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NITROGEN FERTILIZER REQUIREMENTS FOR GRASS SEED PRODUCTION IN NON-BURN POST-HARVEST RESIDUE MANAGEMENT SYSTEMS

W.C. Young III, T.B. Silberstein, and J.M. Hart

Presented in this report are data from the final year of a three year study (initiated in 1988) examining the interaction between post-harvest residue management and spring nitrogen (N) fertilization on perennial ryegrass (*Lolium perenne*) and tall fescue (*Festuca arundinacea*). As growers shift from thermal to non-thermal residue management of grass seed fields the ability to predict nutrient response over time for different species over several post-harvest residue management systems is desired. In addition, perennial crops may be influenced by the duration of treatments; thus, older stands may respond differently to the same treatment when measured over time.

Two locations for both perennial ryegrass and tall fescue were selected for study in fields established by Willamette Valley seed growers in 1987. Initial post-harvest residue management treatments were made following harvest of the first seed crop in 1988. Identical residue management treatments were positioned in the same locations following seed harvest in 1989 and 90.

At each site, straw residue was baled following harvest and straw weight estimates (ton/acre) were recorded. Straw was then returned in an equal weight to main plots receiving an open burn treatment. In addition to the open burn treatment, four other stubble management treatments were established. Each of these five treatments is 20 x 100 ft, and is replicated four times as main plots in a split-block (N treatments) experimental design.

Main plot post-harvest management treatments are listed below:

(1) Open burn with full straw load
(2) Propane burn stubble (straw residue baled)
(3) Flail chop stubble (straw residue baled)
(4) Propane burn stubble + Enquik
(5) Flail chop stubble + Enquik

All residue management treatments were completed August 23-25. Enquik was applied on October 9 at all locations at the recommended rate of 15 gallons per acre, with an equal volume of water, plus 0.25% nonionic surfactant. In addition to the contact herbicide/desiccant activity, Enquik contains 1.9 pounds of ammonic nitrogen and 2.0 pounds of sulfate sulfur in each gallon. Thus, those plots <u>not</u> treated with Enquik, were fertilized with 145 pounds per acre ammonium sulfate [$(NH_4)_2SO_4$] to maintain equal N and S nutrition across all plots. Standard soil-active herbicides were applied to all plots in mid-November.

Single-spring N subplot treatments were applied March 29. Urea fertilizer (46-0-0) was used at all sites to achieve spring nitrogen treatment rates of 60, 100, 140 lb N/a. Total N applied (fall + spring) in these treatments was 90, 130, 170 lb N/a, respectively.

1991 Results

Open burn, propane burn, and flail chop post-harvest treatments all resulted in similar seed yields (Table 1). In only one exception (Pleasure perennial ryegrass), seed yield from propane burning was less than the open burn treatment. Perennial ryegrass seed yield was less effected by residue management (P-value < 0.10) when compared to tall fescue (P-value < 0.05). The use of Enquik following either flail chop or propane burn treatment was detrimental to seed yield at both tall fescue locations and to the flail chop treatment in Regal perennial ryegrass. Enquik treatment was applied earlier in 1990 (October 9) to reduce impact on crop yield (see Ext/CrS 80, p. 13 and Ext/CrS 83, p. 12). However, even with an early application the response was similar to that reported in 1989 and 1990.

Spring N rates above 60 lb/a increased seed yield significantly at all sites except the Martin tall fescue field (a forage-type tall fescue). Perennial ryegrass seed yield continued to increase with higher rates of spring-applied nitrogen. In Pleasure perennial ryegrass 140 lb/a of spring-applied N (170 lb N/a total) resulted in a significantly higher seed yield. This trend was also observed for Regal perennial ryegrass. Seed yield of Rebel II tall fescue, however, was not affected by increasing the rate of spring-applied N above 100 lb/a (130 lb N/a total).

Table 1. Effect of residue management and spring nitrogen rate on seed yield of two perennial ryegrass and two tall fescue varieties, 1991.

Treatment	Perennial ryegrass: Regal	Perennial ryegrass: Pleasure	Tall fescue: Martin	Tall fescue: Rebel II
	(lb/a)			
Residue Management				
Open burn	1509	1715	1026	1351
Propane burn	1456	1456	1000	1408
Flail chop	1546	1589	980	1291
Propane + Enquik	1348	1585	606	949
Flail chop + Enquik	1293	1469	752	1012
LSD 0.05 (0.10)	(164)	(155)	75	221
Spring N Rate				
60 lb N/a	1171	1455	873	1096
100 lb N/a	1508	1524	893	1221
140 lb N/a	1611	1708	852	1290
LSD 0.05	114	56	NS	135

3-Year yield summary

Complete statistical analysis across all three years have not yet been completed, however, cumulative effects can begin to be assessed by comparing trends in results reported over time. The statistical values at the bottom of each column in the tables below are for individual year results only.

The two tall fescue varieties responded similarly to residue treatments, but differently to nitrogen management (Tables 2 and 3). Martin forage-type tall fescue does not appear to need as much nitrogen as Rebel II turf-type tall fescue to obtain optimum yields. Both varieties were very sensitive to fall-applied Enquik, which indicates the importance of fall tiller growth and development on subsequent seed yield. This is consistent over all three years and is observed in the 3-year average. Open-field burning does not show any crop yield advantage over propane burn or flail chop treatments for tall fescue varieties studied in this experiment. Nitrogen requirements for non-burning treatments are about the same as for burn treatments. Other fertility requirements (such a potassium) may be different as shown in an accompanying article in this publication.

Table 2. Effect of residue management and spring nitrogen rate on seed yield of Rebel II tall fescue, 1989-91.

Treatment	1989	1990	1991	Avg.
	(lb/a)			
Resident Management				
Open burn	726	1977	1351	1351
Propane burn	1208	1906	1409	1508
Flail chop	1078	1769	1291	1379
Propane + Enquik	921	1635	949	1168
Flail chop + Enquik	880	1688	1012	1193
LSD 0.05 (0.10)	185	(223)	221	--
Spring N rate				
60 lb N/a	980	1781	1096	1286
100 lb N/a	953	1784	1220	1319
140 lb N/a	954	1820	1290	1355
LSD 0.05 (0.10)	NS	NS	(123)	--

Table 3. Effect of residue management and spring nitrogen rate on seed yield of Martin tall fescue, 1989-91.

Treatment	1989	1990	1991	Avg.
	(lb/a)			
Resident Management				
Open burn	1072	1207	1042	1107
Propane burn	1108	1185	1000	1097
Flail chop	1199	1230	980	1136
Propane + Enquik	861	1121	605	862
Flail chop + Enquik	1010	1212	752	991
LSD 0.05* weight es-				
Spring N rate				
60 lb N/a	1083	1173	873	1043
100 lb N/a	1035	1217	902	1051
140 lb N/a	1033	1183	851	1022
LSD 0.05	NS	*1	NS	--

*1 Residue management x spring N rate interaction significant at $P<0.05$.

The two perennial ryegrass varieties responded to residue management in a manner similar to tall fescue (Tables 4 and 5). Residue treatments averaged across the three years show comparable yields for all three main residue treatments (open burn, propane burn and flail chop), however, some benefit to open burning was seen in Pleasure perennial ryegrass. Regal perennial ryegrass was less affected by residue treatments over the 3-year average in this experiment. Both ryegrasses respond to higher nitrogen rates as the stands age, with the third year being most responsive to the highest rate. It is not apparent at this time why the ryegrass stands may need more spring nitrogen as they age. The perennial ryegrasses were less sensitive to applications of Enquik than tall fescue, and showed less deleterious effect from its use. Although the 3-year average for both perennial ryegrasses indicates a slight yield drop compared to the same treatments without Enquik, other factors, such as seedling control and fertility needs should also be considered.

Table 4. Effect of residue management and spring nitrogen rate on seed yield of Regal perennial ryegrass, 1989-91.

Treatment	1989	1990	1991	Avg.
	------------- (lb/a) -------------			
Resident Management				
Open burn	1161	1391	1509	1353
Propane burn	1214	1394	1456	1354
Flail chop	1175	1299	1546	1340
Propane + Enquik	1145	1298	1348	1264
Flail chop + Enquik	1146	1361	1293	1266
LSD 0.05 (0.10)	NS	NS	(164)	--
Spring N rate				
60 lb N/a	1173	1171	1171	1172
100 lb N/a	1167	1404	1508	1360
140 lb N/a	1163	1471	1611	1415
LSD 0.05	NS	199	114	--

Table 5. Effect of residue management and spring nitrogen rate on seed yield of Pleasure perennial ryegrass, 1989-91.

Treatment	1989	1990	1991	Avg.
	------------- (lb/a) -------------			
Resident Management				
Open burn	1431	1608	1715	1584
Propane burn	1532	1478	1575	1528
Flail chop	1429	1412	1589	1477
Propane + Enquik	1401	1352	1585	1446
Flail chop + Enquik	1263	1282	1584	1376
LSD 0.05 (0.10)	NS	172	(155)	--
Spring N rate				
60 lb N/a	1350	1359	1527	1412
100 lb N/a	1365	1431	1524	1440
140 lb N/a	1519	1489	1777	1595
LSD 0.05 (0.10)	(135)	66	56	--

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POTASSIUM FOR GRASS SEED NUTRITION

D.A. Horneck, J.M. Hart, W.C. Young III and T.B. Silberstein

Introduction

Political pressures and lack of adequate burn days have caused Western Oregon grass seed growers to modify straw disposal and field sanitation practices. Displacement of annual open field burning by physical straw removal also removes nutrients, especially potassium (K), that would be recycled by open-field burning.

Growers and fertilizer dealers realize physical removal of straw presents the need for substantially different K management than open-field burning. The first question raised is the impact of straw removal on seed yield. Other questions follow, including fertilization changes necessary to produce satisfactory seed yields without burning. To answer these questions a three-year field experiment was initiated. Complete statistical analyses have not been completed. Yearly analyses have been completed and are mentioned in the text where appropriate. The objective of this article is to present trends and observations that are meaningful to a grass seed producer.

Methods

Sites planted to perennial ryegrass and tall fescue (PR and TF) with high and low (H and L) soil test K (H-PR, L-PR, H-TF and L-TF, respectively,) were treated with burn and bale straw management in combination with, and without potassium fertilization (K^0 and K^+). Initial K soil test levels for the high and low sites were 218, 164, 55 and 78 ppm for tall fescue and perennial ryegrass, respectively. Straw yield, seed yield and soil test levels were sampled annually at each site. Soil was sampled at the 0-1 and 0-6 inch depth for all three years. Soil sampling in 1990 also included samples to a depth of 24 inches. Tissue and soil samples were analyzed for K. The 1991 soil sampling at the H-TF site occurred after fertilization with 200 lb/a 18-18-18. Also at this site the annual burn plots were moved after the 1989 harvest as the result of the stand loss from the 1988 burn.

Results

Soil test K levels are shown in Table 1. Several trends are apparent between residue management, fertilizer treatment, sample depth and stand age. K^+ treatments typically have higher soil test levels than the K^0. Annual burn treatments have higher K levels than baled, especially in the 0-1 inch sample. The 0-1 inch K soil test levels for annual burn treatments increased over stand life, where as the 0-6 inch samples tended to decrease, particularly where no K fertilization occurred. These trends can be explained by the nutrient cycling that occurs during a burn. Burning concentrates nutrients at the surface that are taken up from throughout the soil profile. This is reflected in higher surface soil K levels.

Soil K levels decreased with depth at the two high K sites and increased with depth at the low soil test K fields. This is a result of K management. Historically, most grass seed fields were burned, requiring minimal K fertilization to build up soil test K levels. The two high sites show a K build-up from previous surface K applications resulting in high surface and lower subsoil k levels. This is best observed in 1990 data. The low sites show an increase in soil K with depth, which is probably the result of little or no fertilizer application and K removal by seed harvest. Grass seed K nutrition probably comes from a combination of topsoil and subsoil reserves. When topsoil reserves are adequate, little K is taken up from the subsoil. However, when 0-6 inch K levels are low, grass roots will take up K from lower depths. Topsoil and subsoil levels may need to be depleted before grasses show yield responses to K fertilization. In this study the L-PR site has the lowest soil test K in both the topsoil and subsoil, therefore, it would be the most likely of the four sites to show a yield response to K fertilization.

Table 1. Soil test levels at four K sites by grass, year and treatment.

Location	depth in.	Bale K^+	Bale K^0	Annual Burn K^+	Annual Burn K^0
		(ppm)			
1989					
H-TF	0-1	327	312	1124	1052
	0-6	288	272	482	477
L-TF	0-1	72	58	85	63
	0-6	54	62	59	63
H-PR	0-1	184	200	217	276
	0-6	177	163	150	206
L-PR	0-1	57	52	74	66
	0-6	57	52	75	60
1990					
H-TF	0-1	270	225	471	464
	0-6	266	225	305	317
	6-12	221	209	197	208
	12-24	148	174	146	138
L-TF	0-1	60	57	89	88
	0-6	53	48	72	70
	6-12	56	66	64	63
	12-24	108	100	109	113
H-PR	0-1	339	305	318	294
	0-6	192	173	182	193
	6-12	183	148	162	141
	12-24	164	156	164	138
L-PR	0-1	73	66	103	101
	0-6	56	59	83	70
	6-12	57	56	62	58
	12-24	80	98	81	100
1991					
H-TF	0-1	441	448	552	545
	0-6	302	258	361	329
L-TF	0-1	79	66	98	96
	0-6	38	37	45	46
H-PR	0-1	407	293	438	383
	0-6	207	158	225	183
L-PR	0-1	71	57	184	118
	0-6	37	32	84	44

Rapid decreases in soil K levels under straw removal systems are understandable when K removal rates are taken into consideration (Table 2). Straw removal depletes available soil K. The average K soil test in the 0-1 inch layer at the tall fescue high soil test site in 1990 was 468 ppm in burned plots, and 248 ppm in baled plots. The 220 ppm difference represents 60 to 70 lb K/a. A similar reduction in soil test K was measured in the 0-6 inch layer (246 ppm baled vs 311 ppm burned). This reduction in K soil test represents 130 lb K/a, which approximates the amount removed in tall fescue straw.

Straw K uptake increased with stand age (Table 2). This increase in K uptake is most apparent at the high K sites. Especially in the K+ baled treatment. For example, 1989 straw K uptake was 102 lb/a and increased to 281 lb/a in 1991 at the H-TF site, K+, baled treatment, whereas K uptake in the annual burn treatment increased from 101 to 182 lb K/a. Similar trends are observed in the low K sites, but at a smaller magnitude. Increased straw K uptake over time is created in by increases in straw drymatter production and tissue K concentrations.

Table 2. Grass straw K uptake by grass, year and treatment for four K sites.

Location	Bale		Annual Burn	
	K^+	K^0	K^+	K^0
	------------(lb/a)------------			
1989				
H-TF	102	100	101	78
L-TF	33	31	32	33
H-PR	43	45	39	53
L-PR	45	30	50	38
1990				
H-TF	200	183	136	148
L-TF	45	26	62	53
H-PR	58	49	75	66
L-PR	43	34	80	45
1991				
H-TF	281	232	182	197
L-TF	51	37	62	64
H-PR	102	92	76	82
L-PR	30	21	55	53

Straw K uptake was dependent on fertilization, stand age, grass type, soil test level and residue management. K fertilization did not have a consistent effect on K uptake where residue was burned, even at the low soil test K sites. Where residue was baled, however, K fertilization increased K uptake (Table 2) even where soil test levels exceeded 300 ppm K in the top inch (Table 1). Grass species influenced K uptake. Tall fescue produced greater dry matter than perennial ryegrass. In addition to increased dry matter tall fescue straw had a higher percentage of K at the high soil test sites; both contribute to tall fescue taking up more K than perennial ryegrass. Correspondingly, soil test level markedly influenced K uptake for both perennial ryegrass and tall fescue. Increases in straw K uptake with increased soil test level were greater with tall fescue than perennial ryegrass.

For example, in 1991 the high tall fescue site averaged 223 lb/a K uptake with 2.4% tissue K in the straw, where the low site averaged 53.5 lb/a and 0.69%. Perennial ryegrass in 1991 averaged 88.0 lb/a, 1.36%, 39.8 lb/a and 0.64% for uptake and tissue K at the high and low sites, respectively. Perennial ryegrass and tall fescue differed in straw K uptake by 135 lb/a between high sites and only 14.5 lb/a between low sites. Some of these differences are in part due to differences in straw production, since the H-TF site out produced the other sites during the course of this study.

Grass seed growers should note that baled tall fescue liberally fertilized with K will remove more K than perennial ryegrass grown in similar environments. The two grasses when grown on low K soils may have similar tissue K concentrations and uptake.

Reductions in soil test K or initial low soil test did not necessarily decrease seed yield. In 1990, seed yield increased with K fertilization only at the low soil test perennial ryegrass site. Here, K fertilized plots averaged 1469 lb/a while plots receiving no K averaged 1363 lb/a. A similar average yield difference existed between burned and baled plots at this site, but was not significantly different (1468 lb/a burned vs 1364 lb/a baled). In 1991, the interaction of grass species, straw management and K fertilization significantly influenced seed yield (Table 3). However, K fertilization failed to increase seed yield. These grasses are obtaining sufficient K for seed yield despite low (<100 ppm) surface soil test K levels. A lack of yield response to K fertilization where surface K levels are low may be related to subsoil K supply.

Table 3. Seed yield by grass, year and treatments, for four K sites.

Location	Bale		Annual Burn	
	K^+	K^0	K^+	K^0
	------------(lb/a)------------			
1989				
H-TF	1176	1170	623	649
L-TF	1154	1058	1157	1041
H-PR	1403	1409	1479	1431
L-PR	1122	1152	1064	1085
1990				
H-TF	1827	1686	1782	1892
L-TF	1327	1270	1337	1287
H-PR	1381	1279	1534	1627
L-PR	1422	1306	1516	1420
1991				
H-TF	1421	1349	1176	1334
L-TF	966	977	897	1042
H-PR	1654	1749	1575	1423
L-PR	1542	1559	1513	1603

Summary
Tall fescue produced more straw with a higher K concentration than perennial ryegrass at the high K soil test sites. This results in more K removed for tall fescue than perennial ryegrass. K removal is reflected in decreased soil test K in the 0-1 and 0-6 inch soil layers. K depletion or initial low soil test K values do not necessarily indicate yield responses to K fertilization. Only at the low soil test K (61 ppm) ryegrass site in 1990 was seed yield increased when fertilized with K.

Growers should monitor surface and subsoil soil test K. Applications of K fertilizer when surface soil test K is above 100 ppm have not produced a seed yield response. K uptake beyond crop needs is luxury consumption. Luxury consumption occurs in these grasses when K soil test levels exceed 100 ppm. Straw K concentration increases when K fertilizer is applied. Subsequent removal of the K fertilizer occurs with straw removal. Luxury consumption affects how K needs to be managed for grass seed production. Where fields are burned, high K uptake by these grasses has minimal long term effect on K management because of nutrient cycling. Where straw is harvested, careful attention needs to be given to soil test levels and K fertilization rates. Where high K levels exist, a rapid decline in soil test K level can be expected, unless K rates potentially as high as 350 lb/a K, are applied. A realistic soil test level (100 ppm) should be maintained, as recommended by Oregon State University.

THIRD-YEAR RESPONSE OF TALL FESCUE AND PERENNIAL RYEGRASS TO LIME AND PHOSPHOROUS DURING A FOUR YEAR STUDY

D.A. Horneck and J.M. Hart

Introduction
Results from a 1987 Department of Environmental Quality funded survey of Willamette Valley grass seed fields showed stratification of nutrients and soil pH within the surface 6 inches of soil. The survey also showed the vast majority of the 77 fields sampled had pH values less than 5.2 and P levels greater than 50. Questions regarding lime and P management were generated from this survey data and grower interests.

Fertilization strategies must be evaluated as growers shift to nonburning management of grass seed residue. Phosphorus (P) is a key element in plant nutrition due to its immobility and sensitivity to acidic and cool wet soils. Thus, research is needed to determine optimum P application rate, timing and method in relation to liming and cultural practices.

The objectives for this project were to: 1) Assess the effect of soil pH, especially surface soil pH, on seed yield for turf-type perennial ryegrass and tall fescue; 2) Evaluate the effect of P rate, application method and timing with varying soil pH on seed yield and P uptake in grass seed production; 3) Compare the agronomic and economic benefits of lime incorporation and surface application for grass seed production.

Lower soil pH is a result of perennial surface applications of the preferred, less expensive, ammoniacal N fertilizers. Leaching and crop harvest removes Ca^{+2}, Mg^{+2}, K^{+} and Na^{+} thus aiding the soil acidification process. As soil pH decreases, P availability is also assumed to decrease. The acidified soil surface resulting from N transformations, crop removal and leaching is also the recipient of P fertilizer applications. Low pH's have been cited by growers and dealers as a reason for continued P application even though soil P levels may substantially exceed OSU critical levels.

Acidic soils are amended by lime applications. Many Willamette Valley crops respond to liming with additional growth, yield and/or quality. Lime incorporation is preferred after of application. However, incorporation is not practical in established perennial grass seed fields. Topdressing lime is the only feasible alternative. Topdressing lime is considered to be less efficient than incorporation in quickly neutralizing soil acidity in the plow layer because of its poor mobility. Topdressing lime is probably only effective within the surface inch for the first year after application. Gardner and Kauffman topdressed lime on grass seed fields with inconclusive results (Personal Communication). Topdressing lime may not neutralize lime as quickly as when incorporated, however, it will neutralize the equivalent amount of acidity, just over an extended time. Little data are available evaluating surface acidity, P application methods and P rates for grass seed production, though lime and P fertilization are recommended in OSU Fertilizer Guides (Doerge et al). 1991 is the first year all lime treatments, incorporated and surface applied, in this study were evaluated.

Methods and Materials
Two experimental sites with low soil pH (5.2) were established with perennial turf-type grasses for seed production. Perennial ryegrass (*Lolium perenne* cv SR 4000) was seeded in Bashaw clay (typic pelloxerert) at G & R Farms, Shedd, Oregon (Saddle Butte Site) where soil test P was 12 ppm. Tall fescue (*Festuca arundinacea* cv Falcon) was seeded in Woodburn silt loam (aquultic Argixeroll) at the Oregon State University Hyslop Crop and Soil Science Farm near Corvallis, Oregon where soil test P was 60 ppm. Perennial ryegrass and tall fescue were seeded in 30 cm rows in fall of 1988 and spring of 1989, respectively. Carbon was surface banded at planting and the fields were treated with 2.5 lb ai/a diuron.

A split-plot design was used with three and four replications in a factorial arrangement for Saddle Butte and Hyslop, respectively. The main plots were lime with 0, 2 and 4 t/a. The 4 t/a lime rate was incorporated prior to planting. The 2 t/a lime rate was surface applied in the fall of 1990 at both sites. Subplots were P rates of 0, 30, 60 and 90 lb P/a applied as a band (spring and fall) and broadcast, annually. All P treatments were applied at establishment.

Hyslop and Saddle Butte were both annually treated with oxyfluoren and diuron in the fall in combination with spot spraying by hand with glyphosate. Nitrogen was applied at 40 lbs/a in the fall and 100 lbs/a in the spring as ammonium sulfate. Tissue samples were harvested in March, May and August and subsequentially analyzed for total P and total N. ANOVA for seed yield, seed weight and plant tissue data was performed.

