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RESIDUE MANAGEMENT PRACTICES FOR GRASS SEED CROPS GROWN IN THE WILLAMETTE VALLEY

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

Comprehensive residue management trials have been underway on seed growers' farms in the Willamette Valley since 1992. Research has been conducted on several important perennial grass seed crops including perennial ryegrass, tall fescue, orchardgrass, creeping red fescue, Chewings fescue, and Highland bentgrass. We have examined five to seven residue management alternatives at each of 15 on-farm sites. These residue management techniques include: (i) removal of straw by baling (bale only); (ii) baling straw, followed by flail chopping stubble (flail); (iii) baling, flailing, followed by residue removal with needle-nose rake (rake); (iv) baling, followed by removal of residue by vacuum-sweeper (vacuum-sweep); (v) repeatedly chopping straw and stubble (3 times) with no removal (flail 3X); (vi) baling, followed by incineration of straw and stubble by propane burner (propane); and (vii) open-field burning. The purpose of this report is to provide an update on the progress of this research.

Effectiveness of Straw and Stubble Management

Two schools of thought govern how Willamette Valley seed growers approach residue management in grass seed crops. One subscribes to the belief that most or all residue must be removed from the field in order to maintain a productive stand and to provide a conducive environment for pest control. The other contends that most or all residues can be managed to decompose in the field thereby enhancing beneficial soil characteristics. The residue management strategies examined in our study differ in efficiency of straw and stubble removal. The amount of residue present with no removal (flail 3X) was essentially constant from year to year in perennial ryegrass and tall fescue, but increased sharply from 1992 to 1993 in orchardgrass (Table 1). Most of the straw remaining after the flail 3X treatment had decomposed prior to seed harvest in 1993 and 1994. Baling removed most of the straw remaining in the field after harvest in both years. Stubble height was reduced by the flail treatment (Table 2) but no additional straw was removed from the field. The rake generally removed more than half of the straw remaining after baling. The vacuum treatment was most effective in removing straw and reducing stubble height. Stubble heights for the residue treatments employed in 1993 were similar to those observed in 1992 (Table 2).

Table 1. Crop residue remaining after nonthermal management.

Crop	Year	Treatment: Flail 3X	Bale	Flail	Rake	Vacuum
		(lb/a)				
Perennial ryegrass	1992	6192	1401	1573	815	291
	1993	5624	1707	2022	1013	321
Tall fescue	1992	6826	2346	2158	1141	381
	1993	7383	1168	1989	839	254
Orchard-grass	1992	4289	780	1114	482	132
	1993	6454	510	2710	620	177
Creeping fescue	1992	--	--	2911	1008	377
	1993	--	--	4275	873	152
Chewings fescue	1992	--	--	2117	987	194
	1993	--	--	3082	568	88
Highland bentgrass	1992	--	--	1785	961	94
	1993	--	--	3484	1685	112

Table 2. Stubble height after nonthermal residue management.

Crop	Year	Treatment				
		Flail 3X	Bale	Flail	Rake	Vacuum
		(inch)				
Perennial ryegrass	1992	1.7	2.3	1.6	1.6	1.5
	1993	1.8	2.0	1.7	1.7	1.7
Tall fescue	1992	2.6	3.6	2.7	2.7	2.4
	1993	2.8	3.3	2.7	2.6	2.5
Orchard-grass	1992	2.8	3.8	2.8	3.5	3.5
	1993	3.1	6.1	3.4	4.4	3.5
Creeping fescue	1992	--	--	2.1	2.1	1.2
	1993	--	--	1.6	1.5	1.3
Chewings fescue	1992	--	--	1.6	1.5	1.1
	1993	--	--	1.3	1.3	1.3
Highland bentgrass	1992	--	--	2.4	2.3	0.7
	1993	--	--	1.0	1.0	1.0

Response of Fall Regrowth to Residue Management Strategies

The post-harvest regrowth period is the most critical phase in the development of yield potential in perennial grass seed crops. Seed growers must employ management practices that result in the maximum number of tillers of sufficient maturity prior to the onset of winter. Inadequate fall regrowth can lead to losses in seed yield and reduced productivity of the stand.

