Because of the broad geographic range where crimson clover naturally is found and its limited representation in available germplasm collections, more sources of unique germplasm should be acquired and evaluated to increase the genetic base of present collections. This research should help crimson clover breeders identify new sources of genetic diversity and possibly useful traits that can be incorporated into their cultivars.

For a more detailed report of this research see: J.J. Steiner, E. Piccioni, M. Falcinelli, and A. Liston. 1998. Germplasm Diversity among Cultivars and the NPGS Crimson Clover Collection. Crop Science 38:263-271; or write to Jeffrey Steiner, National Forage Seed Production Research Center, USDA-ARS, 3450 SW Campus Way, Corvallis, OR 97331; or access the web site at: www.http://pwa.ars.usda.gov/nfsprc/steiner/steinerj.htm for more information about germplasm research.

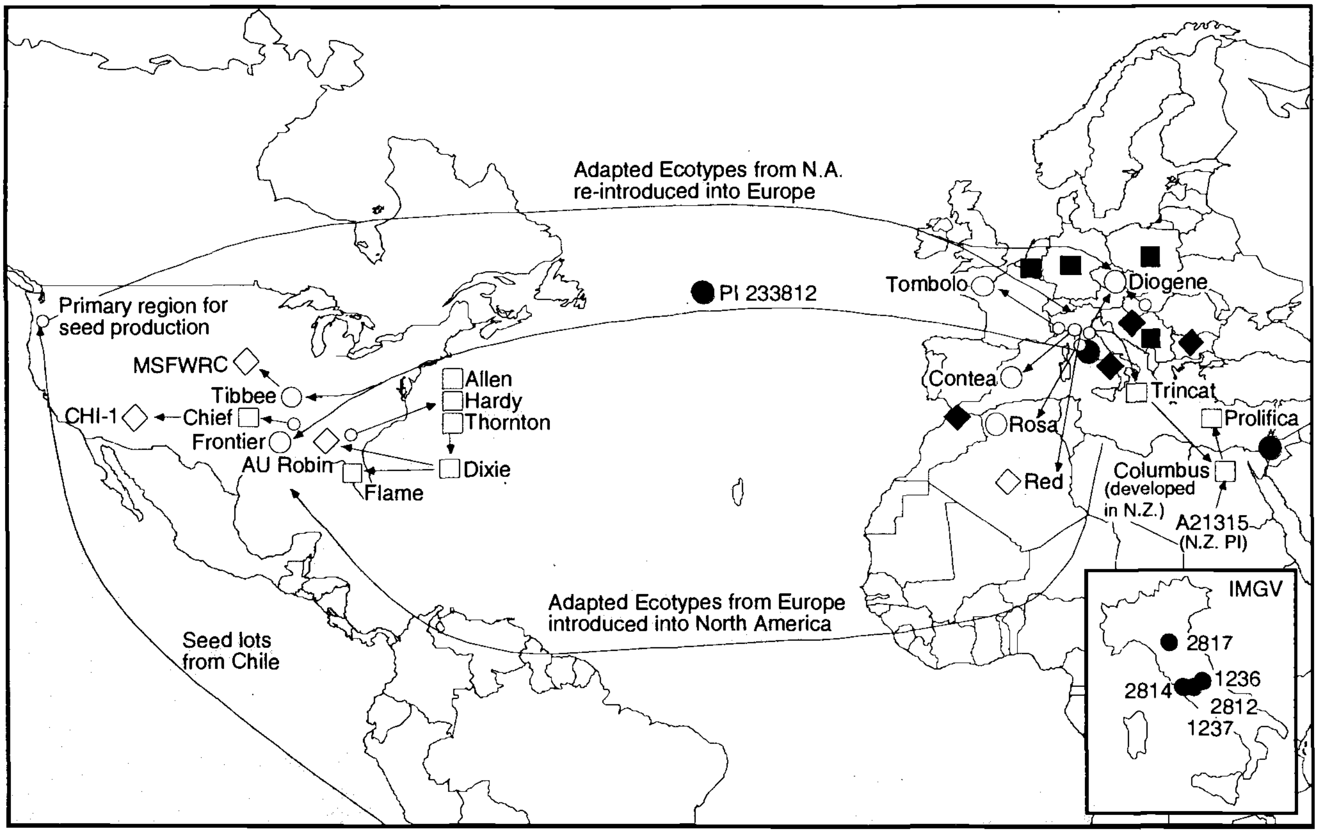

Figure 1. The origins, distribution, and generalized pedigrees of NPGS accessions, cultivars, germplasms, and natural ecotypes of crimson clover from Europe and North America. The symbols: ◊ , O, indicate cultivars for RAPD Groups A, B, and C, respectively. The symbols: ♦, ●, ■ indicate NPGS accessions and collected Italian ecotypes for RAPD Groups Groups A, B, and C, respectively. Arrows indicate the direction of introduction and generalized pedigree lineage. The symbols of open-circles with an attached arrow indicate the geographical location where a cultivar or germplasm originated. Insert figure shows the origins of the five natural ecotypes from the germplam collection at the Istituto di Miglioramento Genetico Vegetale, Universita' di Perugia, Perugia, Italy.

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