Results and Discussion

Lime and P main effects will be viewed independently since no significant interaction existed between lime application, P rate or P application method for seed yield. Phosphorus rate and method of application produced no significant differences in seed yield at either site for 1990 and 1991 (Tables 1 & 2). No seed yield differences for method of P application was expected or observed since P application rate produced no seed yield increase.

Table 1. Grass seed yield for P rates, 1990 and 1991.

	Tall Fescue		Perennial ryegrass	
P rates	1990	1991	1990	1991
(lb/a)	(lb/a)			
0	858	709	1435	1533
30	809	635	1391	1538
60	760	615	1433	1490
90	819	662	1409	1536
LSD 0.05	NS	NS	NS	NS

Table 2. Grass seed yield for P application methods, 1990 and 1991.

	Tall fescue		Perennial ryegrass	
Method	1990	1991	1990	1991
	(lb/a)			
Broadcast	842	651	1407	1529
Band, Fall	766	650	1443	1516
Band, Spr.	827	609	1402	1520
LSD 0.05	NS	NS	NS	NS

No yield response from P was expected at the Hyslop site where soil test P (Bray-P1) was 60 ppm. However, a seed yield increase from P application was expected at the Saddle Butte site where soil test P was 12 ppm. Phosphorus fertilization is recommended by Oregon fertilizer guides for new and established stands when P soil test levels are below 25 and 30 ppm, respectively. Low P uptake in the straw (five pounds per acre for perennial ryegrass in 1990) may be at least partially responsible for lack of seed yield response to P. Lack of seed yield response to P may be due to reducing soil conditions from poor drainage at Saddle Butte and the resulting increased P levels in the soil solution. P levels in the soil solution are currently being investigated at both the Hyslop and Saddle Butte sites.

Two factors contribute to low P uptake of perennial ryegrass. First turf-type perennial ryegrass does not produce a large dry matter yield relative to tall fescue, averaging 4858 and 4859 lb/a for the 1990 and 1991 July harvests, respectively. This is roughly one half the 10573 lb/a produced by the tall fescue at Hyslop in 1991. Secondly, P concentration of mature grass is low, averaging 0.10% for both perennial ryegrass and tall fescue. This results in tall fescue taking up twice as much P as perennial ryegrass in the straw. Low P concentration in headed ryegrass is reported by Kelling and Matocha (1990). The low P demand of perennial ryegrass was supplied by the soil even though soil test P levels indicated a response to P fertilization. Tissue P was sufficient since neither P rate nor method of application influenced tissue P concentrations or P uptake (data not shown). The low P demand was not indicative of lower seed yields at the Saddle Butte site. The industry average seed yield for SR 4000 in 1990 was equivalent to the Saddle Butte average of 1450 lb/a (Seed Research Inc., Personal Communication). Phosphorous applications, however, did tend to increase seed weights in 1991 (data not shown).

Lime applications increased seed yield at the Hyslop site when compared to the unlimed check in 1990 (Table 3). The only significant difference in seed yield at the Saddle Butte site was between the two unlimed plots during 1990 (Table 3). The same trend existed for the 1989 harvest at Saddle Butte. Since the 2 t/a lime rate was not applied until after the 1990 harvest this treatment should have been identical to the 0 t/a rate. Seed yield did not respond to lime application in 1991 at either site. Data from 1989 and 1990 have shown trends for seed yield and early growth response to lime application (Table 3). The trend of early increased growth did not continue in 1991 at Hyslop (Table 4) or Saddle Butte (not shown). No explanation can be provided for the difference in yields provided from the two identical unlimed treatments at Saddle Butte. Lime clearly increased seed yield at the Hyslop site in 1990, even with the low seed yields produced from the first harvest. There is also no explanation for the continued relatively poor yields by Hyslop site in 1991.

Table 3. Grass seed yield for Lime treatments, 1990 and 1991.

Lime	Tall fescue 1990	Tall fescue 1991	Perennial ryegrass 1990	Perennial ryegrass 1991
(t/a)	(lb/a)			
0	740	610	1464	1541
2	*818	715	*1337	1488
4	877	586	1451	1536
LSD 0.05	115	NS	118	NS

* This plot initially received no lime and was topdressed with 2t/a after the 1990 seed harvest.

Conclusions should not be made at this juncture. Seed yields have been obtained for 3 years from the Saddle Butte site and only two years from the Hyslop site. A minimum of three and four years data collection from Saddle Butte and Hyslop site is planned, respectively. Data analysis has currently not been performed across years. Tissue sample analysis for total N and total P have also not been completed. To date however, there are, some indications that lime increases seed yield for both grasses when soil pH is 5.2. The predictability of seed yield response to lime seems to be variable at this pH. As soil pH values fall further yield responses to lime would be expected to become more frequent, thus more predicable. OSU Fertilizer Guides recommend lime be applied when the soil pH is below 5.5, which based on this research, is confirmed.

Table 4. Tall fescue straw yield for Lime treatments at Hyslop, 1991.

Lime	March	May	July*
(t/a)	(lb/a)		
0	2892	5892	10852
2	2387	6664	10549
4	2432	6660	10318
LSD 0.05	431	NS	NS

* This harvest is straw removed by baling and does not include seed or straw removed by flail chopping and subsequent vacuuming.

Lack of growth and seed yield response by tall fescue to liming and P application may be explained in part by the inherent variability of these grasses. 1991 coefficients of variation (CV) were 33% across the field for the March harvest for both perennial ryegrass and tall fescue. This variation may have hidden yield differences that existed. As the growing season progressed CVs for perennial ryegrass decreased from 33% to 25% to 19% for the March, May and July sampling dates, respectively. This emphasizes the fact that stands are variable and irregular growth occurs especially in the winter and early spring.

The soil pH after liming at the Saddle Butte site was 6.7 and at the Hyslop site, 6.0. These pH's indicate that the soil at both sites probably will not need lime for several more years. The high pH at the Saddle Butte site indicates a lime application higher than necessary. These data suggest that liming grass grown for seed production produces an annual return for an extended period of years.

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PERENNIAL RYEGRASS RESPONSE TO CROP RESIDUE REMOVAL METHODS AND HERBICIDE TREATMENTS

G.W. Mueller-Warrant, W.C. Young III, and M.E. Mellbye

The legislative agreement to phase down field burning will inevitably increase growers' reliance on herbicides and mechanical methods to control weeds in established perennial grasses grown for seed. In perennial ryegrass, failure to adequately control volunteer seedlings can result in a classification of last-year-eligible (LYE) for certification, potentially forcing growers to replant sooner than otherwise necessary. Dramatic differences exist between burned and non-burned fields in both densities and patterns of emergence of various weeds, including volunteer crop seedlings. Differences may also exist in regrowth vigor, tiller number, and tiller size class distribution of the established crop. Attempts to control volunteer perennial ryegrass well enough to meet seed certification standards in non-burned stands have sometimes destroyed the crop. It is therefore vital to examine both weed control efficacy and crop tolerance of proposed herbicide and residue removal treatments.

A two-year study was initiated in 1989 to compare the effects of 15 herbicide treatment sequences in combination with five post-harvest residue removal methods in two perennial ryegrass stands, one Pleasure and one Regal. The dominant weed at both sites in both years was volunteer perennial ryegrass. Herbicide treatments were applied as subplots 8 ft. wide by 20 ft. long within residue removal mainplots, with four replications per site. All treatments except the no-herbicide checks were applied to the same plots in both years of the study. Locations of the untreated checks were shifted in the second year due to establishment of excessive numbers of seedlings in the checks during the first year. Success in controlling volunteer perennial ryegrass was evaluated by examining 300 separate 1-inch square locations per plot for the presence or absence of seedlings. This estimate of volunteer perennial ryegrass ground cover was then converted to percent control relative to cover in the bale-only check, which was the weediest treatment in all cases.

Crop residue removal for all plots started after harvest with raking the straw and baling. The bale-only (BO) plots received no further mechanical treatment. The flail chop (FC) plots were cut to a 3-inch stubble height after baling. The crew-cut (CC) plots were cut to a 1-inch stubble height with a flail head, the material collected in a stackwagon and removed. The propane flame (PP) plots were burned once at 3 mph. Field burning (FB) was simulated by two separate passes with the propane flamer in the first year at the Regal stand, and by spreading the full straw load back on the plots and burning it in the other 3 tests.

Preemergence (PRE) herbicides were applied October 20 and 25, 1989, and October 16 and 15, 1990, to the Pleasure and Regal stands. Postemergence (POST) herbicides were applied December 6 and November 30, 1989, and December 6, 1990, to the same stands. Some of the volunteer perennial ryegrass emerged before PRE herbicides were applied in all tests except the first year at the Pleasure stand. These early germinating seedlings came from cracks in the soil, and were much more abundant in the second year of testing because of rain in late August of 1990. While the largest cohort of seedlings were always those that germinated in response to late October rainfall, the early germinating seedlings posed the greatest challenge to herbicides. Volunteer perennial ryegrass was larger at time of POST herbicide application in the second year of the study than in the first, especially the early germinating cohort.

The 15 herbicide treatments included a factorial combination of 4 PRE with 2 POST herbicide treatments, a no-herbicide check, and 6 other treatments where PRE Prowl was followed by additional POST treatments. Prowl was selected over Goal, Dual, and Treflan as the PRE herbicide in these additional treatments because of its better performance in preliminary testing. Data presented in the tables includes main effects of residue removal methods averaged over the 14 herbicide treatments excluding the check, corresponding values for the untreated (no-herbicide) checks, and main effects of herbicides when averaged over all 5 residue removal methods. The herbicide main effects are presented as means for the 4 PRE treatments averaged over 2 POST treatments, means for the 2 POST treatments averaged over 4 PRE treatments, and 7 of the 15 individual treatments, 3 of which are also part of the PRE by POST factorial. The 3 least interesting treatments are omitted from the herbicide effects tables. Except for the untreated checks, interactions between residue removal methods and individual herbicide treatments are not presented in the tables, but some of them are discussed in the text.

Weed Control

Volunteer ground cover in the BO untreated check was high in both years at both sites. Without herbicide treatment, PP and CC controlled about one third to one half of the volunteer perennial ryegrass compared with FC and BO (Table 1). FB performance without herbicides was highly variable, ranging from 40% control in 1990 Pleasure to 97% in 1991 Regal. The 1990 Regal FB treatment was actually two passes with a propane flamer instead of a straw burn, and was no better than the single PP treatment. When combined with herbicides, FB was the poorest residue removal method in terms of weed control in 1990 Pleasure but the best method at both sites in 1991. PP was not quite as good as FB in 1991. The relative performance of herbicides in FB plots was poorer than in the other residue removal treatments, considering the large number of potential seedlings that were killed by the fire itself. Carbon left on the soil surface from the field burn presumably adsorbed much herbicide, particularly from the PRE applications.

In the CC plots, herbicides effectively controlled the seedlings that germinated in late October, but had some problems with those that germinated earlier from cracks in the soil. Among the non-burn treatments, weed control was always best in CC and worst in BO. Weed control from herbicides in FC plots was similar to that in BO in 1990 Regal, almost as good as that in CC in 1990 Pleasure, and intermediate in 1991 at both sites. There was an increase from 1990 to 1991 in percent ground cover by "year-old" perennial ryegrass plants between the rows (data not shown). This increase generally corresponded to those seedlings not controlled in the first year.

Table 1. Effect of crop residue removal method on volunteer control in two perennial ryegrass varieties, 1990 and 1991.

Crop Residue Removal Method	Pleasure 1990	Pleasure 1991	Regal 1990	Regal 1991
	(% control vs Bale-only check)			
Avg. over 14 Herbicides				
Crew-Cut	97.9	89.0	86.0	88.0
Flail Chop	96.7	83.0	83.2	79.3
Bale-Only	93.1	73.8	82.9	74.7
Field Burn	90.9	91.5	91.4	98.0
Propane	98.4	85.3	92.0	94.1
LSD 0.05	2.2	5.0	5.0	6.2
No-Herbicide Checks				
Crew-Cut	36.9	48.7	36.7	34.4
Flail Chop	15.2	5.4	3.4	29.5
Bale-Only	0.0	0.0	0.0	0.0
Field Burn	40.2	81.4	10.2	97.2
Propane	50.8	25.4	45.5	56.2
LSD 0.05	7.3	13.4	10.2	13.0
LSD(0.05, check vs 14 herbicide avg.)	5.2	9.4	6.6	8.6
Bale-only check % volunteer ground cover:	70.7	58.3	73.5	64.0

All four PRE herbicides performed well in the 1990 Pleasure stand (Table 2). In both 1991 tests, Dual was more effective than Prowl. Prowl was more effective than Treflan or Goal in both years at the Regal site. Application of POST Diuron and Goal+Diuron improved control over that of Prowl alone in all cases. Prowl was the only PRE herbicide that was also applied without a sequential POST in these tests, but other studies have shown that Dual requires some type of sequential POST treatment to achieve a reasonable degree of success, whereas PRE Goal applied alone can sometimes work nearly as well as Prowl.

Table 2. Effect of herbicide treatment on volunteer control in two perennial ryegrass varieties, 1990 and 1991.

Treatment	Pleasure 1990	Pleasure 1991	Regal 1990	Regal 1991
(lb ai/a)	(% control vs Bale-only check)			
PRE Herbicide Main Effects[1]				
0.25 Goal	94.4	83.5	80.5	74.9
2.0 Prowl	95.6	84.3	89.3	88.7
1.5 Dual	96.4	92.8	92.1	95.2
2.0 Treflan[2]	95.2	81.3	74.8	81.7
LSD 0.05	3.2	4.1	4.1	3.7
POST Herbicide Main Effects[3]				
0.125 Goal + 1.2 Diuron	95.3	86.2	83.1	86.9
1.6 Diuron	95.4	84.7	85.2	83.3
LSD 0.05	1.6	2.9	2.0	2.6
Selected Treatment Combinations				
PRE 0.25 Goal/ POST 0.125 Goal +1.2 Diuron	94.4	82.1	77.8	77.7
POST 0.25 Goal +0.2 Kerb	96.1	72.4	92.7	88.7
PRE 1.5 Dual/ POST 1.6 Diuron	96.1	92.1	92.1	95.2
PRE 2.0 Prowl/ POST 0.125 Goal +1.2 Diuron	95.2	85.6	88.7	91.9
PRE 2.0 Prowl/ POST 0.125 Goal +0.5 Sencor	98.0	90.3	93.7	92.1
PRE 2.0 Prowl	90.2	77.5	84.9	82.7
Untreated	28.6	32.2	28.9	43.5
LSD 0.05	3.2	5.7	4.1	5.3

[1]Avg. over POST Diuron and Goal+Diuron.
[2]Balan applied to Regal in 1990.
[3]Avg. over all 4 PRE herbicides.

Following all 4 PRE herbicides at both sites in both years, a POST tank-mix of Goal plus 1.2 lb ai/a Diuron controlled volunteer perennial ryegrass roughly as well as a sequential POST application of 1.6 lb ai/a Diuron without Goal. However, there was a slight advantage to the Goal plus Diuron tank-mix in 1991. A POST application of 0.125 lb ai/a Goal plus 0.2 lb ai/a Kerb without any PRE herbicide controlled seedlings well in 1990, but severely injured the crop. In 1991, control from this treatment was poorer. The best weed control in both years at both sites was given by PRE Dual followed by POST Goal plus Diuron, PRE Dual followed by POST

Diuron, and PRE Prowl followed by POST Goal plus Sencor (or Lexone). PRE Prowl followed by POST Goal plus Diuron controlled weeds somewhat less effectively than the very best treatments, but was still noticably better than PRE Goal followed by POST Goal plus Diuron. The main group of seedlings surviving any of the herbicide treatments was the early germinating cohort. Earlier application of the POST portion of the most successful herbicide treatment sequences would probably have improved the control of these early germinating seedlings. However, it is unknown whether earlier application of the POST treatment would have increased crop injury. It would be necessary to achieve about 96% control of volunteer perennial ryegrass at the densities encountered in these tests to fully meet seed certification standards. However, many of the treatments controlled seedlings in the combine trails well enough to easily pass a visual 'windshield' test, and only fell down in their ability to control seedlings in the cracks.

Crop Tolerance and Seed Yield

These two perennial ryegrass stands differed somewhat in their seed yield response to burn versus non-burn management, especially in the second year. When treated with herbicides, FB and PP both outyielded CC, FC, and BO in the Regal perennial ryegrass in 1991 only (Table 3). When averaged over the 14 herbicide treatments, there were no consistent differences in seed yield among the residue removal methods in the other 3 tests. In the three non-burn treatments, establishment of thick 'carpets' of volunteer perennial ryegrass in the no-herbicide checks clearly reduced seed yield compared to the 14-herbicide averages in 5 out of 12 cases, and showed a trend down in 2 others. Problems with failure to adequately control volunteer seedlings also developed by the second year of Prowl-only treatment in flail chop management of Regal perennial ryegrass, where its 1045 lb/a yield was significantly lower than that of most of the other herbicide treatments. While the reasons for this yield loss where thick 'carpets' of volunteer perennial ryegrass established were not investigated, this phenomenon is an obvious concern for seed growers shifting toward non-burn management.

Table 3. Effect of crop residue removal method on seed yield of two perennial ryegrass varieties, 1990 and 1991.

Crop Residue Removal Method	Pleasure 1990	Pleasure 1991	Regal 1990	Regal 1991
	(lb/a)			
Avg. over 14 Herbicides				
Crew-Cut	1471	1567	1398	1330
Flail Chop	1513	1504	1464	1385
Bale-Only	1394	1580	1406	1312
Field Burn	1451	1680	1421	1523
Propane	1442	1554	1365	1504
LSD 0.05	234	136	98	108
No-Herbicide Checks				
Crew-Cut	*1202	*1330	1487	1186
Flail Chop	*1185	1471	1433	1377
Bale-Only	1291	+1408	*1239	1380
Field Burn	1520	1679	1521	1433
Propane	1413	1623	*1572	1438
LSD 0.05	350	296	242	301

+,* Within the same crop residue removal method, yield of the untreated check differs from that of the 14-herbicide average at the P=0.10 or 0.05 level, respectively.

There were no consistent differences among PRE Goal, Prowl, Dual, and Treflan in Pleasure perennial ryegrass seed yield (Table 4). In the Regal stand, PRE Dual followed by POST Diuron or Goal plus Diuron reduced seed yield in 1990 when averaged over all residue removal methods. In 1991, PRE Dual caused very severe visual damage to perennial ryegrass during the harsh winter. Damage was more striking when the POST treatment following PRE Dual was Goal plus 1.2 lb ai/a Diuron rather than 1.6 lb ai/a Diuron without Goal. There was an interesting interaction between residue removal method and Dual treatment for 1991 Regal seed yield. In the BO and FC plots, Dual followed by Diuron averaged 1564 lb/a of seed, significantly outyielding the overall average for all other treatments involving Dual, 1388 lb/a of seed. Dual followed by Diuron treatment in BO and FC apparently caused a roughly optimal amount of injury, possibly similar to the effect of fire in the FB and PP plots. While it would probably be difficult to reliably repeat an 'optimal' amount of injury, it is useful to know that the best treatments in relation to seed yield are not necessarily those showing the least visual foliar injury.

Table 4. Effect of herbicide treatment on seed yield of two perennial ryegrass varieties, 1990 and 1991.

Treatment	Pleasure 1990	Pleasure 1991	Regal 1990	Regal 1991
	(lb ai/a)			
PRE Herbicide Main Effects[1]				
0.25 Goal	1521	1591	1470	1406
2.0 Prowl	1449	1624	1469	1485
1.5 Dual	1487	1612	1310	1423
2.0 Treflan[2]	1414	1612	1382	1401
LSD 0.05	86	86	72	92
POST Herbicide Main Effects[3]				
0.125 Goal + 1.2 Diuron	1476	1611	1411	1447
1.6 Diuron	1459	1609	1404	1410
LSD 0.05	61	61	51	65
Selected Treatment Combinations				
PRE 0.25 Goal/ POST 0.125 Goal +1.2 Diuron	1542	1612	1419	1487
POST 0.25 Goal +0.2 Kerb	1192	1416	1387	1325
PRE 1.5 Dual/ POST 1.6 Diuron	1459	1583	1315	1449
PRE 2.0 Prowl/ POST 0.125 Goal +1.2 Diuron	1450	1578	1532	1504
PRE 2.0 Prowl/ POST 0.125 Goal +0.5 Sencor	1429	1655	1353	1412
PRE 2.0 Prowl	1500	1592	1490	1285
Untreated	1332	1502	1450	1363
LSD 0.05	122	122	102	130

[1]Avg. over POST Diuron and Goal+Diuron.
[2]Balan applied to Regal in 1990.
[3]Avg. over all 4 PRE herbicides.

Averaging over all PRE herbicides, POST application of the full rate of Diuron or a tank-mix of Goal plus reduced rate of Diuron had similar effects on seed yield, averaging within 16 lb/a of seed over all four tests. Given that in some cases the Goal plus Diuron tank-mix was slightly more effective in controlling volunteer perennial ryegrass, the general absence of differences in seed yield between these two POST treatments is encouraging.

The Goal plus Kerb treatment reduced seed yield compared to the best herbicide treatment in each test, but less severely than was expected based on degree of foliar damage during the winter. In any individual test, several herbicide treatments produced equivalently high yields. The only treatment consistently in the highest yielding group in all 4 tests, however, was PRE Prowl followed by POST Goal plus 1.2 lb ai/a Diuron. Treatments falling into the highest yielding group in 3 out of 4 tests included PRE Prowl by itself, PRE Prowl followed by POST Goal plus 0.5 lb ai/a Sencor, PRE Goal followed by POST Goal plus 1.2 lb ai/a Diuron, and PRE Dual followed by POST 1.6 lb ai/a Diuron. However, PRE Prowl by itself controlled only an average of 84% of the volunteer perennial ryegrass, which would be unsatisfactory in most cases. Similary, PRE Goal followed by POST Goal plus Diuron controlled only an average of 83% of the volunteer perennial ryegrass.

Perennial ryegrass appears quite resilient, and can tolerate serious foliar injury during the winter with only minor effects on seed yield. Indeed, some of these effects may even be beneficial. Treatments including PRE Dual followed by some POST herbicide will provide best control of perennial ryegrass germinating early from cracks in the soil, but at a risk of moderate crop injury. PRE Prowl followed by POST Goal plus Sencor provides similar control at similar risk. PRE Prowl followed by POST Goal plus Diuron is safer, but more likely to miss the early germinating volunteers coming from cracks in the soil. CC improves control of volunteer perennial ryegrass compared with FC and BO residue removal. Yield advantages to burning existed in only 1 out of 4 tests. Allowing volunteer seedlings to form dense 'carpets' in non-burned perennial ryegrass stands can seriously reduce seed yields.

TALL FESCUE RESPONSE TO CROP RESIDUE REMOVAL METHODS AND HERBICIDE TREATMENTS

G.W. Mueller-Warrant, W.C. Young III, and M.E. Mellbye

The legislative agreement to phase down field burning will inevitably increase growers' reliance on herbicides and mechanical methods to control weeds in established perennial grasses grown for seed. Dramatic differences exist between burned and non-burned fields in both densities and patterns of emergence of various weeds, including volunteer crop seedlings. Differences may also exist in regrowth vigor, tiller number, and tiller size class distribution of the established crop. It is therefore necessary to examine both weed control efficacy and crop tolerance of proposed herbicide and residue removal treatments.