Thermal management (propane and open burn) increased the number of large basal diameter tillers in creeping red fescue. Other treatments produced significantly fewer large tillers than open burning. Tiller height was increased when the crop was not burned. Residue management had no effect on fall tiller production or other measures of regrowth in Chewings fescue in fall 1993 and only tiller height was impacted in fall 1992.

Fall regrowth was largely unaffected by residue management in the previous summer in tall fescue, orchardgrass, and perennial ryegrass, but a few notable exceptions were recorded. Bale and propane treatments produced the greatest height of regrowth in Manhattan IIE perennial ryegrass and propane burning significantly reduced the number of large basal diameter tillers in Linn perennial ryegrass in 1994.

Tiller production in tall fescue and in orchardgrass was not influenced by residue management method in fall 1993, but tiller number was reduced by bale and rake treatments in Rebel II in fall 1992. Tiller height, however, was influenced by residue management in tall fescue and orchardgrass. The bale only treatment consistently produced tall regrowth compared to other treatments in tall fescue and orchardgrass.

Fall tiller growth and development in Highland bentgrass followed a pattern that was unique among the grass seed crop species that we have studied. Unlike in other species, total tiller production and the production of tillers having large basal diameter were reduced by open burn and propane treatments in Highland bentgrass. Tiller height was increased by more thorough straw and stubble removal treatments (vacuum, propane, and burn). Regrowth height was generally reduced in response to increased thoroughness of stubble and straw management in other species.

Residue management had a marked effect on the number of aerial tillers (tillers produced from axillary buds above the soil surface) present in Linn perennial ryegrass. Fewer aerial tillers were present when the full straw load remained in the field and when the residue was managed by vacuum or propane treatments. Although not statistically significant, aerial tillers tended to increase in all seed crops when not burned, and their presence in the field was further increased by less thorough straw and stubble removal. However, we have not been able to establish a connection between aerial tiller number and seed yield.

Leaf development was not influenced by residue management in Banner Chewings fescue or in Manhattan IIE perennial ryegrass. Tiller maturity (measured by leaf number) in fall 1993 was greatest in the vacuum and open-burn treatments and was least mature in the propane treatment in Highland bentgrass. Leaf development values for Highland bentgrass appear to be an early indicator of yield since the 1994 seed yields were reduced in treatments with lower tiller maturity going into winter (Table 8). The vacuum treatment produced tillers that were less mature than other treatments in creeping red fescue..

Significantly fewer leaves per tiller were present in flail 3X than in other treatments in Crewcut tall fescue. The flail 3X treatment produced fewer 4-leaf tillers going into winter than other treatments, consequently, tillers in this treatment were immature in winter when tall fescue is induced to flower. As a result, seed yield in summer 1994 was lowest in the flail 3X treatment in Crewcut tall fescue (Table 6). The bale treatment produced more mature tillers in Rebel II tall fescue, but tiller maturity in fall 1993 did not impact seed yield in 1994 (Table 5). Orchardgrass tillers showed less maturity in treatments that removed more stubble and straw.

Effect of Residue Management Strategies on Spring Tiller Production

Fertile tiller production was not influenced by residue management in perennial ryegrass, tall fescue, and orchardgrass in 1993, but some differences were noted in 1994. Fertile tiller number was not affected by residue management method at five of the six perennial ryegrass sites. In Manhattan IIE perennial ryegrass, fertile tiller numbers were greatest in the flail and vacuum treatments. Residue management had significant effects on fertile tiller number at three of the five tall fescue sites. Tall fescue fertile tiller numbers tended to be lower in the vacuum treatment. Fertile tiller number was not affected by residue management in Rebel II and Rebel Jr. Fertile tiller number in orchardgrass was highest in the flail 3X and vacuum treatments and was lowest in the rake treatment.