A two-year study was initiated in 1989 to compare the effects of 15 herbicide treatment sequences in combination with five post-harvest residue removal methods in two tall fescue stands, one Martin and one Rebel II. The dominant weed at both sites in both years was volunteer tall fescue seedlings. Herbicide treatments were applied as subplots 8 ft. wide by 20 ft. long within residue removal mainplots, with four replications per site. All treatments except the no-herbicide checks were applied to the same plots in both years of the study. Locations of the untreated checks were shifted in the second year due to establishment of excessive numbers of seedlings in the checks during the first year. Success in controlling volunteer tall fescue was evaluated by examining 300 separate 1-inch square locations per plot for the presence or absence of seedlings. This estimate of volunteer tall fescue ground cover was then converted to percent control relative to cover in the bale-only check, which was usually the weediest treatment.

Crop residue removal for all plots started after harvest with raking the straw and baling. The bale-only (BO) plots received no further treatment other than herbicide application. The flail chop (FC) plots were cut to a 3-inch stubble height after baling. The crew-cut (CC) plots were cut to a 1-inch stubble height with a flail head, the material collected in a stackwagon and removed. CC was done more aggressively in the second year, scalping some of the plants and reducing crop height on through much of the growing season. The propane flame (PP) plots were burned once at 3 mph. Field burning (FB) was simulated by two separate passes with the propane flamer in the first year, and by spreading the full straw load back on the plots and igniting it with the propane flamer in the second year.

Preemergence (PRE) herbicides were applied October 16 and 24, 1989, and October 16 and 23, 1990, to the Martin and Rebel II stands. Postemergence (POST) herbicides were applied December 1, 1989, and December 7 and 5, 1990, to the same stands. Volunteer tall fescue emergence was underway when the PRE herbicides were applied in the second year of the study, but not in the first. Volunteer tall fescue was slightly larger at time of POST herbicide application in the second year of the study than in the first.

The 15 herbicide treatments included a factorial combination of four PRE with two POST herbicide treatments, a no-herbicide check, and six other treatments where PRE Prowl was followed by additional POST treatments. Prowl was selected over Goal, Dual, and Treflan as the PRE herbicide in these additional treatments because of its better performance in preliminary testing. Data presented in the tables includes main effects of residue removal methods when averaged over the 14 herbicide treatments excluding the check, values for the untreated (no-herbicide) checks in each of the residue removal methods, and main effects of herbicides when averaged over all five residue removal methods. The herbicide main effects are presented as means for the four PRE treatments averaged over two POST treatments, means for the two POST treatments averaged over four PRE treatments, and six of the 15 individual treatments, two of which are also part of the PRE by POST factorial. The three least interesting treatments are omitted from the herbicide effects tables. Except for the untreated checks, interactions between residue removal methods and individual herbicide treatments are not presented.

Weed Control

In the absence of herbicides, residue removal methods generally reduced but did not eliminate volunteer tall fescue (Table 1). In 1990, FB was no better than PP with or without herbicides, but this is not surprising since FB in the first year was simulated by merely making two passes with the propane flamer. In 1991, an actual FB was much more effective than PP, providing over 99% control when combined with herbicides and over 90% control even without herbicides. The only non-burn treatment to rival FB was CC for 1991 Martin, which gave 86% control without herbicides and over 99% control with them. Among the non-burn treatments, although CC was always better than FC or BO without herbicides, this was not always the case when combined with herbicides. FC was generally similar to BO, but did give better volunteer control for 1990 Rebel II.

Volunteer ground cover was higher in the Rebel II field than the Martin, and higher in the second year of the study than the first. This trend toward increased weediness in succeeding years in non-burned stands was also seen in an increase from 1990 to 1991 in percent ground cover by "year-old" tall fescue plants between the rows (data not shown). One major difference between the Martin and the Rebel II stands at the start of the experiment in 1989 was the existence for Rebel II of a large number of "year-old" plants between the rows, presumably originating from seedlings not controlled in the 1988-89 growing season.

Table 1. Effect of crop residue removal method on volunteer control in two tall fescue varieties, 1990 and 1991.

Crop Residue Removal Method	Martin 1990	Martin 1991	Rebel II 1990	Rebel II 1991
	(% control vs Bale-only check)			
Avg. over 14 Herbicides				
Crew-Cut	97.4	99.3	90.8	97.2
Flail Chop	91.6	92.4	92.0	75.5
Bale-Only	94.2	90.4	75.1	75.1
Field Burn	95.7	99.3	95.7	99.1
Propane	96.0	97.3	95.8	90.6
LSD 0.05	3.8	5.4	4.0	6.6
No-Herbicide Checks				
Crew-Cut	14.8	86.1	57.3	55.9
Flail chop	-21.9	6.9	37.1	5.1
Bale-Only	0.0	0.0	0.0	0.0
Field Burn	34.9	95.6	49.0	92.7
Propane	41.5	48.2	55.9	46.9
LSD 0.05	9.9	8.7	9.1	10.7
LSD 0.05 (check vs 14 herbicide avg.)	6.5	4.9	6.4	6.5
Bale-only check % volunteer ground cover:	37.8	45.8	64.8	82.7

All four PRE herbicides performed quite similarly in the Martin stand, with a slight advantage to Prowl over Dual in 1991 (Table 2). Prowl and Goal were better than Dual and Treflan in the Rebel II stand both years. Application of POST Diuron and Goal+Diuron improved control over that of Prowl alone in all cases except possibly that of 1990 Rebel II. Prowl was the only PRE herbicide that was also applied without a sequential POST in these tests, but other studies have shown that Dual requires some type of sequential POST treatment to achieve a reasonable degree of success, while PRE Goal applied alone can sometimes work nearly as well as Prowl.

Table 2. Effect of herbicide treatment on volunteer control in two tall fescue varieties, 1990 and 1991.

Treatment	Martin 1990	Martin 1991	Rebel II 1990	Rebel II 1991
(lb ai/a)	(% control vs Bale-only check)			
PRE Herbicide Main Effects[1]				
0.25 Goal	93.6	97.2	90.0	88.8
2.0 Prowl	94.7	97.3	91.3	91.1
1.5 Dual	95.9	95.2	87.3	83.7
2.0 Treflan[2]	94.1	97.0	84.3	85.8
LSD 0.05	2.8	2.1	2.8	2.8
POST Herbicide Main Effects[3]				
0.125 Goal + 1.6 Diuron	97.4	98.2	91.6	88.9
2.4 Diuron	91.8	95.2	84.9	85.8
LSD 0.05	2.0	1.5	1.9	2.0
Selected Treatment Combinations				
PRE 0.25 Goal/ POST 0.125 Goal +1.6 Diuron	97.0	98.5	94.3	90.1
POST 0.25 Goal +2.4 Diuron	98.5	96.8	90.9	77.8
PRE 2.0 Prowl/ POST 0.125 Goal +1.6 Diuron	97.9	98.5	92.8	91.4
PRE 2.0 Prowl/ POST 0.125 Goal +0.75 Sencor	98.0	98.4	93.4	90.0
PRE 2.0 Prowl	86.9	89.9	90.4	84.9
Untreated	13.9	47.4	39.8	40.1
LSD 0.05	4.0	3.0	3.9	4.0

[1]Avg. over POST Diuron and Goal+Diuron.
[2]Balan applied to Martin in 1990.
[3]Avg. over all 4 PRE herbicides.

Following all four PRE herbicides at both sites in both years, the POST tank-mix of Goal plus 1.6 lb ai/a Diuron controlled volunteer tall fescue more effectively than POST application of 2.4 lb ai/a Diuron without Goal. POST application of 0.25 lb ai/a Goal plus 2.4 lb ai/a Diuron without any PRE herbicide controlled seedlings as well as the best other treatments in both years in the Martin stand. In the Rebel II stand in 1991, however, this treatment performed more poorly than most other treatments, including PRE Prowl by itself.

The best weed control in both years at both sites was given by PRE Goal followed by POST Goal plus Diuron, PRE Prowl followed by POST Goal plus

Diuron, and PRE Prowl followed by POST Goal plus Sencor (or Lexone). Although no specific seed certification standards govern the amount of volunteer tall fescue that can be tolerated, 93 to 97% control at the densities encountered in these tests would meet standards equivalent to those for perennial ryegrass.

Crop Tolerance and Seed Yield

These two tall fescue stands differed in their seed yield response to burn versus non-burn management. Whether these differences were only variety effects or were also related to year, soil type, crop density, or pre-existing between-row weediness is unclear. When treated with herbicides, FC, BO, and CC all outyielded FB and PP in Martin tall fescue in 1990 (Table 3). In that test, the no-herbicide checks for FC and BO also outyielded that for PP. In the 1991 Martin test, herbicide-treated CC yielded about 150 lb/a less seed than the other four residue removal methods, which did not differ among themselves. In the same test, the no-herbicide CC outyielded herbicide-treated CC, whereas yield for FP and PP plots were virtually identical without or without herbicide treatment.

Table 3. Effect of crop residue removal method on seed yield of two tall fescue varieties, 1990 and 1991.

Crop Residue	Martin		Rebel II	
Removal Method	1990	1991	1990	1991
	(lb/a)			
Avg. over 14 Herbicides				
Crew-Cut	1240	920	1553	1231
Flail Chop	1264	1090	1605	1343
Bale-Only	1284	1074	1569	1322
Field Burn	1179	1071	1632	1430
Propane	1171	1056	1579	1432
LSD 0.05	54	79	79	124
No-Herbicide Checks				
Crew-Cut	1152	*1159	+1366	*1534
Flail chop	1345	1134	1546	1388
Bale-Only	1359	+1189	1624	1378
Field Burn	1280	1074	1697	+1559
Propane	1144	1083	1626	+1568
LSD 0.05	196	192	318	260

+,* Within the same crop residue removal method, yield of the untreated check differs from that of the 14-herbicide average at the P=0.10 or 0.05 level, respectively.

In 1990 Rebel II, CC yielded less than FB but did not differ from PP. In 1991 Rebel II, CC yielded 200 lb/a less seed than FB or PP. In that test, herbicide treatment depressed seed yield of CC by about 300 lb/a and yield of FB and PP by about 130 lb/a. CC seriously scalped the tall fescue at both sites in the second year. The aggressiveness of CC for the 1990-91 growing season apparently improved the control of weeds at a cost of increased crop sensitivity to herbicides and decreased yield.

Application of PRE Goal clearly decreased seed yield compared to the other PRE herbicides in three out of four tests (Table 4). Including all four tests, this yield loss averaged over 100 lb/a of seed. There were no consistent differences in seed yield among PRE Prowl, Dual, and Treflan. POST application of a full rate of Diuron or a tank-mix of Goal plus a reduced rate of Diuron had identical effects on seed yield, averaging within 1 lb/a of seed over all four tests. Given that the Goal plus Diuron tank-mix was so much more effective in controlling volunteer tall fescue, the absence of any differences in yield between these two POST treatments is extremely encouraging.

In terms of seed yield, the safest treatment among all 14 herbicide treatment sequences was PRE Prowl without any POST follow-up. Averaging over all four tests, this treatment yielded with 4 lb/a of seed of the untreated check. However, PRE Prowl by itself had only controlled an average of 88% of the volunteer tall fescue, which would probably be unsatisfactory in the early life of a stand. Within the group of treatments that also provided the best weed control, the two highest yielding treatments were PRE Prowl followed by POST Goal plus 1.6 lb ai/a Diuron and PRE Prowl followed by POST Goal plus 0.75 lb ai/a Sencor. Dual or Treflan followed by POST Goal plus Diuron also yielded well in all tests, but neither of those two treatments controlled volunteer seedlings as well as the Prowl sequences at the Rebel II site. The POST-only treatment of Goal plus 2.4 lb ai/a Diuron reduced yield relative to the untreated check at both sites in 1991, along with failing to control volunteer tall fescue well enough at the Rebel II site both years.

In conclusion, it appears that some minor yield losses due to herbicides must be tolerated to achieve adequate weed control. The best of the herbicide treatment sequences were able to control weeds with only 40 to 50 lb/a of seed yield loss relative to the no-herbicide checks. Other less optimal treatments caused an additional 100 lb/a of seed yield loss in the process of achieving the same degree of weed control. Effects of residue removal methods on seed yield were variable from year to year and site to site. CC improved weed control over other non-burn methods, but showed the potential to decrease seed yield and increase crop sensitivity to herbicides. Refinements to the CC process regarding when it is done and the severity of crown removal should be pursued, with the goal of retaining its weed control benefits while minimizing adverse effects on yield.

Table 4. Effect of herbicide treatment on seed yield of two tall fescue varieties, 1990 and 1991.

Treatment	Martin 1990	Martin 1991	Rebel II 1990	Rebel II 1991
	------------------- (lb/a)	-----------------		
PRE Herbicide Main Effects[1]				
0.25 Goal	1134	948	1541	1240
2.0 Prowl	1278	1049	1561	1365
1.5 Dual	1216	1106	1630	1399
2.0 Treflan[2]	1227	1077	1580	1382
LSD 0.05	61	57	100	74
POST Herbicide Main Effects[3]				
0.125 Goal + 1.6 Diuron	1206	1040	1588	1348
2.4 Diuron	1221	1051	1569	1346
LSD 0.05	43	40	71	52
Selected Treatment Combinations				
PRE 0.25 Goal/ POST 0.125 Goal +1.6 Diuron	1123	954	1514	1262
POST 0.25 Goal +2.4 Diuron	1202	1025	1563	1353
PRE 2.0 Prowl/ POST 0.125 Goal +1.6 Diuron	1283	1053	1568	1382
PRE 2.0 Prowl/ POST 0.125 Goal +0.75 Sencor	1212	1057	1596	1359
PRE 2.0 Prowl	1261	1105	1626	1432
Untreated	1255	1128	1571	1486
LSD 0.05	87	80	141	104

[1]Avg. over POST Diuron and Goal+Diuron.
[2]Balan applied to Martin in 1990.
[3]Avg. over all 4 PRE herbicides.

ANNUAL BLUEGRASS AND RATTAIL FESCUE CONTROL UNDER NONBURNING SYSTEMS OF RESIDUE MANAGEMENT

M.E. Mellbye, W.C. Young III, T.B. Silberstein, and G.W. Mueller-Warrant

Annual bluegrass and rattail fescue are common contaminants reported by the OSU Seed Laboratory in Willamette Valley grass seed. This field trial was initiated to evaluate the effect of stubble management and herbicide treatments on the contamination of these two weeds in harvested seed from a field of established Derby perennial ryegrass. Results reported here are from the second year of the study.

Three post-harvest residue management treatments were applied in early September, 1990, following seed harvest and removal of straw by baling. Residue management systems were: (1) propane flame, (2) crewcut, and (3) reclip and rake. Each residue management plot was 30 x 112 ft, and was replicated 3 times as main plots in a split-plot design with herbicide treatments as sub-plots.

Five herbicide treatments (listed below) were applied across each residue management block in 7 x 30 ft plots. Preemergence treatments (PRE) were applied October 4 to dry, warm soil (71F); early postemergence treatments (EPOST) were applied November 12; and postemergence treatments (POST) were applied December 13, 1990. In addition, an unsprayed check plot was maintained in each main plot. The soil type was a Bashaw silty clay loam, pH 4.9, and organic matter content of 5.4%.

1. Goal 1.5EC at 1 pt/a - PRE
   Goal at 1 pt/a + Karmex 80W at 2 lb/a - EPOST
2. Goal at 1 pt/a - PRE
   Karmex at 1 lb/a + Sencor 75DF at 0.75 lb/a - EPOST
3. Dual 8EC at 1.5 pt/a - PRE
   Goal at 1 pt + Karmex at 1.5 lb/a - POST
4. Kerb 50W at 0.4 lb/a + Goal at 1 pt/a - PRE
   Karmex at 1.5 lb/a - POST
5. Prowl 4 EC at 2 qt/a - PRE
   Goal at 1 pt + Karmex at 1.5 lb/a - POST

Visual ratings of seedling grass control (0-100%) were made May 5, 1991. Plots were harvested for seed yield on July 22. Field run samples were taken prior to cleaning for purity analysis at the OSU Seed Laboratory. These samples were comparable to combine threshed seed.

Results are reported in Table 1. An important question in this study was, does the degree of residue removal affect annual bluegrass and rattail fescue control under non-burning systems of stubble management. Specifically, was there a significant benefit to the more complete removal accomplished with the crewcut or vacuum approach, or would a less expensive but less thorough method such as the reclip and rake system suffice. In this trial, residue management had significant effects on overall seedling grass control and on annual bluegrass impurity levels in the field run samples. On average, the best visual control and cleanest seed was obtained where herbicides were applied on the crewcut treatment. And, over the two year course of this study, the most consistent weed control, especially of annual bluegrass, was obtained from the crewcut system.

Table 1. Effect of residue management and herbicides on seed yield and purity of field run samples, Derby perennial ryegrass, 1991.

Treatment	Seed Yield	Seedling Grass Control	Field Run Purity Annual Bluegrass	Field Run Purity Rattail Fescue
	(lb/a)	(%)	------(%) -----	
Residue Management[1]				
Propane	1160	92	3.3	0.12
Crewcut	1270	98	1.2	0.098
Re-clip & Rake	1250	82	3.2	0.28
LSD 0.05	NS	9*	2.2*	NS
Herbicide[2]				
Unsprayed Check	860	0	18	7.3
Goal/Goal+Karmex	1330	97	1.1	0.14
Goal/Karmex+Sencor	1205	66	8.6	0.50
Dual/Goal+Karmex	1190	96	2.9	0.10
Kerb+Goal/Karmex	1210	98	1.0	0.10
Prowl/Goal+Karmex	1220	98	0.68	0.08
LSD 0.05	124	11*	1.4*	3.5

[1]Residue management averaged over herbicide treatment and unsprayed check plots.
[2]Herbicide treatments averaged over residue management main plots.
* Residue Management x Herbicide interaction significant at $P<0.05$ probability level.

Residue management did not have significant effects on seed yield, but in both years the crewcut and reclip and rake treatments had slightly higher yields than propane flaming. These results support observations from other trials that less thorough and less expensive methods of stubble management after baling can maintain seed yields comparable to the crewcut approach if done in a timely manner.

Herbicide treatments significantly increased seed yield and quality over the unsprayed check (Table 1). The best treatment overall was Prowl applied preemergence followed by a December application of Goal plus Karmex. This treatment provided excellent rattail control and the best residual control of annual bluegrass into spring. Still, even from the crewcut plots, small amounts of annual bluegrass (0.3%) were found at harvest in the purity analysis.

The registered treatment of Goal followed by Goal plus Karmex provided good control, and the highest seed yield was obtained from this treatment. The treatments that included Dual and Kerb also provided good control, but Dual was not as consistent as Prowl or Kerb as a preemergence material. Data from both years of this trial and from other research suggest that Prowl and Goal have greater crop safety as preemergence treatments in perennial ryegrass than Dual and Kerb.

The least effective herbicide program in reducing impurity levels was the Goal/Karmex + Sencor treatment. Goal plus Karmex and Goal plus Sencor were both more effective on annual bluegrass and rattail fescue than a tank mix of Karmex plus Sencor at the rates used in this trial.

Herbicide treatments varied in their effectiveness across the different residue management practices, resulting in significant herbicide x residue management interactions (Table 2). The herbicide treatment that included Kerb performed the most consistently across different stubble practices (Crewcut 99%, Rake 98% control), while the Karmex plus Sencor treatment fell apart on the reclip and rake system (Crewcut 92%, Rake 36% control). There was a moderate but significant decline in the performance of the other herbicide treatments on the reclip and rake stubble management treatment. For example, the herbicide treatment that included Prowl provided 100% control on the crewcut plots but dropped to 94% on the reclip and rake treatment.

Table 2. Interaction of residue management and herbicide treatment on seedling grass control and poa contamination in field run samples, Derby Perennial Ryegrass, 1991.

Herbicide	Residue Management Propane	Residue Management Crewcut	Residue Management Re-clip & Rake
	(% Seedling Grass Control)		
Unsprayed Check	0	13	10
Goal/Goal+Karmex	99	98	93
Goal/Karmex+Sencor	71	92	36
Dual/Goal+Karmex	96	100	91
Kerb+Goal/Karmex	96	99	98
Prowl/Goal+Karmex	100	100	94
LSD .05	19	19	19
	(% Annual Bluegrass-Field Run Purity)		
Unsprayed Check	15.9	13.7	13.1
Goal/Goal+Karmex	1.2	0.7	1.6
Goal/Karmex+Sencor	11.4	3.9	10.5
Dual/Goal+Karmex	3.9	0.9	3.9
Kerb+Goal/Karmex	1.4	0.6	1.0
Prowl/Goal+Karmex	0.8	0.3	1.0
LSD .05	3.8	3.8	3.8

In summary, good control of both annual bluegrass and rattail fescue was achieved in this study with several sequential herbicide treatments, especially when thorough residue removal was accomplished by crewcutting. The best control was obtained when an effective preemergence herbicide such as Prowl was used, although even this treatment failed to completely eliminate annual bluegrass and rattail fescue from the field run samples. While other trials have shown that acceptable volunteer control can be obtained on less thorough systems of post-harvest residue management, control of annual bluegrass and other troublesome weeds may require either more aggressive herbicide programs or more complete residue removal.

EFFECT OF STUBBLE CLIPPING HEIGHT ON OLDER TALL FESCUE STANDS

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

The amount of stubble left on fields following straw removal by baling can be considerable, and is known to interfere with fall tiller development. Several methods of stubble reduction (e.g., raking, flail chopping, and vacuum sweeping) are currently used by growers to minimize the impact of stubble remaining around the crowns in the stand of baled fields. In addition, as stands age, the overall impact of residue removal methods may have differential effects on crop productivity.

The balance between the amount of stubble remaining and the plant's ability to initiate efficient fall regrowth for the subsequent seed crop is not well understood. Thus, a preliminary study was established in 1990 following harvest of the fifth seed crop in four tall fescue varieties grown at the Hyslop Crop Science Field Laboratory near Corvallis. Each variety had been seeded separately in a large block (200 x 150 ft) in August 1985 for a long-term study investigating row spacing, rate and time of spring nitrogen application, and presence or absence of burning. Varieties planted in this trial were: Fawn, an early maturing forage cultivar, and Falcon, Rebel and Bonanza (early, medium and late maturing, respectively) turf-type cultivars.

Following seed harvest of plots in July 1990, straw was immediately removed from all blocks by flailing into a wagon for transport from the site. A uniform stubble condition similar to the aftermath of baling remained throughout the summer, with some regrowth occurring prior to the establishment of the planned treatments. Two late-season stubble reduction treatments were applied September 25-27 using a vacuum sweep machine developed by Rear's Manufacturing in Eugene, Oregon. This unit, incorporating a brush and flail mechanism, enabled stubble to be clipped and removed ("crew-cut") at heights of 1.0 and 2.5 inches. In our analysis these treatments were compared with the simulated bale-only treatment (stubble flailed to a height of 4.0 inches) accomplished after seed harvest.

Data collected from plots during 1990-91 crop year were analyzed using a split-split-plot design to account for any interaction between 1990 post-harvest treatments and historical management (row spacing and 1986-89 residue management).

Seed yield was significantly affected by the level of stubble removal in all varieties except Falcon (Table 1). In general, however, any late-season removal of stubble reduced yield. Also note that the 1990 residue management of Bonanza significantly interacted with row spacing. In this interaction, an older stand growing in narrower rows was more adversely affected than stands established in wider rows (Table 2). This effect was significant regardless of the 1990 post-harvest management with, the magnitude of the yield reduction most evident when stubble was crew-cut to 2.5 inches.

Table 1. Seed yield of four tall fescue varieties as influenced by 1990 stubble management, row spacing and historical residue management - 1991.

Treatment	Fawn	Falcon	Rebel	Bonanza
	----------	(lb/a)	----------	
1990 Stubble Management				
Flail chop 4.0 in.	1265	816	825	1103
Crew-cut 2.5 in.	1146	738	639	842
Crew-cut 1.0 in.	1024	764	678	845
LSD 0.05	68	NS	65	*1
Row Spacing				
12 in.	1137	735	695	821
24 in.	1152	809	733	1039
LSD 0.05	*2	NS	NS	*1
1986-89 Residue Management				
Propane Burn	1128	746	670	926
Flail Chop	1161	799	758	934
LSD 0.05	*2	NS	61	NS

*1 Significant stubble management x row-spacing interaction $P<0.05$.
*2 Significant row-spacing x prior residue interaction significant $P<0.05$

Table 2. Interaction of 1990 stubble management and row spacing on seed yield of Bonanza tall fescue, 1991.

	1990 Stubble Management		
Row Spacing	Flail chop 4.0 in.	Crew-cut 2.5 in.	Crew-cut 1.0 in.
	--------------(lb/a)------------------		
12 in.	1029	639	797
24 in.	1177	1045	894
LSD 0.05	75	75	75

Fertile tiller density of Fawn and Bonanza was also reduced when stubble was cut short (Table 3), similar to the seed yield reductions noted above. Tiller number was not affected by stubble management in Falcon or Rebel. Also of interest is that all four varieties produced more fertile tillers per unit area when grown at wider row spacing. Historical residue management practiced at these sites had no effect on fertile tiller population.

Table 3. Fertile tiller population of four tall fescue varieties as influenced by 1990 stubble management and row spacing, 1991.

Treatment	Fawn	Falcon	Rebel	Bonanza
	---------(number/sq yd)---------------			
1990 Stubble management				
Flail chop 4.0 in.	351	278	198	378
Crew-cut 2.5 in.	363	215	182	251
Crew-cut 1.0 in.	255	270	186	218
LSD 0.05 (0.10)	(85)	NS	NS	127
Row Spacing				
12 in.	283	180	155	215
24 in.	363	328	223	351
LSD 0.05	61	80	54	75

Results from this preliminary investigation suggest that older stands of tall fescue are sensitive to close clipping of stubble. Cutting stubble too low resulted in less fall regrowth and fewer fertile tillers. In addition to low clip height, applying these treatments in late September may have magnified the detrimental effects relative to more timely use of the vacuum sweep technique. In this situation (older stands with straw removal in mid-July), the less intensive, simulated bale-only treatment was higher yielding when compared to later applied secondary stubble management practices.

POST-HARVEST RESIDUE MANAGEMENT EFFECTS ON SEED YIELD IN FINE FESCUE SEED PRODUCTION

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

Crop yield reductions resulting from increased residue left on a creeping red fescue (cv Cindy) in 1990 were primarily associated with lack of fertile tiller development. In order for fall regrowth to produce mature fertile tillers, the type and position of new vegetative growth is important. Tillers starting higher in the canopy, due to the presence of crop residue and vegetative tillers from the previous year will not develop as well as basal tillers formed out of the plant's crown. Results from 1991 are reported is this article.

In order to understand the effects of the different post-harvest residue treatments over time, this experiment will continue through harvest 1992 to provide data over three sequential years. This multiple year study will help determine what alternative residue management practices are effective on fine fescue and can be implemented to lieu of open field burning as the acreage of allowed burning decreases. In addition, a second field planted in spring 1989 to a chewings fescue (cv Center) was included in the study in the fall of 1990, and will be evaluated with similar treatments for the 1992 crop year, providing two years of data. First-year residue treatment effects on Center fine fescue are discussed in this article.

Post-harvest residue treatments were applied in 1990 following seed harvest over the same plots as 1989 treatments in Cindy fine fescue. Five treatment plots were arranged in a randomized complete block design with four replicates. Each plot was 23 feet by 150 feet to allow for swathing and combining at least a full swath width. First-year residue management treatments were applied to the Center field with a similar experimental design. Plots at the Center field were 22 feet by 120 feet and the late open burn treatment was not included. Treatments established and dates of application are listed in Table 1.

Table 1. Post-harvest residue treatment application dates, 1990.

Residue treatment	Date of application	
	Cindy	Center
1) Early open burn	August 16	August 28
2) Late open burn	September 14	not included
3) Propane burn	August 16	August 28
4) Crew-cut	September 7	September 7
5) Flail chop	September 7	September 7

Straw on open burn plots was spread by combine. On all other plots, straw was either baled (Cindy) or raked off (Center) prior to residue treatments. Open burn treatments were ignited and full straw load was allowed to burn freely, simulating an open field burn. The propane burn plot was passed over at 3 - 5 MPH with a standard Rear's field flamer pulled behind a tractor. The crew-cut treatment was applied using a Rear's crew-cutter equipped with brushes to loosen and remove chopped and loose residue into an attached container. Cutting height of the crew-cutter was set to leave 1 inch or less of stubble. The flail chop treatment was performed using a Brady chopper set to flail the stubble 3 - 4 inches tall. The flail treatment returned residue to the ground. All other cultural practices were handled by the cooperating farmers.

Plots were swathed and harvested by the farmer. A full swath width was taken down the middle of each plot. Combine output for each plot was collected into 30-gal garbage cans and weighed. Sub-samples of approximately 300 grams were taken from each plot to assess cleanout and thousand seed weight. Percent cleanout of the sub-samples was used to convert the actual combine yield to an equivalent clean seed yield. All plots were swathed mid July and combined on July 22 and August 3 for Cindy and Center, respectively.

The flail chop treatments left the greatest level of crop residue and effectively covered the crown area with straw, forcing any new tillers to elongate much further than other treatments before reaching light. Fertile tiller number, the factor with the greatest influence on seed yield, was significantly decreased in the Cindy field (Table 2) and showed a trend for reduction in Center with the flail chop treatment (Table 3). The decrease in fertile tiller number is consistent with results observed in 1990 (Ext/Crs 83 p.10). Seed yield responses to treatments indicates residue removal by open burn, propane burn and crew-cutting are similar as contrasted with the flail chop treatment which reduced yield. The observed differences in yield may be a response to the amount and type of light on the crown caused by the level of residue left rather than the effect of a thermal treatment such as burning.

Table 2. Effect of residue management on seed yield, fertile tiller number and potential seed number on Cindy creeping red fescue, 1991.

Residue treatment	Seed yield	Fertile tillers	Potential seeds
	(lb/a)	(no./sq yd)	(000's/sq yd)
Early Open Burn	853	1650	73.2
Late open Burn	729	1463	62.8
Propane Burn	786	1492	67.3
Flail Chop	444	928	38.0
Crew-cut	799	1815	67.7
LSD 0.05	78	433	7.2

Table 3. Effect of residue management on seed yield, fertile tiller number and spikelets per panicle on Center chewings fescue.

Residue treatment	Seed yield	Fertile tillers	Spikelets per panicle
	(lb/a)	(no./sq yd)	(no./pan)
Early Open Burn	1033	1623	45
Propane Burn	1071	1638	53
Flail Chop	952	1331	46
Crew-cut	1031	1856	37
LSD 0.05	70[1]	NS	7

[1]P value= 0.074, LSD reported at 0.10

In this second year of study the cumulative detrimental effect of crop residue was even more apparent. In this year's first harvest of Center the flail chop affected yield at a $P < 0.10$. Also as a note of interest, the capability of the plant to compensate for lack of, or excessive, growth can be seen in the results from the spikelets per panicle variable with Center (Table 3). In the crew-cut treatment, though the fertile tiller number was large, the number of spikelets per panicle was decreased significantly and may have limited yield by compensating these two factors.

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EFFECTS OF POST-HARVEST RESIDUE MANAGEMENT ON KENTUCKY BLUEGRASS SEED YIELD AND SEED QUALITY IN CENTRAL OREGON

D.D. Coats, W.C. Young III and F.J. Crowe

A two year survey was conducted to determine the influence of various treatments on crop growth and development, and seed yield of Kentucky bluegrass (*Poa pratensis* L.) in central Oregon. Initially, ten sites were selected representing three stand ages and three variety types. Treatments included close-clipping, close-clipping with propane flaming, bale only (no stubble management), and *in situ* burning of stubble remaining following baling (field treatment). At four of the ten sites sheep were fenced into one-half of each plot thus, superimposing grazing over the various main treatments. The second year, three of the ten sites were selected for the final phase. Second year treatments were as the first, with the inclusion of a flail-chop treatment.

Seed yields were expressed as a percent of the field treatment. Over all testing sites for the first year, close-clipping with propane was 93% of that of field treatment, followed by close-clipping at 85%, and 70% for the bale-only treatment. Seed yield of the five treatments (flail-chop added in 1990-91) in the second year was 112%, 97%, 93%, and 74% for close-clip and propane, close-clip, flail-chop, and bale-only treatments, respectfully.

Age of Stand: Seed yield decreased with increasing stand age. For the 1989-90 crop year, seed yield of second-year stands showed only 3% variation among the close-clipped, close-clipped with propane, and field treatments. The bale-only treatment, however, yielded 63% of field treatments. For third-year stands, the close-clipped with propane and bale-only treatments differed little in seed yield (77% of field treatment) and were between the close-clipped (54% of field treatment), and field treatment. Fourth-year stands were consistent with those of second-year stands where the bale-only treatments were lower yielding followed by, close-clip, close-clip with propane and field treatment.

1990-91 crop year showed the close-clip with propane treatment and the close-clip treatment both out-performing the field treatment with 122%, and 106% respectfully on the third-year stands. The flail-chop and the bale treatments yielded 95% and 84%, respectfully, of field treatment. For fourth-year stands, flail-chop and close-clip with propane were 89% of field treatment yield, and close-clip followed by bale at 77% and 52%, respectfully, of field treatment yields.

Variety Type: Semi-dwarf varieties out yielded tall and dwarf type cultivars. Dwarf plant types showed less variation among residue treatments. In the tall and semi-dwarf varieties, close-clipped and bale-only treatments yielded less than close-clipped with propane and field treatments (1989-90 crop year only).

Grazed Treatments: In 1989-1990 ungrazed areas out-yielded grazed areas. This results agrees with observations of many growers for that year. In most years, however, these same growers report the opposite effect. Across the treatments an upward trend in both grazed and ungrazed areas was comparable to the overall summary: field treatment yielded the highest, both close-clipped treatments yielded slightly less, and the bale-only treatment yielded least.

Tiller Development: In the 1989-90 crop year fertile tiller development was reduced in the bale-only treatment. Close-clipped and close-clipped with propane treatments were intermediate, with the close-clipped with propane treatment having the greater number of fertile tillers of the two close-clipped treatments. The field treatment resulted in the greatest number of tillers. In 1990-91, the flail-chop and bale treatments had the lowest numbers of tillers. However close-clip with propane and close-clip treatments had higher tiller numbers than the field treatment.

Seed yield decline with stand age has been demonstrated by Canode and Law (1975, 1977), and Evans and Canode (1971), as was observed in our study. Difference in yield by variety type are also well known aspects of Kentucky bluegrass seed production (Hickey and Ensign 1981, Canode and Law 1977), and we also found this in our investigation.

Other treatment trends support general grower experiences and past investigations with respect to open-field burning vs bale-only treatment. The bale only treatments showed etiolated regrowth in the fall which is in agreement with Canode and Law (1975, 1977) as well as Ensign, Hickey and Bernardo (1982) who conducted a study with shading of Kentucky bluegrass. These investigators concluded that seed yield from plants shaded by 62% for 150 days did not differ from plants where the residue was only baled off. Field burning encouraged higher fertile tiller number and yield. This increase was true for the older stands, but was even more pronounced on younger stands. With respect to fertile tiller number and seed yield, variations of close-clipping were intermediate, between the open field burning and the bale-only treatment.

Our observed trends in seed yield among other residue management approaches were similar for grazed and ungrazed areas. When yield among other treatments were averaged together, the ungrazed areas out-yielded the grazed areas by an average of 157 lb/a. We have no immediate explanation for why the ungrazed area was superior in 1989-90, when growers usually report the opposite effect. Grazing seems to be a complicated management practice in terms of the time of year for grazing, the number of animals grazing and length of the grazing period. Grazing was not investigated at in 1990-91 crop year.

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EFFECTS OF ANNUAL RYEGRASS RESIDUE MANAGEMENT ON DAYTON SOIL ORGANIC CARBON DISTRIBUTION AND RELATED PROPERTIES

M.F. Chapin and J.H. Huddleston

Soil organic matter is a major contributing factor responsible for the soil chemical, physical and biological properties. The quantity and composition of soil organic matter found within the soil profile both reflect and control the inherent fertility of a given soil. Understanding the soil organic matter dynamics under different straw residue management systems is essential for informed use of agricultural land.

Management systems which annually burn crop residues minimize the addition of organic residues to soils, and lead to substantial losses of organic carbon (C) and nitrogen (N) from the system through both volatilization and convection of ash particulate in the smoke. If it were not for burning, these nutrients would be otherwise incorporated into the soil and stabilized into the soil organic matter through natural decomposition processes. Thus, annual burning of crop residues can lead to substantial net losses of organic C and N from the surface few cm of a soil, which may cause an associated decrease in the soil's potential to cycle and provide nutrients for plant growth (Skidmore et al., 1986). Conversely, some management systems that incorporate organic residues (e.g. manures, straw residues or sod-like or grass seed crops) may actually increase the soil organic C and N (Biederbeck et al., 1980; Rasmussen et al., 1980).

It has been observed frequently that soils under management systems for which residues are removed by burning or hauling away have lower soil organic C and N concentrations as compared with soils for which straw residues are incorporated into the soil (Rasmussen et al., 1980; Skidmore et al., 1986; Powlson et al., 1989).

Since the development of the grass seed industry in the 1930's open field burning has been the most desirable and effective management used by farmers to remove crop residues and to control weed seed and disease problems. However, because of political and public pressures to minimize the impact on air quality, by the 1970's some farmers opted to incorporate annual ryegrass straw residues into the soil as an alternative method of straw disposal to open burning. The influence of subsequent incorporation of straw residues on soil organic matter levels and long-term fertility prompted this study to investigate the effects of straw residue management systems on the total organic C and N content, biological activity and on the bioavailability of organic C in soils.

Field and Laboratory procedures

Four fields were chosen to represent each of two straw management systems, burn and plow. Each field was located in either Linn or Benton County, on Dayton silt loam soil and planted to annual ryegrass for a minimum of 40 years. Fields slected to represent the burn treatment have been annually burned continuously for 40 to 50 years. Fields selected to represent the plowed treatment were burned continuously for approximately 30 to 40 years, after which they were managed to incorporate straw residues for the next 10 to 20 years. One native site (Cogswell-Foster Preserve, Nature Conservancy) was selected to represent pre-cultivation conditions. All sampling was done after harvest in late summer, but before incorporation or burning of crop residues. Soil samples were collected from the central portion of each genetic horizon, at four different locations at each field.

Prior to laboratory analysis a separate, composite sample (labeled E/transition) was made for each of the four individual sets of samples collected in the field, by combining subsamples of equal weight from each of the master (A_1 and E) and transition (AE) horizons which were located between the Ap and $2Bt_1$ horizon. Two chemical and two biological properties were measured for each of the soil samples collected for the Ap, $2Bt_1$ and E/transition horizons. The chemical properties measured were total organic C and total N. The biological properties measured were microbial enzyme activity (ß-glucosidase) and microbial respiration. Enzyme activity and microbial respiration have been expressed on a per gram C basis to evaluate the effects of management system on C bioavailability. The data were analyzed by hierarchical analysis-of-variance method.

Results and Discussion

Because only one native, uncultivated site was sampled and analyzed, it was not possible to make any kind of statistical evaluation of the effects of cultivation on the amounts and distributions of the chemical and biological properties measured in this study. Nevertheless, the data from the single undisturbed site are presented in Tables 1 through 6 to provide baseline or potential values representative of an undisturbed soil, and to allow some comparisons. These data do suggest that cultivation of a virgin soil does indeed reduce the total organic C, total N, enzyme activity and microbial respiration in the Ap horizon, regardless of management system. These data clearly show that the concentration of total organic C, N and biological activity decrease with depth in the soil. This is normal for mineral soils, and thus it is not of interest to compare the differences in these soil properties between horizons of the same soil profile.

Table 1. Effects of straw management on total soil organic carbon.

Residue Management	Soil Horizon[1] (Depth) Ap (0-17cm)	E/trans (17-40cm)	$2Bt_1$ (40-60cm)
	-------------	$(g\ C\ kg^{-1}$ soil)	-------------
Burn	17.7b	9.8b	4.5b
Plow	22.0b	11.7b	4.0b
SE (6df)	1.04	1.52	1.45
Undisturbed	34.5	10.0	6.1

[1]Values followed by different letters are significantly different at 5% level.

Straw residue management system had a pronounced effect on both of the chemical properties measured. Soils for which straw residues were incorporated by plowing had higher average total organic C values in the Ap and E/transition horizons than soils for which straw residues were burned (Table 1). The effect was statistically significant ($p < .05$) only for the Ap horizon, but there does seem to be a consistent trend for the E/transition horizon. Deeper in the soil, there was no difference in total organic C as a function of straw management system.

The effect of straw management practice on total N content and distribution (Table 2) parallel closely those for total organic C. This is an expected result because of the close relationship between soil organic C values and soil nitrogen values. The mean total N content for the Ap horizon of the plowed sites was higher than the burned sites, but perhaps because of the small sample size, natural variability of soils, and natural variability in the N content of soil organic matter, the difference was not significant.

Table 2. Effect of straw management on soil nitrogen content.

Residue Management	Soil Horizon[1] (Depth) Ap (0-17cm)	E/trans (17-40cm)	$2Bt_1$ (40-60cm)
	-------------	$(g\ N\ kg^{-1}$ soil)	-------------
Burn	2.0a	0.9a	0.7a
Plow	2.3a	1.3a	0.6a
SE (6df)	0.14	0.17	0.06
Undisturbed	3.4	0.9	0.7

[1]Values followed by different letters are significantly different at 5% level.

Possible reasons for the observed difference between the burned and plowed treatments merit further consideration. The question is whether burning simply brings about a greater loss of carbon than plowing, or whether plowing straw residues into the soil has actually increased carbon levels above those that would have been found had the residues been continually burned. Data from this study alone are not adequate to answer this question, but these data, coupled with those from other studies in the Willamette Valley and elsewhere, do suggest a plausible explanation.

It is widely recognized that cropping of native grassland soils generally decreases the organic C and N contents. However, soils are dynamic systems, and in time organic C and N levels will adjust to the disturbance. The amount and rate of adjustment depend on factors such as climatic conditions, rates of added organic materials and tillage intensity. If cultivated under the same management system, the rate of soil organic C and N loss will decrease and eventually stabilize at a new equilibrium level for that system (Rasmussen et al., 1980).

Management systems that minimize the addition of organic residues to soils (e.g. burning) attain new equilibrium levels for organic C and N substantially lower than the native soil equilibrium levels. In contrast, management systems that incorporate large quantities of organic residues into the soil help maintain original soil organic C and N levels, and would be expected to be substantially higher than those established under a burn management system.

Given the history of straw management practices for annual ryegrass in the Willamette Valley, the most plausible explanation for the observed difference in total organic C between the burned and plowed treatments is that burning reduced total organic C to new levels that had reached equilibrium in all annual ryegrass fields within the first 30 years of burning. However, subsequent cessation of burning and incorporation of straw residues has increased soil organic C to levels that are significantly higher than in the continually burned soils.

Several lines of evidence support this conclusion. First, Dayton is a poorly drained soil, and high water tables, cool temperatures, and reducing conditions all would tend to keep decomposition rates of added residues low for long periods of time. Evidence of this was apparent during field sampling of plowed soils. Concentrations of partially decomposed straw residues from previous years' tillage were visible, both distributed throughout the Ap horizon and in mats located at the interface between the Ap and A_1 or E horizon below. These straw residues are high in lignin and phenolic compounds, which resist microbial decomposition and favor the formation of stable soil organic compounds, such as humic acids.

Second, data from Laurent (1979) corroborate this hypothesis. Laurent measured organic C in samples of Dayton and several associated soils taken in both 1965 and 1975. He found that total organic C levels in soils continually cultivated to annual ryegrass under a burn management system for approximately 35 years had essentially stabilized.

Finally, these data support other studies which have shown that total organic C and N levels of soils under management system for which residues were removed by burning have been increased by incorporating straw residues into the soil (Skidmore et al., 1986; Powlson et al 1989).

Generally, soil management practices that affect the soil organic C and N contents, also affect microbial activity. Therefore, the indices of microbial respiration, using cumulative CO_2-C evolved during a 32 day incubation period and enzyme activity potential (ß-glucosidase) were used to evaluate the effects of straw management system on both microbial activity and mineralizable C content.

Table 3. Effect of straw management on soil microbial respiration using total CO_2-C evolved g^{-1} soil during a 32 day incubation period.

	Soil Horizon[1] (Depth)		
Residue Management	Ap (0-17cm)	E/trans (17-40cm)	$2Bt_1$ (40-60cm)
	---------- (μg CO_2-C g^{-1} soil) ----------		
Burn	1193b	773b	351b
Plow	1598a	873b	337b
SE (6 df)	78	123	41
Undisturbed	2278	778	345

[1]Values followed by different letters are significantly different at 10% level.

Table 4. Effect of straw management on Beta-glucosidase activity expressed on a g^{-1} C basis.

	Soil Horizon[1] (Depth)		
Residue Management	Ap (0-17cm)	E/trans (17-40cm)	$2Bt_1$ (40-60cm)
	-------- (μg PNG g^{-1} soil * hr^{-1}) --------		
Burn	90.0b	29.5b	20.0a
Plow	120.3a	31.4b	13.2b
SE (6df)	10.4	5.5	2.2
Undisturbed	213.7	31.8	14.0

[1]Values followed by different letters are significantly different at 10% level.

The patterns of distributions of both total CO_2-C evolved (Table 3) and enzyme activity (Table 4) parallel closely those of soil total organic C and N content. These were expected results because of the close relationship between total organic C, N contents and microbial activity. The data suggest that microbial activity and the mineralizable C content have been significantly increased ($p < 0.10$) in the Ap horizon as a result of straw incorporation into the soil. A similar trend is apparent for the E/transition horizon; however the differences in the overall mean CO_2-C evolved are not significant. An increase in microbial activity such as these, in the field, may increase in the soil's potential to cycle and provide nutrients for plant growth. This could be of agronomic significance by allowing fertilizer applications to be reduced (Powlson et al., 1989).

There has been concern that long-term burning of crop residues causes volatilization of the active or bioavailable C compounds, important as energy sources for microbial activity, and result in a build up of biologically inert or carbonized C derived from the crop residue ashes (Rasmussen et al., 1980; Powlson et al., 1989). A significant decrease in the soil bioavailable C pool or a build up of carbonized C may not be apparent from the differences in the total organic C content of soils under different management systems. However, it could potentially decrease the soil fertility status, mineralization potentials, C and N cycling and microbial activities.

Table 5. Effect of straw management on soil microbial respiration using total CO_2-C evolved g^{-1} C during a 32 day incubation period.

Residue Management	Soil Horizon[1] (Depth) Ap (0-17cm)	E/trans (17-40cm)	$2Bt_1$ (40-60cm)
	(μg CO_2-C g^{-1} C)		
Burn	67660b	81937b	82502b
Plow	73442a	74430b	90052b
SE (6 df)	4743	4554	7955
Undisturbed	66221	76930	56557

[1]Values followed by different letters are significantly different at 10% level.

Microbial respiration and ß-glucosidase activity data have been presented on a per gram C basis, to allow for the analysis of the effects of management system on the bioavailability of soil organic C. A reduction in the proportion of the bioavailable C fraction (e.g. the readily decomposable fresh plant residues, live roots, microbial C, water soluble C) or an increase in the proportion of refractory material or carbonized C, relative to the total C pool of the burned soil, would result in lower CO_2-C evolved and enzyme activity values when expressed on a per gram carbon in comparison to the undisturbed or plowed soil.

The data in Tables 5 and 6 indicate that the burn management system has no effect on the bioavailability of organic C. There were no differences in the mean values for both CO_2-C evolved g^{-1} C or enzyme activity g^{-1} C for any horizon between the plowed, burned or undisturbed soil. These results were not surprising in that the straw residue ash of the burned soils are not mechanically incorporated into the soil.

Table 6. Effect of straw management on Beta-glucosidase activity expressed on g^{-1} C basis.

Residue Management	Soil Horizon[1] (Depth) Ap (0-17cm)	E/trans (17-40cm)	$2Bt_1$ (40-60cm)
	(μg PNG g^{-1} C * hr^{-1}))		
Burn	5093b	3381b	4472a
Plow	5465a	2619b	3496b
SE (6df)	338	261	578
Undisturbed	6191	3148	2295

[1]Values followed by different letters are significantly different at 10% level.

Summary

Straw management system strongly influenced the total organic C and N content, and microbial activity in the surface two soil horizons. Soil organic C and N content were significantly greater in the Ap horizons of soils for which straw residues have been incorporated than soils for which straw residues have been annually burned. The collective evidence suggests, however, that the significant differences observed between burning and plowing is not due to greater losses of soil organic C and N as a result of burning. Rather they suggest that organic C levels have increased as a result of a change in management. Soil organic C and N levels are still lower than native soil levels, but it is not known whether or not these levels have yet reached their equilibrium value. Incorporation of straw residues has increased the total soil mineralizable C content and microbial activity, which may correspond to an associated increase in the soils potential to cycle and provide nutrients for plant growth, thereby allowing fertilizer applications to be reduced. Straw management system had no effect on organic C bioavailability.

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RESPONSE OF PERENNIAL RYEGRASS TO NITROGEN MANAGEMENT IN COMBINATION WITH CERONE PLANT GROWTH RETARDANT

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

This study was initiated to further examine crop responses in growth and seed production using Cerone, a slow ethylene-releasing, foliar applied, plant growth retardant in combination with nitrogen management. Higher nitrogen rates can promote excessive plant growth resulting in premature crop lodging, causing less than ideal conditions for pollination, seed fill, and disease control. Application of plant growth retardants may improve upright plant habit and delay or reduce lodging to better utilize higher nitrogen rates through increased seed production.

Test plot evaluations on perennial ryegrass and tall fescue were conducted in 1988 and 1989 with limited results as to the effectiveness in lodging control and subsequent effect on seed yield. Continuing interest by Rhone-Poulenc Ag Company in other grass seed crops encouraged us to establish research plots at Hyslop Crop Science Field Laboratory on perennial ryegrass. Results from 1990 were presented in Ext/CrS 83, p. 17. The results reported here are for the second year (1991) of study on cv Caravelle perennial ryegrass established during the fall of 1989.

Crop residue remaining after plot harvest was removed by flailing into a wagon using a Brady chopper. The stand was propane burned for further residue management the first week of October 1990. Standard weed control and fertility practices were used. The plot site was fertilized with a broadcast application of 200 lb/a 10-20-20-7 (20 lb N/a) on January 4, 1991.

To test the effects of Cerone and spring N management a factorial arrangement of all combinations of both factors were arranged in a randomized complete block design. Cerone was applied in several combinations of time and rate to evaluate chemical control at differing stages of development and growth. Nine regimens of timing and rate were used along with an untreated check. Two spring N rates (100 and 140 lb/a) were applied in combination with all Cerone treatments making a total of 20 treatments (10 Cerone x 2 N). Spring N (urea) was split-applied with 50 lb N/a on February 25 and 40 or 90 lb N/a on April 18 to the low or high nitrogen treatment rates, respectively. Cerone applications were made May 14, June 2, and 7 at the sequential stages of growth as listed in Table 1. Cerone was applied using compressed air on a bicycle sprayer with an 8 foot side mounted boom.

Evaluations prior to maturity included: an assessment of lodging and severity of lodge, and estimations of yield potential using fertile tiller populations and potential seed sites on spikes. These samples are used to compare potential crop yield with the actual seed harvest. One application of Tilt fungicide was applied May 23 for rust control. Plots were harvested July 25 using a small plot harvester equipped with a sickle bar cutter and draper to allow bagging of the plot into large burlap sacks. The bagged material was air dried and threshed to remove the seed for cleaning and weighing.

Table 1. Treatment schedule for perennial ryegrass showing time and rate of Cerone application, 1991.

Time of application			Total
1st & 2nd nodes visible	Flag leaf emerged	Approx. 30 % heads emerging	Cerone Rate Applied
---------- (lb ai/a) ----------			
0.75	0.75	0.75	2.25
1.00		1.00	2.00
1.00	1.00		2.00
1.00	1.00	1.00	3.00
0.75	1.50		2.25
1.50			1.50
1.50	1.50		3.00
1.50	1.50	1.50	4.50
1.50		1.50	3.00
---	---	---	check

Cerone treatments had no significant effects on seed yield or any other plant growth and yield component factors measured. However, the higher rate of nitrogen increased seed yield and plant growth responses such as crop lodging (Table 2) and panicle length (Table 3).

Table 2. Effect of spring N rate on seed yield, severity of lodging, and fertile tiller density, 1991.

Spring N rate	Clean seed yield	Lodging severity	Fertile tillers
(lb N/a)	(lb/a)	(1-5)[1]	(no./sq yd)
100	1338	3.3	2359
140	1408	4.2	2596
LSD 0.05	66	0.4	NS

[1]Scale: Range is from 1 (vertical) to 5 (flat on ground)

The seed yield response to the higher nitrogen rate appears to be from the increase in florets per spikelet and resulting increase in potential seed number.

Table 3. Effect of spring N rate on florets per spikelet, potential seed number, and panicle length, 1991.

Spring N rate	Florets per spikelet	Potential seed number	Panicle length
(lb N/a)	(no.)	(000/sq yd)	(in)
100	6.4	336.7	7.2
140	7.1	406.7	7.6
LSD 0.05	0.4	53.7	0.3

These data show little effect from applications of Cerone. In this stand lodging due to the higher nitrogen rate was not detrimental to seed yield as compared with the lower nitrogen rate. In addition, the increased yield from the higher rate of split-applied N indicates the plants' ability to utilize nitrogen supplied after fertile tiller initiation and during seed head development.

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EFFECTS OF CERONE AND FUNGICIDE APPLICATION ON REBEL II TALL FESCUE SEED PRODUCTION

M.E. Mellbye, W.C. Young III, and P.A. Koepsell

Cerone is a growth retardant used to reduce lodging in cereal and grass seed crops. Use of Cerone on winter wheat in the Willamette Valley has sometimes increased foliar disease on varieties susceptible to septoria, unless a suitable fungicide is also applied. In the absence of lodging in winter wheat, Cerone also tends to increase test weight and decrease yields slightly.

In tall fescue, there is a complex of fungi causing leaf spot disease symptoms during spring growth. After head emergence stem rust can become a severe problem under warm moist conditions. It is not known if Cerone has an impact on the development of these diseases in tall fescue. The objective of this trial was to evaluate the effects of Cerone and fungicide treatments on seed yield and disease severity on Rebel II tall fescue.

Cerone and fungicide treatments were applied alone or in combination to an established stand of Rebel II tall fescue in Linn County on May 13, 1991, at the head emergence stage of growth (50% of heads emerging). Cerone 4L was applied at 1.5 pt/a. Fungicide applications included Bravo 720 6EC at 2 pt/a and Tilt 3.8EC at 4 oz/a. Treatments were replicated five times in a randomized complete block.

Leafspot disease severity was evaluated July 1, 1991 during flowering, by estimating the head and leaf area damaged by disease (0-100%). Ten tillers were scored per plot. The degree of crop lodging was also evaluated. Plots were harvested for seed yield on July 12, 1991. At this site in 1991, the incidence of leafspots was low to moderate, no stem rust was observed, and lodging was moderate.

Cerone and fungicide treatments both had significant affects on disease severity (Table 1). All the fungicide treatments reduced disease area compared to the unsprayed check, even on the heads where the incidence of disease was very low (less than 2%). Cerone did not have an effect on the heads, but did reduce the diseased area on the flag leaf and second leaf. The same trend was observed in this trial in 1990.

Table 1. Seed yield, lodging score, and disease ratings on Rebel II Tall Fescue, treated with Cerone and fungicide, 1991.

Treatment[1]	Seed Yield	Lodging Score	Area Diseased Head	Flag Leaf	Second Leaf	1000 Seed Wt.
	(lb/a)	(1-5)[2]	------ (%) -----			(g)
Fungicide						
Unsprayed Check	1390	3.2	1.40	39	76	2.34
Bravo	1610	3.5	0.25	23	60	2.29
Tilt	1460	3.8	0.36	21	60	2.38
Bravo+Tilt	1610	2.7	0.28	24	65	2.35
LSD 0.05	NS	0.6	0.45	8*	8	NS
Growth Retardant						
No Cerone	1560	3.7	0.64	32	70	2.29
Cerone	1470	2.8	0.50	21	61	2.39
LSD 0.05	NS	0.4	NS	6*	7	0.07

[1]Rates: Cerone 4L at 1.5 pt/a; Bravo 720 at 2 pt/a; Tilt 3.8EC at 4 oz/a. Unsprayed check and fungicide treatments averaged over Cerone plots; growth retardant plots averaged over fungicide plots.

[2]Lodging Score: 1=none, 2=slight, 3=moderate, 4=severe, 5=complete

*Fungicide x growth retardant interaction significant at $P<0.05$ probability level.

Cerone significantly reduced lodging and increased 1000 seed weight, but did not increase seed yields. These effects are similar to what has been observed on winter wheat.

Although there were reductions in disease ratings when fungicides were applied there were no significant yield increases. The results in this study cannot be used to support the economic value of fungicides on tall fescue under low disease pressure. If experiments were conducted under high disease pressure, significant yield response would be more likely. While fungicide tank mixes with Cerone also reduced the degree of lodging and disease ratings, there was again no significant effect on seed yields.

Acknowledgment: Help in disease evaluation was provided by R.E. Welty, research plant pathologist, USDA-ARS.

TOLERANCE TO FENOXAPROP (HORIZON 1EC) IN TANK MIXES WITH BROADLEAF HERBICIDES AND LIQUID NITROGEN IN TALL FESCUE GROWN FOR SEED

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

In 1987 the herbicide fenoxaprop (Horizon 1 EC) was registered for use on fields of tall fescue and perennial ryegrass grown for seed in Oregon. The two major weeds controlled by fenoxaprop are wild oats and rough stalk bluegrass. The usual application timing for optimum control of rough stalk bluegrass is between late February and April 1. Broadleaf herbicides and spring nitrogen applications are made during this same time period. In an effort to reduce the number of trips over a field, growers were interested in tank mixing Horizon with various broadleaf herbicides and/or liquid nitrogen solutions. Since there was no research data available on crop tolerance to such combinations, Hoechst-Roussel Inc., manufactureres of Horizon, sponsored the establishment of trial plots to evaluate several tank mix possibilities.

In the spring of 1990 trials were established on two fields of tall fescue. One site was a three year old field of Monarch tall fescue in Washington County, and the second site was a 6 month old Cimarron tall fescue field located in Marion County. Treatments were applied on March 16, 1990; plots were replicated 3 times. Visual evaluations were made at approximately 1, 2 (data not shown), and 5 week intervals following application (Table 1). Crop tolerance was rated good (less than 10% injury) for all treatments except the three-way tank mixes with broadleaf herbicides and UN32 liquid nitrogen and the Horizon plus Express combinations. The greatest crop injury occurred from Horizon plus the high rate of Express on the field of Cimarron.

In 1991 additional work was done to evaluate a new formulation of fenoxaprop, alone and in combination, with three different broadleaf herbicides and with solution 32 (liquid N fertilizer). The new formulation is a single isomer fenoxaprop (HOE 46360-05H), which is expected to be granted a label for use by 1993. The current commercial formulation of the mixed isomer Horizon was also included in the trial.

Table 1. Summary of visual crop injury ratings on tall fescue at two locations approximately 5-6 weeks after treatment, 1990.

Treatment	Rate	% Crop Injury[1] Monarch	Cimarron
	(lb ai/a)	(4-26-90)	(5-8-90)
Horizon	0.25	0	0
Horizon + MCPA	0.25 + 0.75	6.0	8.3
Horizon + Curtail M	0.25 + 0.87	3.3	5.0
Horizon + Buctril	0.25 + 0.38	5.0	6.7
Horizon + Bronate	0.25 + 0.75	5.0	3.3
Horizon + Stinger	0.25 + 0.19	1.6	3.3
Horizon + UN32	0.25 + 10 gal	0	3.3
Horizon + MCPA + UN32	0.25 + 0.75 + 10 gal	11.6	18.3
Horizon + Curtail M + UN32	0.25 + 0.87 + 10 gal	6.7	11.
HOE 6001	0.09	1.6	6.7
Horizon + Express	0.25 + 0.0156	11.7	8.3
Horizon + Express	0.25 + 0.0312	13.3	25.0
Untreated check	--	0	0

[1]Injury rating: 0 = none; 100 = complete loss of plant

This trial was established on a three year old Bonanza tall fescue field near Silverton. Treatments were applied on March 27, 1991; plots were replicated 4 times. Visual injury evaluation and seed yields were taken on this trial. The greatest visual injury occurred with the Horizon + MCPA tank mix (Table 2). The other treatments did not appear to cause significant crop injury, suggesting that the new single isomer HOE46360-05H provides comparable crop tolerance in tank mixes as does the current formulation of Horizon. Seed yield varied between treatments but was not significantly different at the 5% level.

Table 2. Summary of visual crop injury ratings and seed yield data on Bonanza tall fescue, 1991.

Treatment	Rate	% Crop Injury[1]	Seed Yield
	(lb ai/a)	(4-26-91)	(lb/a)
Check	0	0	1754
HOE 46360-05H	0.1	5	1813
HOE 46360-05H + MCPA ester	0.1 + 0.75	11	1863
HOE 46360-05H + Stinger	0.1 + 0.19	5	2095
HOE 46360-05H + Buctril	0.1 + 0.38	10	1934
HOE 46360-05H + Sol 32 (50% by vol)	0.1	8	1976
Horizon + MCPA ester	0.25 + 0.75	16	1719
LSD 0.05	--	--	NS

[1]Injury rating: 0 = none; 100 = complete plant loss.

Acknowledgment: This research was partially supported by a grant from Hoechst-Roussel Corporation.

RESPONSE OF ROW SPACING AND SEEDING RATE ON TWO TURF-TYPE TALL FESCUES

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

The rapid increase of acreage planted during the 1980's to new turf-type tall fescue varieties raised questions as to the range of row spacings and seeding rates necessary for optimum seed production of over the life of the stand. Growth characteristics and yield over several years in turf-type tall fescues were observed to be different from forage-type tall fescues in response to standard cultural practices.

In 1985, a preliminary study began using plant density circles to evaluate the range of row spacings and seeding rates resulting in optimum seed production in four varieties of tall fescue (Fawn, Falcon, Rebel, and Bonanza). The circle plantings were sampled between 1986-88 for seed yield and other agronomic characteristics. Results from the circle plantings were subsequently incorporated into a replicated factorial experiment. The new study was late-fall planted in 1987 using two of the above varieties (Falcon and Bonanza) over a range of four row spacings (12, 18, 24, and 30 inch) and two seeding rates (3.5 and 7.0 lb/a). 1988 was considered an establishment year with the first seed harvest taken in 1989, followed by harvests in 1990 and 91.

Management of the row spacing and seeding rate study includes standard herbicide and fertilizer programs. Fertilizer applications include 25-30 lb N/a in the fall/winter using a complete fertilizer and 100 lb N/a (urea) split-applied in spring at the vegetative and reproductive growth stages. Following harvest, residue was removed by flail chopping into a wagon using a Brady chopper. Stubble was then removed to 1-2 inches using a Rear's-type crew-cutter.

Foot-row and panicle samples were taken during pollination for tiller and yield component analysis to estimate potential yield for comparison with actual yield. Plots were harvested at optimum seed moisture content using a small plot harvester and bagged into burlap sacks for later threshing and weighing.

Seed yield results found response to all main factors in the experiment. Varietal differences were consistent across all years with Bonanza consistently yielding better than Falcon (Table 1). Also, the lower seeding rate appears to be better throughout the experiment so far (Table 1). Note that in 1989 the interaction between row spacing and seeding rate was significant (Table 1). In this interaction, seed yield was highest at the 12 inch rows planted to the lowest seeding rate (Table 2).

Table 1. Seed yield response to three main factors, 1989-91.

Treatment	Seed yield 1989	1990	1991	Avg.
	(lb/a)			
Variety				
Falcon	1159	1060	605	941
Bonanza	1738	1256	1014	1336
LSD 0.05	81	59	60	--
Row Spacing				
12 inch	1645	1206	734	1195
18 inch	1511	1168	800	1160
24 inch	1363	1157	864	1128
30 inch	1274	1102	842	1073
LSD 0.05 (0.10)	*1	(67)	85	--
Seeding Rate				
3.5 lb/a	1498	1205	852	1185
7.0 lb/a	1398	1111	767	1092
LSD 0.05	*1	59	60	--

*1 Row Spacing x Seeding Rate interaction significant at $P < 0.05$ probability level.

During the second and third years (1990 and 1991), the optimum row spacing appears to shift from the narrow rows (as in 1989) to the wider rows (Table 1). Factors contributing to this shift may be the time tall fescue plants take to establish and occupy the soil area available. The narrow row spacing utilized the soil area more rapidly early in stand life, but as the stand aged, seed yield declined much more rapidly in the narrow rows than in the wider rows. The wider rows were still spreading into the available resources over time thereby slowing the yield decline so that by the third year the wide rows outyielded the narrow rows. In contrast to this, a tradeoff occurred in 1989, when the planting density was too high (7.0 lb/a) possibly causing competition for the same resources and resulting in fewer plants reaching maturity as shown by the interaction in Table 2.

Table 2. Row spacing x seeding rate interactions for seed yield, 1989.

Seeding rate	Row spacing (inch) 12	18	24	30
(lb/a)	(lb/a)			
3.5 lb/a	1775	1461	1405	1353
7.0 lb/a	1515	1562	1321	1194
LSD 0.05	162	162	162	162

The shift to improved seed production in wider rows has occurred over three years, and as the experiment is continued the impact of row spacing will become better understood. The response of yield to main factors without interactions became more dominant as the stand aged with optimum row spacing increasing such that by 1991, the best seed yield is no longer 12 inch rows but closer to 24 inch rows. Though the marked decline in yield after the first year of seed production is typical for turf-type tall fescues, in 1991, a later than normal (late September) crew-cut residue treatment may have further affected seed yield by delaying fall regrowth and tiller development.

Seed size (1000 seed weight), fertile tiller density and potential seed number are measurable components that can be used to explain causes for seed yield differences. In this experiment seed size was affected only by varietal differences. In contrast, fertile tiller density and potential seed number responded not only to varietal differences, but also to the row spacing and seeding rate treatments (Table 3 and 4).

Table 3. Fertile tiller density as affected by three main factors, 1989-91.

Treatment	1989	1990	1991	Avg.
	Fertile tiller density			
	---------- (no./sq yd) -------------			
Variety				
Falcon	425	283	172	294
Bonanza	553	320	309	394
LSD 0.05	81	*1	41	--
Row Spacing				
12 inch	519	336	213	356
18 inch	437	291	259	329
24 inch	514	312	246	358
30 inch	487	266	244	332
LSD 0.05	*2	NS	NS	--
Seeding Rate				
3.5 lb/a	502	340	265	369
7.0 lb/a	476	264	216	318
LSD 0.05	*2	*1	41	--

*1 Variety x Seeding Rate interaction significant at $P<0.05$ probability level.
*2 Row Spacing x Seeding Rate interaction significant at $P<0.05$ probability level.

Table 4. Potential seed number as affected by three main factors, 1989-91.

Treatment	1989	1990	1991	Avg.
	Potential Seed Number			
	-----------(000's/sq yd) ------------			
Variety				
Falcon	173.5	111.3	82.3	122.4
Bonanza	222.0	131.1	138.9	164.0
LSD 0.05 (0.10)	(35.0)	(18.0)	18.5	--
Row Spacing				
12 inch	219.5	123.1	89.1	143.9
18 inch	173.6	118.1	108.8	133.5
24 inch	201.4	133.3	121.3	152.0
30 inch	196.6	110.2	123.1	143.3
LSD 0.05	*1	NS	26.1	--
Seeding Rate				
3.5 lb/a	207.9	139.9	120.1	156.0
7.0 lb/a	187.6	105.5	101.0	131.4
LSD 0.05	*1	22.3	18.5	--

*1 Row Spacing x Seeding Rate interaction significant at $P<0.05$ probability level.

In 1990, Bonanza tall fescue produced more fertile tillers at the lower seeding rate (Table 5). Fewer fertile tillers resulted in lower yields as shown under Seeding Rate in Table 1. In 1991, the effect of row spacing on fertile tiller number showed no differences across all row spacings, consistent with seed yield responses (Table 1). These data indicates that the lower seeding rate (3.5 lb/a) provided more fertile tillers and subsequently higher seed yield (Table 3).

Table 5. Variety x seeding rate interactions for total tiller population (1989) and fertile tiller density (1990).

Interaction		1989 Total tillers	1990 Fertile tillers
		-------- (no./sq yd) ------	
Variety x Seeding Rate			
Falcon	3.5 lb/a	1276	299
	7.0 lb/a	1213	268
Bonanza	3.5 lb/a	1390	380
	7.0 lb/a	1714	259
	LSD 0.05	270	60

Potential seed number, which combines fertile tiller number, spikelets per panicle, and florets per spikelet, reflected actual seed number when compared to all treatments factors in the experiment (Table 4). This indicates that the ratio of potential seed number to actual seed number (floret site utilization) may be constant over time and strengthens the relationship of fertile tiller number with actual seed yield.

Harvest index is a ratio of the seed weight produced to the total dry matter produced. As shown in Table 6, there are varietal differences in the efficiency of the plant to convert dry matter into seed yield. In this example, Bonanza tall fescue produces more seed per pound of dry matter than Falcon tall fescue. Over time, row spacing also influenced harvest index (Table 6 and 7). No difference in harvest index was observed in 1989. The following year (1990), varieties interacted with row spacing, indicating that Falcon and Bonanza respond to stand age differently. Finally, in 1991, row spacing responses are very different as compared with 1989. Over time, as the row spacing increased, the harvest index also increased, indicating the wider row spacings are becoming more effective at converting energy and resources into seed.

Higher seeding rates resulted in a lower harvest index. The response to seeding rate and row spacing in 1991 was the result of a large number of tillers remaining vegetative up to harvest (Table 7). This is especially evident in Bonanza tall fescue were the vegetative tiller population in the narrow row spacing is almost twice the vegetative tiller population in widest row spacing (Table 7). These tiller data show how the 1991 harvest index for row spacing was increased (Table 6) as the row spacing widened. Though there were no more fertile tillers produced in the wider row spacings, fewer vegetative (and total) tillers were produced. With fewer vegetative tillers, plant dry matter production from non-fertile tillers was less, causing the harvest index to increase.

Table 6. Harvest index as affected by three main factors, 1989-91.

Treatment	Harvest index 1989	1990	1991	Avg.
	----------(%)----------			
Variety				
Falcon	15.2	13.7	8.3	12.4
Bonanza	19.4	18.9	12.8	17.0
LSD 0.05	0.6	*1	0.5	
Row Spacing				
12 inch	17.3	14.9	9.1	13.8
18 inch	17.2	15.7	10.0	14.3
24 inch	17.8	16.9	11.4	15.4
30 inch	17.0	17.5	11.6	15.4
LSD 0.05	NS	*1	0.7	
Seeding Rate				
3.5 lb/a	18.1	16.8	11.1	15.3
7.0 lb/a	16.6	15.7	10.0	14.1
LSD 0.05	0.6	0.7	0.5	

*1 Variety x Row Spacing interaction significant at $P < 0.05$ probability level.

The results so far in this research will help provide information to make better decisions as to what management practices can be used. Looking at the crop over a short term rotation (2-3 year) may result in a much different planting scheme than over a longer term (3+ years). This research is planned to continue through five crop years in order to follow the different planting options and how they can be best utilized. For the short term, the narrow rows are better, but as time progresses this shifts to favor wider rows. Another important result from this study is the need to be careful of seeding rates. In this study, the higher seeding rate was detrimental to yield.

Table 7. Variety x row spacing interactions for harvest index (1990) and vegetative tiller density (1991).

Interaction		1990 Harvest index	1991 Vegetative tillers
		(%)	(no./sq yd)
Variety x Row Spacing			
Falcon	12 inch	12.7	1228
	18 inch	13.7	1126
	24 inch	13.8	954
	30 inch	14.4	845
Bonanza	12 inch	17.2	2011
	18 inch	17.7	1799
	24 inch	20.0	1012
	30 inch	20.7	1091
	LSD 0.05	1.4	341

Acknowledgment: The research was partially supported by a grant from the Oregon Tall Fescue Commission.

DOWNY BROME CONTROL EAST OF THE CASCADES

G. Mueller-Warrant

Downy brome (*Bromus tectorum* L.) control and Kentucky bluegrass tolerance were studied at three sites in central and eastern Oregon, and at several sites in central Washington in the 1989-90 growing season. Modified versions of the most promising treatments were tested again in the 1990-91 growing season at Madras.

Environmental conditions (weed growth stage, date of herbicide application, and water) had dramatic effects on the performance of herbicides against downy brome. In the first year, the most reliable treatment for downy brome control across all sites was 0.75 lb ai/a Sinbar applied early (Table 1). Unfortunately, crop tolerance to this treatment was marginal. Kentucky bluegrass stands were seriously injured, but did recover. A lower rate of Sinbar (0.5 lb ai/a) gave less complete control of downy brome, but also caused less serious crop injury. A tank-mix of 20 oz (0.25 lb ai/a) Goal plus the lower rate of Sinbar was applied early (Sept. 13 and 26, 1989) at the two sites where late summer rainfall/irrigation germinated the downy brome early, and it was applied late (Oct. 17 and 31, 1989) at the other two sites. Where it was applied early, this treatment controlled downy brome as effectively as the higher rate of Sinbar alone. Where the tank-mix was applied late, it did not adequately control downy brome. The poorer control from late versus early application of the Sinbar+Goal tank-mix to similar-size downy brome may be related to lesser amounts of water or lower levels of sunlight following the later application date. The tank-mix damaged crops about as seriously as the higher rate of Sinbar alone.

Results with Sencor/Lexone differed from those with Sinbar in several important features. The soil life of Sencor is much shorter than that of Sinbar, and application timing and prompt activation with water are both critical. Rates of Sencor were based on past experience with the limits of Kentucky bluegrass tolerance. The maximum rate labeled for use on Kentucky bluegrass is 0.38 lb ai/a. These rates proved to be too low to control downy brome when Sencor was applied alone. Poor performance may also be related to inadequate post-application watering at the Madras site (late application) and the LaGrande site (early application). A tank-mix of 20 oz Goal plus 0.25 lb/a Sencor was a spectacular success at Mesa, WA, in tall fescue growing on sand. That tank-mix gave 100% control of large (3-tiller) downy brome with almost no tall fescue damage. The treatment was somewhat damaging to Kentucky bluegrass and perennial ryegrass. The tank-mix of 20 oz Goal plus 0.38 lb ai/a Sencor was less impressive at the Oregon sites in the 1989-90 growing season. Failure at LaGrande was probably due to inadequate water after application. The partial suppression seen at Madras and Culver probably indicated a need for slightly higher rates or addition of another herbicide to the mix, possibly a low rate of Sinbar.

Goal applied alone was not nearly as effective as it has been west of the Cascades. This is probably related to how quickly soils east of the Cascades dry out after watering. The best results with Goal were obtained with early application at Madras. Under these conditions (preemergence timing, good post-application water), 1.0 lb ai/a Goal (80 oz) gave 98% season long control of

Table 1. Downy brome (BROTE) control and Kentucky bluegrass yield 1989-90.

Herbicide treatment[1]		Madras, Oregon site Date applied[2]	BROTE Control	Seed yield	Culver, Oregon site Date applied[2]	BROTE Control	Seed yield
	(lb ai/a)		(%)	(lb/a)		(%)	(lb/a)
Sinbar	0.5	Sep 26	81 b	857 bc	Sep 26	62 bc	1246 ab
Sinbar	0.75	Sep 26	98 a	944 abc	Sep 26	86 a	1190 ab
Banvel	2.0	Oct 31	98 a	826 c	Sep 26	48 cd	1179 ab
Banvel	3.0	Oct 31	97 a	705 d	Sep 26	64 b	1036 b
Sencor	0.38	Oct 31	36 d	NH[3]	Sep 26	40 d	1117 b
Sencor	0.5	Oct 31	35 d	NH	Sep 26	51 bcd	1373 a
Goal	0.5	Sep 26	65 bc	1056 a	Sep 26	0 e	1090 b
Goal	1.0	Sep 26	98 a	983 ab	Sep 26	0 e	1091 b
Goal	0.25	Oct 31	48 cd	NH	Sep 26	0 e	NH
Goal	0.5	Oct 31	52 cd	NH	Sep 26	--	--
Goal/	0.25/	Sep 26/					
Goal	0.25	Oct 31	70 bc	NH	--	--	--
Goal+	0.25+						
Sinbar	0.5	Oct 31	48 cd	NH	Sep 26	82 a	1182 ab
Goal+	0.25+						
Banvel	2.0	Oct 31	95 a	667 d	Sep 26	56 bc	1238 ab
Goal+	0.25+						
Sencor	0.38	Oct 31	69 bc	909 bc	Sep 26	66 b	1174 ab
Untreated			0 e	825 c		0 e	1180 ab

[1]Some treatments were applied at greater than labeled rates. Always consult current registrations before applying any herbicide.

[2]Downy brome (BROTE) growth stages: Preemerge Sept. 26 at Madras, 3-leaf Sept. 26 at Culver, 4-leaf to 1-tiller Oct. 31 at Madras. All plots were irrigated after Sept. 26 herbicide application. Downy brome infestation was heavy at Madras, medium at Culver.

[3]NH means the treatment was not harvested for yield.

downy brome. Control with 40 oz Goal applied early or split 20 oz early plus 20 oz late was 65 to 70%. Late application was somewhat less effective than early application. Results with Goal at the other sites were less favorable than those at Madras, reinforcing the need for ample water after application and small weeds or preemergence timing to make Goal work.

Banvel was applied at 2 and 3 lb ai/a by itself and at 2 lb ai/a tank-mixed with 20 oz Goal. It was highly effective with late application at Madras, where the low rate alone worked as well as the high rate or the low rate plus Goal. At Culver, Banvel was only applied at an early timing because brome was already up by then. Banvel was not nearly as effective at Culver, despite being irrigated in. Even the high rate gave only 64% control. Higher soil temperatures at this 5 week earlier application may have increased the amount of microbial breakdown and decreased the quantity of Banvel in the soil during winter. The greater amount of post-application water at Culver (because treatments were applied earlier) compared to Madras (late treatment) may have also leached Banvel deeper into the soil and reduced the concentration near the soil surface during the winter. Prolonged root exposure to Banvel along with some type of additional environmental stress is required to control grassy weeds. Banvel gave no control at LaGrande, probably because of the early application timing and the absence of any irrigation or rainfall for the first month after application. Delayed application would probably not have worked any better there, as continued growth by the downy brome would have made it even harder to control.

Kentucky bluegrass seed yield was reduced at Madras but not at Culver by the high rate of Banvel applied alone or the low rate tank-mixed with Goal. This difference in yield at Madras between the two rates of Banvel, both of which controlled downy brome, suggests that use of the lower rate would be advisable under conditions in which Banvel works well. Despite considerable foliar damage, Sinbar, Sencor, and Goal generally had no consistent effects on yield. This is probably because the bluegrass plants were not actually killed and because the injury was transitory, disappearing by spring. Spring applications of herbicides such as Sencor that damage bluegrass leaves have previously been shown to reduce seed yield.

Results in the 1990-91 growing season at Madras confirmed the superiority of Goal+Sencor tank-mixes over Sencor alone (Table 2). All three rates of the Goal+Sencor tank-mixes controlled downy brome well, with somewhat greater crop injury at the higher rates. The same pattern occurred for the Goal+Sinbar+Sencor tank-mixes. The highest rate of the three-way tank-mix injured bluegrass less than the highest rate of the two-way tank-mix, suggesting that the key factor determining injury was the Sencor rate. These crop injury ratings were made in early May, by which time injury should have disappeared if yield was to be unaffected. This test was not harvested because a shortage of irrigation water forced this field out of seed production in 1991.

Table 2. Downy brome (BROTE) control and Kentucky bluegrass injury 1990-91.

Herbicide treatment[1]		Culver, Oregon site Date applied	BROTE Control	Crop injury
	(lb ai/a)		(%)	(%)
Sencor[2]	0.38	Nov 13	71 c	10 b
Sencor	0.5	Nov 13	87 b	15 bc
Sencor	0.62	Nov 13	76 bc	28 d
Goal+ Sencor	0.25+ 0.38	Nov 13	99 a	11 b
Goal+ Sencor	0.25+ 0.44	Nov 13	99 a	19 c
Goal+ Sencor	0.25+ 0.5	Nov 13	100 a	26 d
Goal+ Sinbar+ Sencor	0.25+ 0.25+ 0.25	Nov 13	98 a	11 b
Goal+ Sinbar+ Sencor	0.25+ 0.25+ 0.31	Nov 13	100 a	18 c
Goal+ Sinbar+ Sencor	0.25+ 0.25+ 0.38	Nov 13	98 a	16 bc
Banvel	3.0	Nov 13	96 a	1 a
Untreated			0 d	0 a

[1]Some treatments were applied at greater than labeled rates. Always consult current registrations before applying any herbicide.

[2]Metribuzin is sold in identical form under tradenames of both Sencor and Lexone. Use of either tradename to describe a treatment does not imply exclusion of the other.

DISTRIBUTION OF ERGOT (*CLAVICEPS PURPUREA*) AMONG KENTUCKY BLUEGRASS GROWN FOR SEED IN CENTRAL OREGON

D.D. Coats, S.C. Alderman and F.J. Crowe

Ergot, caused by *Claviceps purpurea*, is an important pathogen of Kentucky bluegrass grown for seed in central Oregon. Losses caused by this disease include yield loss due to seed replacement, reduced value of seed cleanings as feed, decreased harvest efficiency due to honeydew, and animal illness due to consumption of ergot in seed cleanings. In spite of frequent losses to ergot, the disease is believed to be suppressed with the use of post-harvest open field burning (Hardison, 1980). With the increased awareness of air quality, post-harvest open field burning may be decreased or eliminated. Understanding the occurrence, distribution, and intensity of ergot in a period before the anticipated decrease in field burning would be helpful in comparing any subsequent changes in incidence after open field burning is curtailed, and for evaluation of future alternative control measures.

In 1989 a survey conducted in central Oregon showed that seven percent of the fields were infected with ergot (Alderman, 1989). This survey was based on a sample of 400 seed heads from each of 60 fields.

The objectives of this study were to: (1) Determine the distribution, incidence, and severity of ergot in central Oregon; (2) Determine distribution of ergot among infected weed grasses; (3) Compile currently used management practices and (4) Examine the feasibility of possible control strategies.

Ergot evaluation in fields

A list of grass seed production fields was obtained from a computer data base established by the Oregon Seed Certification Service. One hundred and fifty fields were randomly selected for the survey. Copies of aerial photographs were obtained for each field, to identify sampling locations. In addition, for each field selected a 454 gram sample, of combine run and clean seed, was collected from the local seed companies. These samples, will be assessed for incidence and severity of ergot.

Ergot evaluation in grass weeds

Ergot in weed grasses was assessed in June (peak flowering time of Kentucky bluegrass) and in July (bluegrass harvest). Sample sites, including roadways or field edges, were selected at random across the entire bluegrass growing region in central Oregon. A total of 127 sites were selected. At each site all seed heads within a two meter square area were collected. Grass species and number of ergot sclerotia of each grass were determined.

Management practices

Following harvest, growers were surveyed for management practices, including: type of irrigation (sprinkler or furrow) and timing, fertilizer rate and timing, soil type and post-harvest burning. These data will be analyzed to determine if any practices or combination of practices are associated with ergot.

Results

Preliminary results from this survey include the following: (1) Ergot was detected in 15% of the fields surveyed; (2) Infected fields were located primarily in the Culver-Matolius area; (3) Ergot was detected in 8 out of 30 varieties sampled; and (4) Weed grasses hosting ergot included brome, wild rye, tall fescue and Kentucky bluegrass. Final results will be reported after all data is compiled and evaluated.

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ASSESSMENT OF ERGOT AND BLIND SEED IN 1990

S. C. Alderman

A survey of ergot and blind seed disease, initiated in 1988, was continued in 1990. The survey was based on samples submitted to the OSU Seed Lab. Samples with ergot were identified within the purity section of the seed lab computer data-base. Samples examined for blind seed were selected at random from lists of seed samples generated from the data-base. Blind seed tests were conducted using a seed washing technique in which conidia of *Gloeotinia temulenta* (causal agent of blind seed) were washed from seeds and identified under a microscope. Ergot was detected by visual inspection of the seed for ergot sclerotia. Grasses included in the survey were colonial bentgrass, creeping bentgrass, Kentucky bluegrass, tall fescue, red fescue, chewings fescue, orchardgrass, annual ryegrass, and perennial ryegrass.

The level of ergot among grasses grown for seed in 1986 through 1990 varied between 5 and 12% (Figure 1). Of 2,610 samples of selected cultivars examined in 1990, ergot was detected in 243 samples (9%). Grasses most commonly associated with ergot included colonial bentgrass, creeping bentgrass, Kentucky bluegrass, and chewings fescue. A low level of ergot was detected in tall fescue, red fescue, or orchardgrass samples. Ergot was not detected in annual or perennial ryegrass.

Blind seed was found primarily in tall fescue and perennial ryegrass. The percent of samples with blind seed in perennial ryegrass between 1986 and 1990 ranged from 2-3 percent (Figure 2). In 1990 blind seed was detected in 3% (8 out of 242) samples examined. In tall fescue, the percent of samples with blind seed ranged from 5 to 10%. In 1990 20% of samples (40 out of 199) contained blind seed.

Although a 10% increase in blind seed was observed in tall fescue it is not clear if this signals the initial stages of an increase in the disease or simply represents the natural variation in blind seed levels among years. An examination of 1991 samples is planned and will be important in evaluating the results of the 1990 survey. In samples containing blind seed less than 1% of seeds were infected. Thus, between 1986 and 1990, blind seed levels were not high enough to reduce germination.

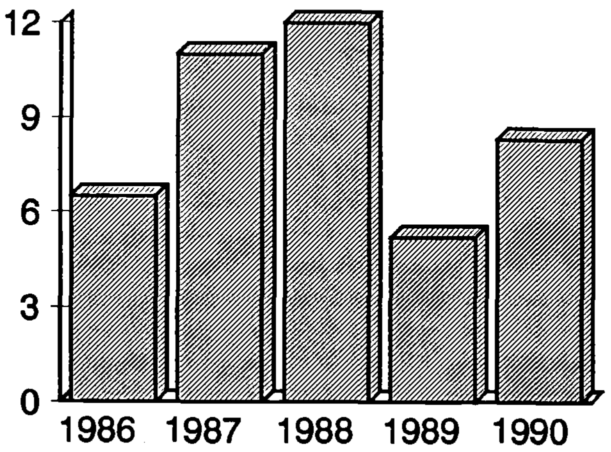

Figure 1. Percent of OSU Seed Lab samples with ergot in 1986 through 1990.

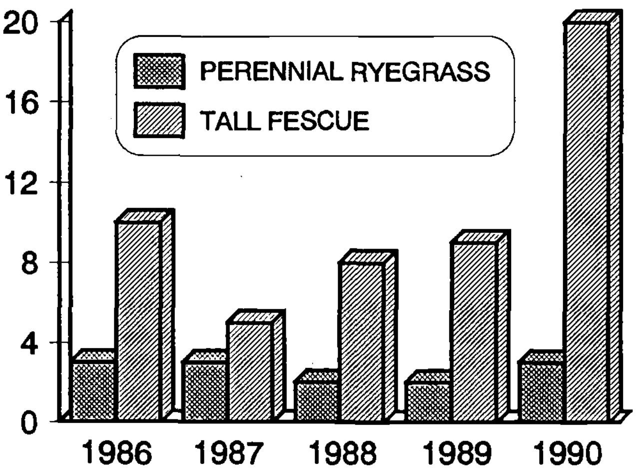

Figure 2. Percent of OSU Seed Lab samples with blind seed in 1986 through 1990.

THE ROLE OF STEM CARBOHYDRATES IN LODGED GRASS SEED CROPS

S.M. Griffith

Grass stems function in accumulating and remobilizing reserve assimilates. The major carbohydrate reserves in stems of temperate grass are fructan (fructose polymer) and sucrose (Pollock and Chatterton, 1988). Following anthesis, contribution of stem carbohydrate reserves to final seed yield has been reported to range from 10 to 25% in wheat and to 80% for barley (Borrell et al., 1989). Mobilization of stem reserves during seed fill may permit the seed to attain higher growth rates, particularly when photosynthesis becomes limiting (Fisher, 1983). Recent work indicated that stem reserves contribute to seed fill in Italian ryegrass when photosynthetic capacity was reduced (Griffith, 1992).

Reported here is a summary of an ongoing field investigation determining the role of stem carbohydrates in providing assimilates for seed growth and development under conditions of limited carbohydrate supply. It is hypothesized that stem carbohydrates play an important role in providing carbohydrate for seed fill in lodged grass seed crops.

Field plots (10' x 10') were established at Hyslop farm, Corvallis, Oregon, in 1990 for 'Marshall' Italian ryegrass, and in 1989 for 'Linn' perennial ryegrass and 'Fawn' tall fescue. Species were arranged in a completely randomized block design and replicated four times. Lodging occurred naturally or was imposed artificially for tall fescue, Italian ryegrass, and perennial ryegrass approximately six days prior to anthesis. Within each replication, 50% of the plot area was fenced with rope to maintain plants upright. At timed intervals, fertile tillers were harvested and divided into stem, leaves (including leaf sheaths), rachis, and spikelets. Stems were subdivided into three equal segments. Tissue samples were analyzed for total water-soluble carbohydrates. Seed yield components (seed number per spike/panicle, total seed weight per spike/panicle, and single seed weight) of cleaned seed were determined.

The 1990 field data showed that tall fescue seed yield components were unaffected by lodging (Table 1). In contrast, lodging reduced seed number per spike and total seed weight per spike in Italian and perennial ryegrass by 39% and 30%, and 27% and 22%, respectively. Final seed weight was unaffected by lodging in all species. Interestingly, there was an inverse relationship (r^2 = 0.82) between seed size and seed number per spike/panicle.

Greater than 90% of the final total stem carbohydrate accumulated in upright Italian and perennial ryegrass and tall fescue by anthesis (data not shown). Stems contained a higher carbohydrate concentration compared to leaves. All species had relatively similar stem carbohydrate concentrations per unit dry weight, but differed in total carbohydrates per stem. Tall fescue stem and leaf total carbohydrates were 2-fold greater than Italian ryegrass and 4-fold greater than perennial ryegrass. Lodging reduced stem and leaf total carbohydrate levels and carbohydrate concentrations in all species. In lodged plants, stem and leaf dry matter and carbohydrate levels decreased while seed dry weight accumulated at near control rates.

In summary, these data indicate that lodged herbage grass utilizes stored pre-anthesis assimilates, primarily in the stem, to buffer against reduced post-anthesis photoassimilate supply to maintain seed growth.

Table 1. The effect of lodging on seed yield components of tall fescue (*Festuca arundinacea*), Italian ryegrass (*Lolium multiflorum*), and perennial ryegrass (*L. perenne*) in 1990. Seed yield data were obtained from cleaned and separated seed. Values are means of four replicates.

Species	Condition	Seed Number per Head	Single Seed Weight	Total Spike Seed Yield
			(mg)	(mg)
Tall Fescue	Upright	146	2.69	393
	Lodged	152	2.39	363
I. Ryegrass	Upright	89	1.47	131
	Lodged	*54	1.68	*91
P. Ryegrass	Upright	60	1.41	85
	Lodged	*44	1.50	*66

* = significance at the α = 0.05 level

Acknowledgment: The author wishes to thank Barbara Dolph and Donald Streeter for technical assistance.

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MULTIPLE BRANCHING IN SPIKES OF PERENNIAL RYEGRASS

S.M. Griffith and J. Burr

A perennial ryegrass (*Lolium perenne* L.) floral tiller can infrequently develop into an atypical branched spike. As reported previously (see *1990 Seed Production Research*, pp.23), two cultivars of perennial ryegrass, 'Calypso' and 'Caravelle' produced an abnormally large number of branched spikes per unit area (<1%) in 1990. In 1991, branching occurred at very low frequency in the same fields examined in 1990 of Caravelle at Central Point and Woodburn, Oregon, and Calypso at Central Point, Oregon.

Genetic Contamination

It was not known if spike branching originated from contaminated seed as a result of cross-pollination the previous year. Electrophoretic profiles of total seed protein from branched and unbranched spikes showed similar protein banding patterns for each cultivar but quite distinct patterns from tall fescue seed protein profiles (data not shown). This suggests that branched spike mother plants were not a product of cross-pollination with another species (e.g., tall fescue).

Herbicide Induced

There was some speculation that the applications of phenoxy herbicides may have induced atypical spike branching. In 1991, a study was conducted to determine if phenoxy herbicides, similar to those applied to the field crops in 1990, would trigger the branching response. Plots were laid out in a randomized block design with four replications. Plots were located at Gervais, Oregon (O.M. Scott & Sons). Using the same breeder seed used at Central Point and Gervais, plots were planted and sprayed at rates of 0.5x, 1x, and 2x with a mixture of a Buctril 2E (1x = 1 pint/A), MCPP (1x = 6.4 oz./A) 2,4-D amine (1x = 6.4 oz./A), Banvel (1x = 4.0 oz./A), and MCPA (1x = 8.0 oz./A). Herbicides were applied on April 18 and May 9. One meter quadrants were cut from each plot after the crop was fully headed and the number of branched and normal spike type heads counted. After counting one replication, only two branched spikes were found. Since the frequency of branched spikes appeared to be extremely low and no differences in plots were found, the remaining replications were not counted. For 1991, the low frequency of branched spikes in the plots at Gervais, Oregon, was similar to the low population of branched spikes found in the foundation field at Central Point, Oregon, in 1991. This would suggest that the number of branched spikes was more likely to be a factor of a genotype and/or environment interaction rather than herbicide induction or foreign pollen fertilization.

Seed Yield

Does the branched spike offer a seed yield (weight per spike) advantage over the single spike? To address this question, seed yield data were collected and analyzed from 50 branched and unbranched spikes. The combined averaged data for 1990 and 1991 showed that branched spikes contained 27% to 42% more seeds than unbranched spikes (Table 1). Total seed yield (weight per spike) was not significantly different among cultivars, although mean values were often greater among branched spikes. Single seed weight was lower for branched spikes. These data indicate that final seed weight may be limited by assimilate supply. Until stable populations of branched spike genotypes can be developed, estimates of agronomic seed yield per unit area can not be determined.

Table 1. Seed yield components of single and branched spikes of perennial ryegrass (*Lolium perenne* L.) cultivars 'Calypso' and 'Caravelle'. Data were collected from 50 each of single and branched spikes.

Cultivar Spike Type	Seed Number		Single Seed Weight		Total Seed Weight	
	1990	1991	1990	1991	1990	1991
	(seeds/spike)		(mg/seed)		(mg/spike)	
Caravelle						
Single	67	94	2.2	1.9	145	176
Branched	*102	*127	*1.5	*1.6	145	201
Calypso						
Single	74	ND	2.0	ND	148	ND
Branched	*94	ND	*1.8	ND	*169	ND

* = significance at the $\alpha = 0.05$ level
ND = not determined

Summary

Potential seed yields are never realized in perennial ryegrass primarily because of poor seed set. Factors responsible for reduced seed set in perennial ryegrass are not known. Experimentally, branched spike genotypes may become a useful "tool" to study the physiological factors regulating floral/seed development and seed fill. Commercially, the development of genetically stable populations of branched spiked genotypes could result in greater seed yields, particularly if seed weight was not sacrificed for greater seed number.

Acknowledgment: The authors wish to thank Rom Van der Hellen for collecting the spikes used in this investigation.

FLUORESCENCE TEST OF RYEGRASS

C. Garbacik and D.F. Grabe

Interpretation of hidden fluorescence in perennial ryegrass. The fluorescence test of ryegrass continues to be an enigma. Problems have arisen over the interpretation of hidden fluorescence in the ryegrass fluorescence test. Hidden fluorescence refers to the faint narrow fluorescent streaks that cannot be seen unless the roots are lifted from the germination paper. It is felt by many that the ryegrass fluorescence test could be improved and standardized if the seedlings were not lifted at the end of the test to look for hidden fluorescence.

The increase in fluorescence percentage after lifting is quite small. In a 1990 Oregon State University Seed Laboratory trial, the average increase in fluorescence after lifting was 0.61%. This trial included 255 samples from 45 varieties.

The significance of hidden fluorescence was determined in a 1991 growout trial in the greenhouse. In this study, 1203 seedlings with hidden fluorescence from 417 seedlots representing 75 varieties were provided by the Seed Testing Laboratory. These were grown under 20-hour days for 5 to 8 weeks. The percentage of seedlings that were annual ryegrass was 3.7%. Combining these results, we found that only 0.02% (0.61 X 0.037) of annual ryegrass in these samples would not have been detected by not lifting. On the basis of this information, a proposal was submitted to AOSA to change the fluorescence testing method so seedlings would not be lifted. The proposal was rejected.

Factors affecting intensity of fluorescence. Because hidden fluorescence is very faint and difficult to see, studies were conducted to determine the effect of various factors on intensity of fluorescence. Factors studied were light quality, light intensity, light duration, germination temperature, KNO_3, and moisture level of the paper. The intensity of fluorescence was measured with a spectrum analyzer with an ultraviolet light source.

Fluorescence intensity was brightest when seedlings were grown in the dark. Fluorescence intensity decreased with each successive increase in light intensity in the germinator (Figure 1). Seedlings exposed to 24 hours light had lower fluorescence intensity than seedlings exposed to 8 hours light daily. Fluorescence intensity was the same when seedlings were grown under incandescent and fluorescent lights of the same intensity.

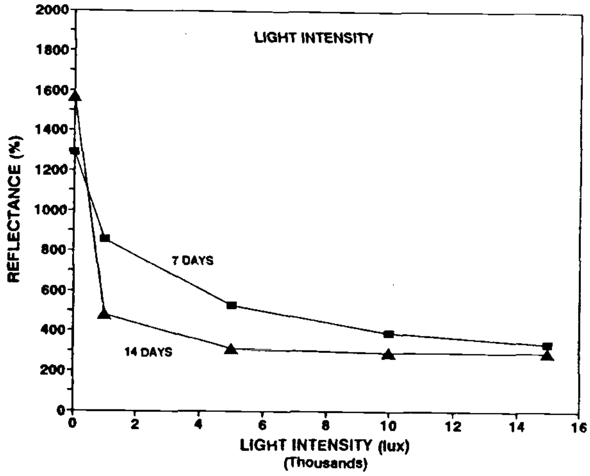

Figure 1. Effect of light intensity during seedling growth on fluorescence intensity of annual ryegrass.

Germination temperature also influenced the intensity of fluorescence. The higher the temperature, the more intense the fluorescence (Figure 2). To compensate for differing growth rates at various temperatures, all seedlings remained in the germinators for 440 degree hours and were approximately the same length.

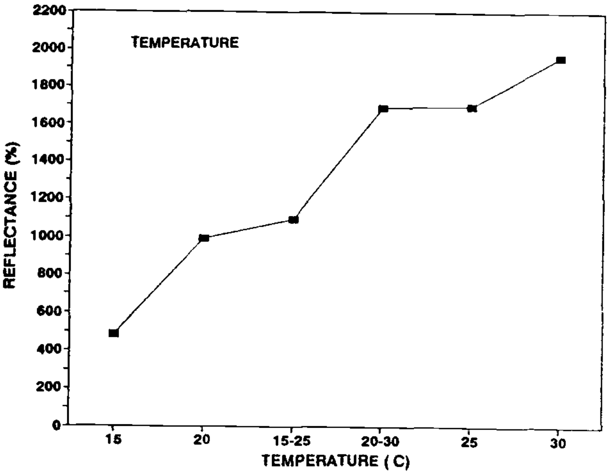

Figure 2. Effect of temperature during seedling growth on fluorescence intensity of annual ryegrass.

No difference in fluorescence was noted when seeds were germinated in KNO_3 or water. Fluorescence intensity was considerably brighter on wet filter paper than after the paper dried. However, the relative brightness remained the same.

STEM RUST DEVELOPMENT IN SIX CULTIVARS OF PERENNIAL RYEGRASS

R.E. Welty and R.E. Barker

Plants from six cultivars of perennial ryegrass were evaluated for reaction to stem rust in growth chambers when 8- and 14-weeks-old and in the field as mature plants. In growth chambers, plants were inoculated with urediospores and rated for resistant or susceptible rust infection types. An average stem rust infection index (ASRII) was used to compare cultivars (Table 1). In addition, plants in the field were assessed for percent infected plants (Figure 1) and severity of infection (Figure 2) and the area under the disease progress curve (AUDPC) was also used to compare cultivars (Table 1).

Table 1. Response to stem rust - Perennial ryegrass (6 cvs)

	ASRII		
Cultivar	8-wk	14-wk	AUDPC
Birdie II	3.99	1.72	116
Linn	4.15	3.06	348
Ovation	4.67	3.22	490
Delray	4.95	4.11	637
Palmer	4.98	4.60	1,004
Yorktown II	4.99	4.64	879
LSD 0.05	0.03	0.12	234

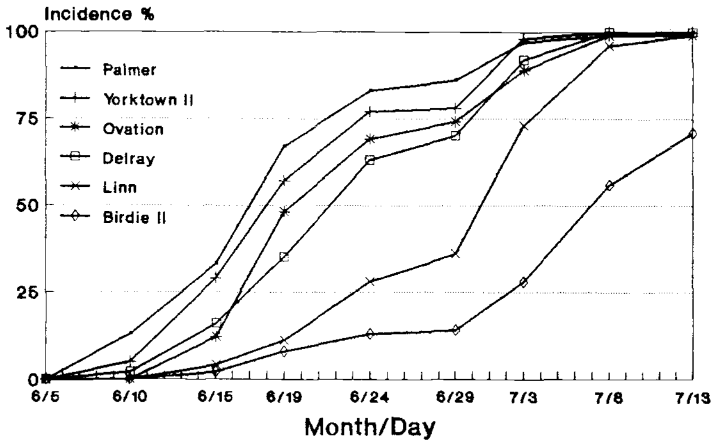

Figure 1. Percent infected plants (% incidence) of six cultivars of perennial ryegrass grown under field conditions (Botany Farm, 1991). Data points are the means of five replications.

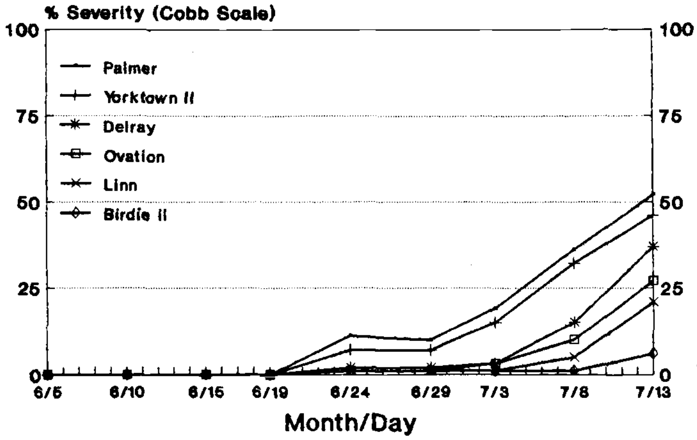

Figure 2. Severity of stem rust infection (0-100%, Cobb Scale) of six cultivars of perennial ryegrass grown under field conditions (Botany Farm, 1991). Data points are the mean of five replications.

Eight-week-old plants of Birdie II and Linn were significantly more resistant to stem rust than Ovation, Delray, Palmer, and Yorktown II. The ASRII was smaller for 14-week-old plants than for 8-week-old plants, but cultivars retained the same disease ranking. Field assessments (AUDPC) indicated Birdie II to be the most resistant, Linn was intermediate, followed by Ovation, Yorktown II, Palmer, and Delray. Birdie II and Linn were slow rusting cultivars. Cultivars reacted similarly in the field and in controlled inoculations. Generally, plants resistant as 14-week-old plants were resistant as adults in the field. However, some plants rated susceptible when 8-weeks-old varied widely in stem rust reaction as adults, some were rated susceptible and some were rated resistant.

VARIATION IN DEVELOPMENT OF STEM RUST IN PERENNIAL RYEGRASS AND TALL FESCUE AT TWO LOCATIONS

R.E. Welty and M.D. Azevedo

Seedlings (hereafter called trap plants) of 'Bonanza' tall fescue and 'Delray' perennial ryegrass were grown in the greenhouse for 6-weeks and exposed for 7-days in field plots of the same cultivar at Botany and Hyslop Farm. After exposure, trap plants were returned to the greenhouse, incubated 14 days, and percent stem rust infected plants were recorded. The study was done to determine if conditions in the field allowed plants to become infected by stem rust. The higher incubation temperature in the greenhouse (~70 F) than in the field (~50 F) allowed for stem rust to develop in less time. A portion of this study was done at Hyslop with Bonanza tall fescue in 1990.

In 1991 (Figure 1), conditions for stem rust infection of Delray occurred earlier than conditions for infection of Bonanza at both locations. Also, conditions for stem rust infection at the Botany Farm preceded conditions for infection at Hyslop Farm. Conditions in the field that allow stem rust infection of perennial ryegrass are different from those for infection of tall fescue, and these conditions are also different for the two locations of the study. Studies are underway to identify the environmental conditions that favor infection of these two grasses by these cultures of stem rust.

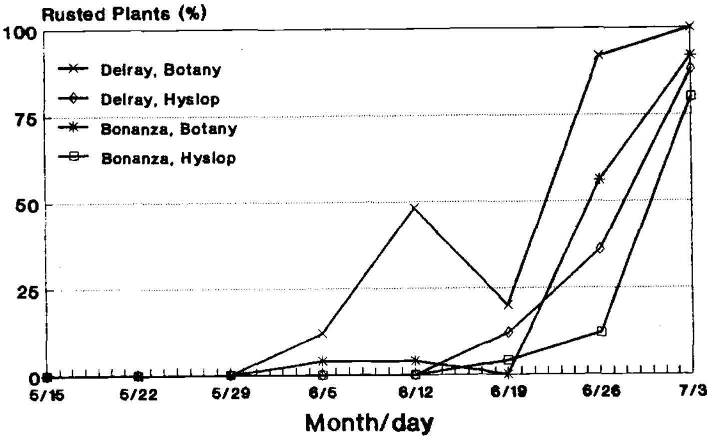

Figure 1. Stem rust development on trap plants of two tall fescue and two perennial ryegrass cultivars at two locations, 1991.

A comparison of stem rust infection periods of Bonanza tall fescue at Hyslop Farm in 1990 and 1991 is shown in Figure 2. The critical infection period in 1991 was over a month later for 1991 than 1990.

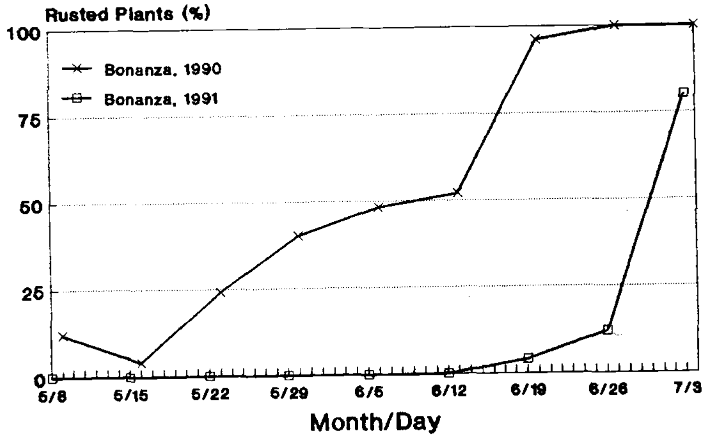

Figure 2. Comparison of stem rust development on trap plants of Bonanza tall fescue at Hyslop Farm, 1990 vs 1991.

In May, 1990, average maximum and minimum daily air temperature was 65.1 F and 43.5 F, respectively, which was -1.1 F and +0.3 F different from normal, respectively. In May, 1991, average maximum and minimum daily air temperature was 61.5 F and 43.2 F, respectively, which was -4.75 F and -0.01 F different from normal, respectively. The lower temperatures in May, 1991 compared with May, 1990, most likely accounted for the delay in the development of stem rust in 1991. When higher temperatures occurred in June, 1991, there was a rapid increase in percent infected plants. This can be noted by comparing the steepness of the rust development curves for Bonanza in 1990 and 1991.

Trap plant studies will continue in 1992 with both species at both locations. The data for 1990 and 1991 indicate the use of greenhouse grown trap plants exposed in the field may be an effective method for predicting stem rust development. If this is possible, fungicide applications may be applied at critical times to be more effective in controlling stem rust.

APPLICATION OF TILT TO CONTROL STEM RUST IN 'DELRAY' PERENNIAL RYEGRASS

R.E. Welty and M.D. Azevedo

This experiment (1991) is a repeat of an experiment done in 1990. For a detailed description of the Materials and Methods, see pages 2 and 3 of the 1990 Seed Production Research Report (Ext/CrS 83). For convenience and for comparisons, data from 1990 and 1991 are presented in Table 1.

In 1991, plant growth and stem rust development occurred later than in 1990 due to lower temperatures in May. Tilt applications for stem rust control in 1991 were about two weeks later than in 1990, and seed harvests were delayed about two weeks. When stem rust occurred, it developed very slowly; no stem rust was observed in the plants in field plots at Hyslop Field Laboratory before harvest. Seven days after harvest, stem rust had developed enough so plants receiving the various plot treatments could be scored for stem rust severity. Seed yield and disease differences among plots were significantly different from each other at P = 0.10; LSDs calculated at P = 0.10 showed seed yields from plots receiving two or three applications of Tilt were significantly higher than nontreated controls. Stem rust severity in all plots treated with Tilt was significantly less (LSD = 0.10) than the nontreated control.

Table 1. Seed yield and stem rust development in 'Delray' perennial ryegrass treated with 1-3 applications of propiconazole (Tilt, 4 oz./A). Hyslop Field Lab., Corvallis, OR. 1990-1991.

Growth Stage at Application[1]	Seed Yield[2] 1990	Seed Yield[2] 1991	Disease Severity[3] (Mod. Cobb Scale) 1990	Disease Severity[3] (Mod. Cobb Scale) 1991
	--- (g/plot) --		-- (0-100%) --	
Check	499	371	29	23
Boot (B)	509	396	12	9
Head Emerge (H)	544	424	2	10
100% head (100)	552	397	1	2
B + H	544	422	3	8
H + 100	582	445	1	2
B + H + 100	599	436	0	1
LSD 0.05	54.9	-.-	6.8	-.-
0.10	-.-	42.5	9.2	12.6

[1]Fungicide application dates
1990 - B=26 Apr; H=9 May; 100=29 May
1991 - B=14 May; H=24 May; 100=11 June

[2]Harvest dates
1990 = 28 June; 1991 = 11 July

[3]Final disease score
1990 = 27 June; 1991 = 16 July

In a two-year comparison, seed yield data for Delray indicated two applications of Tilt, one applied when seed heads are emerging and the second when heads are fully emerged, resulted in the highest seed yield of the treatments tested. One application of Tilt at the boot stage (i.e. before heads emerged) was the least effective fungicide treatment for increasing seed yields. In both years, all applications of Tilt reduced the severity of stem rust when compared to the nontreated controls. Plans are to repeat this experiment in 1992 to provide three years of observations, after which the study will be discontinued.

ENDOPHYTE AND ERGOVALINE CONTENT OF SEED AND STRAW OF TALL FESCUE AND PERENNIAL RYEGRASS PRODUCED IN 1991

R.E. Welty, A.M. Craig, and M.E. Mellbye

Endophyte infected (E+) and endophyte-free (E-) Kentucky 31 tall fescue plants were established at the OSU Botany Farm. The study contained observations based on five E- plants and 25 E+ plants. Fifty seeds were collected at harvest and examined for endophyte by a hyphal-stain method (Figure 1). Fifty pieces of straw were also collected at harvest and both seed and straw samples were also analyzed for ergovaline content (Figure 2). Based on the 30 observations in this study, we found endophyte infection and ergovaline amounts is generally higher in seeds than in straw; even when a plant is E+, the percentage of E+ seeds and E+ straw harvested from this plant may be variable; and the amount of ergovaline in seeds and straw from E+ plants is also variable.

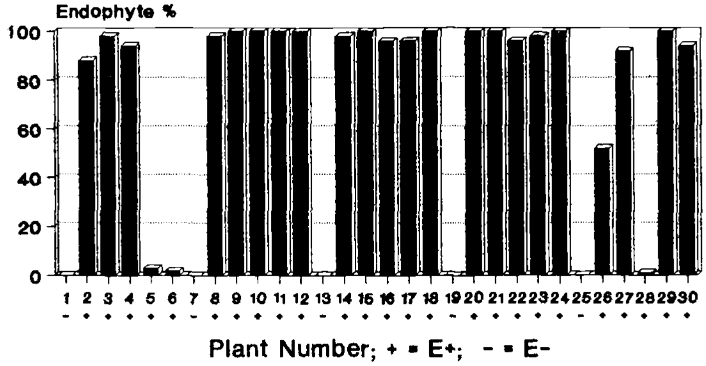

Figure 1. Endophyte infection level of seed from 30 Kentucky 31 tall fescue plants [5 endophyte-free (E-) and 25 endophyte-infected (E+)] grown at the OSU Botany Farm, 1991.

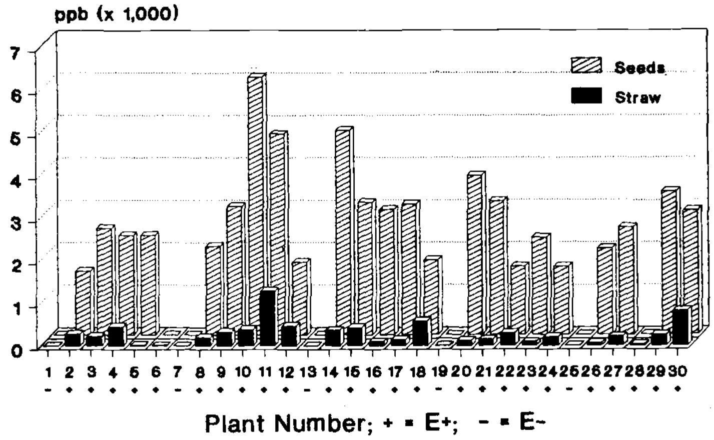

Figure 2. Ergovaline content (ppb) of seed and straw from 30 Kentucky 31 tall fescue plants [5 endophyte-free (E-) and 25 endophyte-infected (E+)] grown at the OSU Botany Farm, 1991.

A pilot study was done to analyze seed and straw from 16 growers fields of tall fescue (Table 1) and 15 growers field of perennial ryegrass (Table 2) for endophyte content and ergovaline amounts. Results of this study are based on a single sample from each field and the study has no replications. Data presented in Tables 1 and 2 are averages for samples within the five endophyte infection ranges, 0-5, 6-25, 26-50, 51-75, and 76-100%.

Table 1. Ergovaline content (ppb) and endophyte infection level in straw and seed of tall fescue produced in growers' fields in 1991.

Endophyte Infection	Fields Sampled	Ergovaline (ppb) Seed	Straw
0-5%	6	61	10
6-25%	3	387	10
26-50%	4	1843	177
51-75%	3	4109	925
76-100%	0	--	--

Table 2. Ergovaline content (ppb) and endophyte infection level in straw and seed of perennial ryegrass produced in growers' fields in 1991.

Endophyte Infection	Fields Sampled	Ergovaline Seed	(ppb) Straw
0-5%	3	10	8
6-25%	3	435	29
26-50%	1	422	74
51-75%	1	2311	247
76-100%	7	2206	443

Ergovaline content in seeds and straw of tall fescue with 51-75% infected seeds contain an average of 4109 ppb ergovaline in seeds and 925 ppb in straw. Ergovaline content in seeds and straw of perennial ryegrass with 51-100% endophyte infected seeds average up to 2206 ppb ergovaline in seeds and up to 443 ppb ergovaline in straw.

Based on this limited survey, straw from cultivars containing more that 25% E+ seeds should be tested for ergovaline before it is incorporated into feed. Seed or seed screenings from cultivars containing more that 25% E+ seeds should not be fed without an ergovaline analysis. Endophyte staining of seeds or straw only rates the potential toxicity of a sample and is not a single reliable test for measuring toxicity. The most reliable test of toxicity is an ergovaline analysis.

In 1992, the study will be repeated with 10 fields of four cultivars (high E+, moderately high E+, moderately low E+, and E-) of tall fescue and perennial ryegrass.

DO DELETERIOUS RHIZOBACTERIA AFFECT PERENNIAL RYEGRASS STANDS?

L.F. Elliott and R.E. Barker

The cause of premature declines in seed grass stands is still unknown. The problem has not been linked to a disease or an insect. It is possible that the environment has either a primary or secondary role, for example, the effects from the recent drought. The problem also could be linked with other factors. Poor performance of other crops such as winter wheat has been linked to deleterious rhizobacteria (DRB). These organisms colonize crop roots, and if numbers are high enough, can severely restrict plant growth. We decided to look at numbers of DRB on roots of perennial ryegrass. We sampled young fields (second year of growth) that appeared to be undergoing severe stand loss. DRB were present on the roots of the plants, but we were unable to make a correlation between DRB and premature stand loss. However, we surveyed several perennial ryegrass varieties to determine if they differed in susceptibility to two inhibitory isolates #19 and #68. These isolates were obtained from the roots of perennial ryegrass undergoing stand decline. These two were chosen from several DRB isolates because isolate #19 severely inhibited root growth while the influence of #68 was moderate. Both were tentatively classified as pseudomonads. The grass varieties did respond differently (Figure 1). The implication of these results are not clear at this point and need to be studied in greater depth.

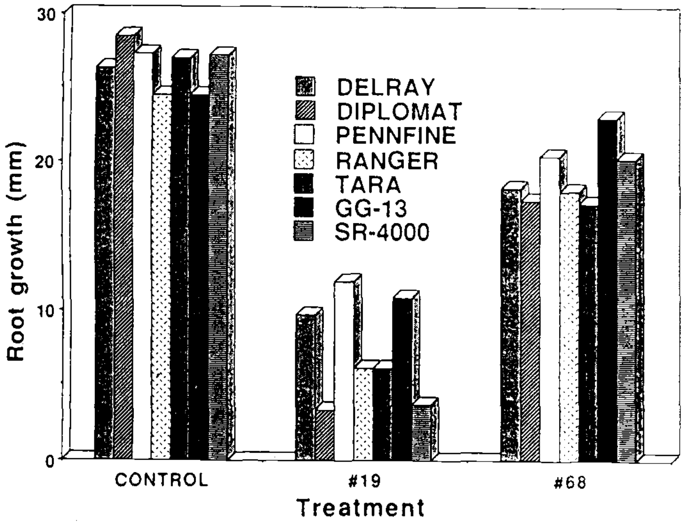

Fig. 1. The effect of two deleterious rhizobacteria strains on varieties of perennial ryegrass.

SEED PRODUCTION POTENTIAL OF GERMPLASM FROM SUBSPECIES OF ORCHARDGRASS

R. E. Barker, D.A. Sleper, and R. E. Welty

Plant collections entered into the U.S. National Plant Germplasm System (NPGS) come from around the world, but once in the system, few accessions are fully evaluated in regions where they may have potential use. Little information on utilization is usually known about subspecies or close relatives of major crops. Orchardgrass (*Dactylis glomerata* L.) is an important forage grass grown in the midwestern USA, but over 90% of the seed is produced in the Pacific Northwest. The NPGS contains over 100 accessions of subspecies of orchardgrass. In 1988, all accessions of *Dactylis glomerata* subsp. *hispanica* (Roth) Nym., except those from Australia, and three accessions of *D. glomerata* subsp. *aschersoniana* (Graebn.) Thell. were obtained from the NPGS.

Our objectives were to evaluate these new accessions in Missouri for forage use and in Oregon for seed production potential. The initial goal was to ascertain if these subspecies had potential for use in the USA, or if they may have genes useful in orchardgrass breeding programs.

In the Oregon trials, seed were germinated in sand and individual seedlings were established in cylindrical containers containing a pasteurized potting mix consisting of peat, loam soil, sand, and pumice (1:1:1:3 v:v). Plants were transplanted to the field when they were about six weeks old. Plots were arranged in a randomized complete block design with four replicates. Each plot consisted of 10 plants from each accession spaced on 10 in. centers within the row and 3 ft. between rows. Plots were fertilized according to soil test and weeds were maintained with chemical and mechanical control. Plots at Mt. Vernon and Columbia, MO were handled similarly to Oregon plants and arranged in the field with the same design and spacing as in Oregon.

There was considerable phenotypic variation among and within accessions for most traits measured in Oregon. Surprisingly, there was nearly as much variation within some accessions as there was among accessions for some traits and data were analyzed on an entry mean basis for comparisons.

All plants at Mt. Vernon, MO died the first winter (1988-89) after transplanting as well as about 80% of the plants at Columbia, MO. The plants that survived the first winter at Columbia died the following winter. The trials grown in Missouri were abandoned because of the lack of winter hardiness.

Plants grown at Corvallis, OR established well and survived the mild winters in this environment. Mature plants, however, were severely injured during the winter of 1990-91 when colder than average temperatures were recorded in December 1990 and again in January 1991. The December 1990 average minimum air temperature was -2.5 °C. Plant survival scores (0 = no injury to 9 = dead) were recorded in the spring of 1991. Overall, every accession had some death and about 25% of individual plants died.

There was a broad range of maturity among accessions. Plant stage of development was visually rated on five dates in each of 1989, 1990, and 1991. The ratings were averaged over the five dates on a plot basis to give a relative maturity value. There was about two weeks difference in maturity among accessions in each of the years. Overall, these subspecies have about the same maturity range as orchardgrass.

In 1989, plants were infected with several diseases; most severe was stripe rust caused by *Puccinia striiformis*. Plants were visually rated for stripe rust at heading (ears had emerged from the boot) and again at maturity (seed milky to hard dough). The rating was a two-stage score for distribution and severity (Table 1).

Diseases present were noted after anthesis in 1990 and 1991 by recording presence or absence of disease symptoms. The relatively most prevalent disease was also noted, but quantification was not attempted. In addition to stripe rust, other diseases present included scald caused by *Rhyncosporium orthosporum*, eyespot caused by *Mastigosporum rubicosum*, and stem rust caused by *P. graminis*. Diseases were more prevalent in 1990 than in 1991. There was considerable variation for each of the diseases within and among accessions. All accessions were susceptible to these diseases, but a few individual resistant plants were observed.

Table 1. Scores of stripe rust infection in 1989.

Trait	Mean	Standard deviation	Minimum	Maximum
Score at heading				
Distribution[1]	4.8	1.6	1.6	8.2
Severity[2]	2.2	0.6	1.3	3.8
Score at maturity				
Distribution	8.3	1.2	6.7	9.0
Severity	2.7	0.5	1.9	3.9

[1]The distribution score was similar to Saari-Prescott, consisting of 0 = no infection, and 9 = all of plant including panicle infected.
[2]The severity score was 1 = no disease, and 5 = very susceptible (>25% infected).

Plots received supplemental irrigation throughout the growing season in 1989 resulting in highly variable seed yields because of indeterminate growth of these subspecies. In 1990 and 1991, three heads per plant were harvested and threshed to determine seed yield per panicle. Plots yields were not recorded to determine pounds per acre to compare with orchardgrass, but there was considerable variation among accessions for seed yield per panicle. None of the accessions exceeded seed yield per panicle that we expect from orchardgrass.

Seed samples were subjectively rated on a scale from 1 (best) to 5 (worst) to determine threshability. Some plants easily released all their seed, but many were difficult to clean and contained numerous double florets. Plots generally did not lodge severely, but there was considerable seed shatter prior to harvest at 44% moisture; more than we anticipate for orchardgrass.

Vegetative regrowth after seed harvest was collected in the fall of 1989 and again in 1990. Foliage from each plot was dried, mixed, and a subsample ground for quality analysis using the cellulase technique in Missouri. There was highly significant variation among accessions and between years (Table 2).

Table 2. Forage quality of aftermath from plants grown in 1989 and 1990.

Trait	Mean	Standard deviation	Minimum	Maximum
1989 crop year				
Crude protein (%)	18.5	2.6	15.9	21.4
ADF[1] (%)	44.0	5.6	41.3	46.9
Dry matter (%)	94.2	12.2	93.8	94.4
NDF[2] (%)	55.9	7.0	51.6	59.3
IVDMD[3] (%)	65.5	8.1	56.5	69.1
1990 crop year				
Crude protein (%)	20.4	2.7	18.7	22.5
ADF (%)	43.9	5.6	40.7	45.8
Dry matter (%)	94.2	12.2	93.7	94.6
NDF (%)	54.2	6.8	49.2	57.4
IVDMD (%)	58.9	7.2	53.1	63.7

[1]Acid detergent fiber
[2]Neutral detergent fiber
[3]*In vitro* dry matter digestibility

Conclusions

1. There is wide variation among and within accessions for *Dactylis* subspecies for most traits. Careful evaluation will need to be done so only the best plants from these accessions are included in a breeding program. These accessions lack winterhardiness and variation for survival will need to be found within accessions.

2. There is ample variation available to expect progress from selection for seed production traits,

but locating disease resistance may be difficult in these accessions without adversely narrowing the germplasm base.

3. Based on chromosome counts, some of the accessions tested may be taxonomically misclassified in the NPGS. Continued research needs to be conducted on the identified accessions.

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CLOVER SEED PRODUCTION RESEARCH APPLICATIONS

J.J. Steiner

The information presented is from the first two years of field research by the USDA-ARS Forage Legume Seed Production Research Program. An effort was made to identify some of the common environmental and cultural constraints which limit seed production in red and white clover and determine how to optimize seed production.

Vegetation Management in Red Clover. Red clover must be hayed in spring to remove undesired early-spring vegetative growth, synchronize time of flowering to pollinator activity, and to disrupt some insect pest life cycles. Twelve different experimental sites were established in grower seed fields in both 1990 and 1991 throughout a six country area in the Willamette Valley. Plots were hayed in one-week intervals during a seven week period from early-May to late-June.

In 1990, for the average of 12 locations, seed yields were generally not affected by haying time unless done in late-season which reduced yield (Figure 1). In 1991, delayed haying time generally resulted in increased seed yields. This was probably due to milder temperatures during flowering and more available soil water from increased precipitation during May 1991 when compared with field conditions in 1990. The response to haying by all individual fields was not the same and depended upon the specific conditions of each field (Figure 2). In both years, fields which has lower seed yield potential responded best when hayed early while high yield potential fields responded best to delayed haying.

The impact of non-optimum time of haying on red clover seed yield in 1990 and 1991 was an average loss for 12 locations of 18 and 13%, respectively. Eight of 12 locations were harvested by the actual growers at non-optimum times in 1990 and four of 12 in 1991. This resulted in an average seed yield loss of 27 and 26%, respectively for the two years. The potential yield loss that could have been achieved by all locations if hayed at the most non-optimum time was 40.1% in 1990 and 35.3% in 1991.

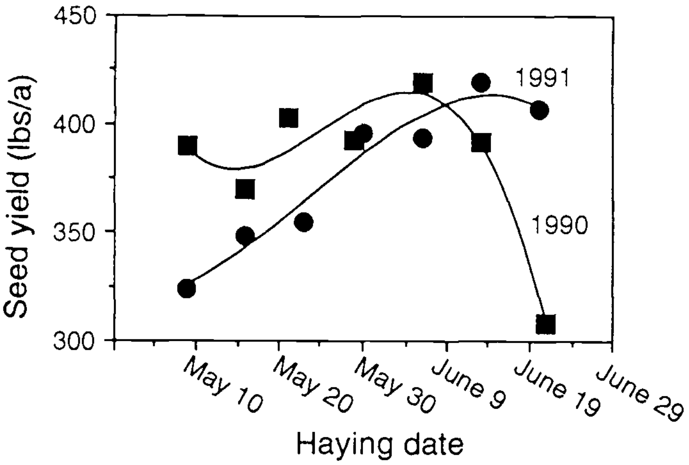

Figure 1. Effect of haying time on red clover seed yield in 1990 and 1991.

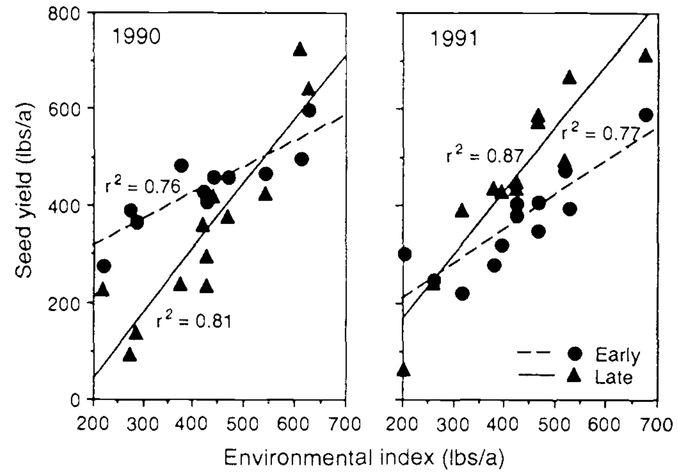

Figure 2. Effect of site productivity on and haying time on red clover seed production.

Water Stress Management in Red Clover Seed Production. Red clover is an erect-growing short-lived perennial. Most of the seeds produced by this crop arise from the stems which grow up from the crowns following haying in spring. There is relatively little seed produced from secondary regrowth following the first flush of regrowth. Water was applied to first and second year stands of Kenland red clover in 1990 and 1991, respectively, with the soil profile filled to water holding capacity: i) immediately after haying, ii) at peak flowering, iii) after haying and at peak flowering, and iv) 50% of field capacity at peak flowering. Two other treatments were a non-watered control and a non-stress, watered twice weekly treatment.

The control yielded less than all other treatments in both years (Figure 3). Second-year seed yields were lower than first-year yields for all treatments. In 1990, the most-efficient seed yields resulted from a single application of water which filled the soil profile either following haying time or at peak flowering. Delaying water application until peak flowering effectively reduced lodging compared with the application following haying. In 1991, seed yield was directly related to the effect of supplemental water on the reduction of root rot (Figure 4). Increasing the frequency of application (the non-stressed and 2x applications) and delaying application (peak flowering versus haying time) reduced the degree of root rot damage, especially compared with the non-irrigated control.

Seed yields in red clover can be expected to be greater with timely irrigation compared with non-irrigated production. Under non-irrigated conditions, it should be expected that seed yields may be greatly lower in the second year of production than the first. This natural reduction can be moderated by use of supplemental irrigation with the soil profile being filled to water holding capacity at the time of peak flowering.

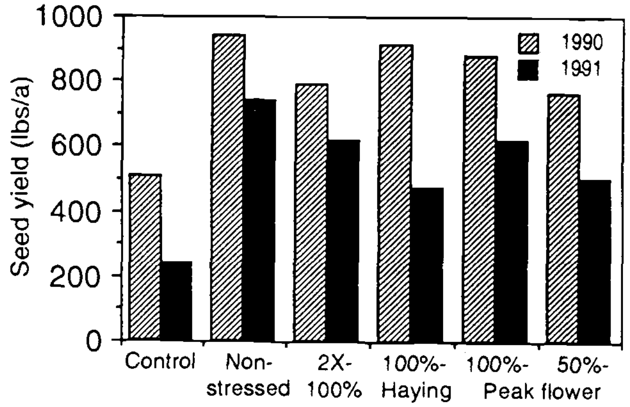

Figure 3. Effect of water application on red seed production in 1990 and 1991.

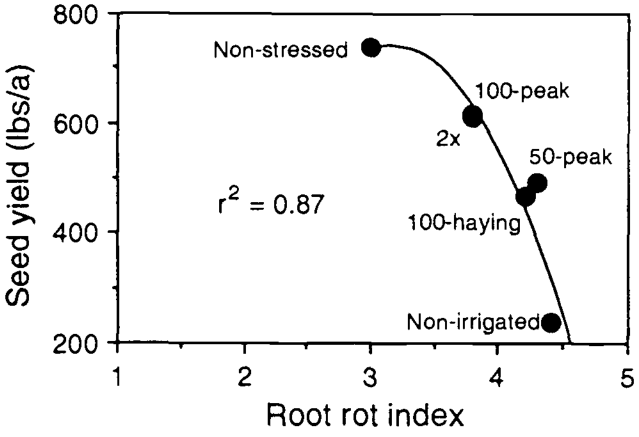

Figure 4. Effect of root rot complex and water application on second-year red clover seed production in 1991.

Water Stress Management in White Clover Seed Production. The indeterminate flowering nature of white clover grown for seed is greatly influenced by the amount of soil-water available to the crop during seed production. Seed yield is reduced by any environmental condition which favors excessive vegetative growth. After haying in early-June, single applications of water were applied to Osceola ladino-type white clover when 25, 46, 68, and 84% of the available soil-water was used in 1990 and 30, 57, 64, and 79% in 1991. This range of water stress was compared to a non-watered control and a treatment which was maintained at field capacity with two irrigations per week. The effects of the differential water treatments were observed in 1990 and 1991.

Seed yield was optimum in 1990 when water application was delayed until 68% of the available soil-water was used by the crop. This treatment maintained an even flush of flowers throughout the growing season. Water applications prior to this resulted in split flowering periods. Plants in the most-delayed application treatment (84%) were unable to re-initiate flowering and mature seeds before harvest. The flowering pattern in this treatment was similar to that of the non-watered control. The unstressed treatment had excessive vegetative development and yielded similarly to that of the control.

In 1991, all of the watered treatments yielded the same or less than the non-watered control (Figure 5). This was due to excessive vegetative growth from the mass of stolons (vegetative stems which creep along the soil surface) which had grown between the planting rows the previous year. Conventional haying does not effectively re-establish the planting rows, so the balance between reproductive and vegetative development needed for optimum seed production is not maintained. Under conditions which result in excessive stolon development during the first year of production, aggressive vegetation management is needed to maintain seed yields in subsequent production years.

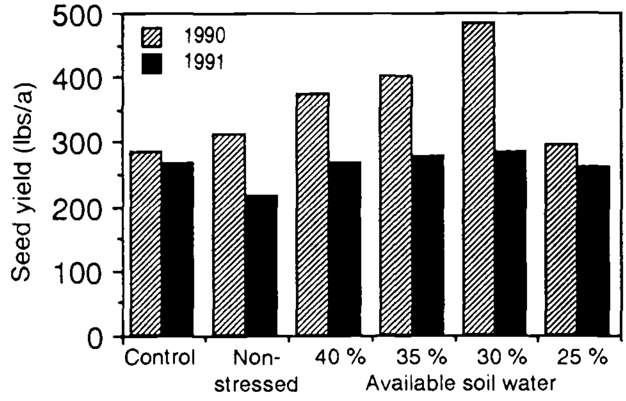

Figure 5. Effect of water application on white clover seed production in 1990 and 1991.

In a second study, the response of different white clover cultivars to water stress was investigated (Table 1). It was found that seed yield for the two intermediate-types (New Zealand white and White Dutch) was lower when watered at the optimum soil-water percentage for Osceola ladino-type. the seed yields of other ladino-types either were unaffected by the application of water or seed yields were increased. These results indicate that different cultivars may respond differently to specific soil-water conditions. Therefore, different cultivars may be best adapted to different production areas. This study was done on second-year stands which did not receive any supplemental water during the first production year.

Table 1. Effect of water application on seed yield of ten white clover cultivars.

Entry	1990 Without Irrigation	1991 Irrigation Without	1991 Irrigation With	Contrast
	(lb/a)			
Brown Loam Syn 2	133.8 b	180.5 d	197.6 d	NS
SRVR Ladino	151.7 b	251.5 bc	217.6 cd	NS
New Zealand White	138.4 b	286.3 b	197.4 d	--
California Ladino	181.7 a	255.0 bc	410.0 a	+
Regal Ladino	122.6 b	188.0 d	324.3 ab	+
White Dutch	145.0 b	380.7 a	330.9 ab	--
Arcadia Ladino	156.3 b	243.8 bcd	292.9 bc	NS
Louisiana S-1	210.5 a	285.9 b	329.6 ab	NS
Titan Ladino	141.4 b	200.8 cd	212.9 cd	NS
Osceola Ladino	207.2 a	250.4 bc	358.9 ab	+
LSD 0.05	46.9	60.7	93.0	

Means followed by different letters are significant at $P \leq 0.05$.

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MEASUREMENT OF SEED DIMENSIONS

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Dimensional measurements of crop and contaminant particles contained in seed lots are made to predict screen and indent pocket sizes for conditioning operations and to determine effectiveness once these procedures are completed. These measurements are presently made by human operators using a microscope equipped with a reticle. A comparison of the distributions of measurements to opening sizes of screens and indent cylinder or disk pockets can then be used for selection of equipment that partitions the material based on dimensional differences.

A machine vision system (MVS) provides an alternative to microscopic measurement of seed by human operators. For applications where a large number of seeds must be measured, MVS would provide distinct advantages over the the usual method. Presently, MVS remain untested for their accuracy compared with the standard method.

Seeds harvested with conventional equipment contain various types and quantities of contaminants that are picked up and mixed with the crop. Contaminants such as weed seeds, inert material, seeds of other crops, and nongerminable seeds from the intended crop must be removed to meet required standards before the seed lot can be sold. The Federal Seed Act requires that seed sold and transported meet certain minimum standards for purity and germination, and contain no noxious weed seed. Extensive conditioning, including threshing, debearding and cleaning, is often required to meet legal or contractual standards.

The seeds of three species of turf and forage grasses were selected for dimensional measurement of length, width and thickness. These were tall fescue, orchardgrass, and perennial ryegrass . Twenty-four seeds were taken from each lot of original material and placed in individually numbered cells so that each seed could be traced throughout the measurement process. Microscopic measurements were made by four individuals familiar with microscopic seed measurement using a stereomicroscope with reticle and seed inspection station. All seeds were individually placed on a viewing apparatus using a vacuum pickup device for manipulating small objects. All seeds were positioned and measured once by each individual before the next individual's measurements were made.

After the 72 seeds were measured by four individuals using the microscope, the same seeds were measured four times using an Intelledex V-200 machine vision system and seed placement device. Each seed was replaced into its numbered cell after measurement so that it could be traced through later replications.

Means, coefficients of variation (CV) and confidence levels from paired t-tests of 24 measurements of length, width and thickness for each species and method of measurement show that precision of MVS measurement of seed was higher than that of human measurement. Six of nine comparisons of CV values showed significant differences ($P < 0.10$) for human versus MVS measurement. Five of these favored machine vision as having significantly lower CV values. Outlying CV values (>10%) occurred 14 times with human measurements and only once with the MVS measurements. Significant ($P < 0.10$) differences were found in all nine comparisons of mean dimensions. Human measurements of length averaged 4.3% larger than MVS. Human width and thickness measurements averaged 2.1% and 12.4% smaller respectively than those of MVS. This degree of accuracy was considered acceptable for predicting screening and indent pocket sizes used for most conditioning operations.

Comparison of individual coefficients of variation for the 72 seeds were made for length, width, and thickness. The results of regression analysis of CV to mean dimensions for each species, dimension and method of measurement show that only MVS measurements of orchardgrass length had significant ($p<0.10$) relationship between CV and mean dimension. This suggested that there was little relationship between seed size and the MVS ability to accurately measure seed dimension.

An average of 104 minutes per human measurer were spent on 72 seeds. This was equivalent to 1 minute 27 seconds per seed compared with 31 seconds per seed with MVS. In a 42 hour period, the described MVS and seed positioning device measured 4900 ryegrass seeds, recorded the data, and shut down automatically with only occasional need for human interaction. A comparable number of human measurements at the average rate achieved in this research would require nearly 120 hours or 15 eight hour days of constant seed measurement. Population studies that previously required prohibitively large numbers of seed measurements by human operators can now be accomplished by MVS with confidence that results are as good as or better than human measurements.

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