No statistically significant effect of residue management on fertile tiller production was observed in Banner Chewings fescue in 1993 and 1994. The fewest fertile tiller numbers in Highland bentgrass were measured in the propane and open-burn treatments in 1994, but no effect on fertile tillers were observed in 1993. Fertile tiller number was dramatically reduced by all nonthermal treatments and propane burning in creeping red fescue in 1994, but the propane treatment produced fertile tiller numbers that were equivalent to burning in 1993.

Impact of Residue Management on Harvest Characteristics

Tillering and leaf development in fall 1992 were largely unaffected by residue management in the previous summer in tall fescue, orchardgrass and perennial ryegrass. Consequently, flowering (expressed by fertile tiller production) and seed yield in the following season were likewise not influenced by residue management in 1993. However, perennial ryegrass seed yield was consistently reduced by flail 3X treatment in the south Willamette Valley in 1994 (Table 3), but flail 3X did not reduce yield in the north valley (Table 4). Conversely, tall fescue seed yields were not reduced by the flail 3X treatment in the south Willamette Valley in 1994 (Table 5), but yields were reduced by the flail 3X treatment in the north Willamette Valley (Table 6). We can not explain why tall fescue and perennial ryegrass responded differently to the same treatment in the same growing region. Orchardgrass seed yields were not affected by management in both years (Table 7).

Fertile tiller production and seed yield in creeping red fescue were greatest when the residue had been burned in the previous summer. In 1993, vacuum and propane treatments produced creeping red fescue yields that were equivalent to burning, however, in 1994, all treatments produced yields that were less than open-burning (Table 8). Fall tiller production in Chewings fescue also responded favorably to nonthermal management, so yields were not affected by residue management in either year (Table 8). Highland bentgrass seed yield was not affected by residue management in 1993, but yield was reduced by flail and propane treatments in 1994 (Table 8). The rake and vacuum treatments produced yields that were equivalent to burning in Highland bentgrass.

Fluorescence tests were conducted on perennial ryegrass seed lots to detect the presence of annual ryegrass. No significant increases in annual ryegrass contamination were observed in perennial ryegrass as a result of residue management technique in all varieties except Linn in 1994. The lowest incidence of fluorescence was detected in flail, vacuum, and propane treatments. Thoroughness of residue removal had no effect on seed germination. Also, it is important to note that contrary to popular opinion, burning did not improve seed germination. Only 3 sites showed significant differences in weed seed levels in seed quality tests conducted in 1994, but weed contamination and control may be the greatest threat to nonthermal management of grass seed crops.

Genetics play a major role in determining how a grass seed crop responds to nonthermal management. Following are some observations we have made on these relationships in our trials:

1. Orchardgrass and tall fescue do not require burning to maintain seed yields nor do they require thorough removal of straw and stubble.

2. Perennial ryegrass and Chewings fescue do not need to be burned, however, these crops do not tolerate much straw or tall stubble remaining in the field.

3. Removing most of the straw and stubble will produce acceptable yields in Highland bentgrass for several years, but productive stand life may be reduced by nonthermal management.

4. Burning is the only method that maintains seed yield in creeping red fescue. Propane treatment does not substitute for burning.

Seed growers should choose residue management strategies for grass seed crops based on crop species grown and economic factors.

Table 3. Residue management effects on perennial ryegrass seed yield in the southern Willamette Valley.

Treatment	Pennfine 1993	Pennfine 1994	Linn 1993	Linn 1994	Oasis 1993	Oasis 1994	Mean over varieties and years
	(lb/a)						
Flail 3X	748 a[1]	646 a	932	633 a	1690	1373 a	1004
Bale	866 b	742 ab	881	687 ab	1855	1655 b	1111
Flail	863 b	836 b	928	730 b	1718	1519 ab	1099
Rake	742 a	730 ab	906	867 c	1778	1438 a	1077
Vacuum	820 ab	783 b	958	895 c	1787	1610 b	1142
Propane	770 a	608 a	906	898 c	1831	1656 b	1112

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

Table 4. esidue management effects on perennial ryegrass seed yield in the northern Willamette Valley.

Treatment	Yorktown III 1993	Yorktown III 1994	Pennant 1993	Pennant 1994	Manhattan IIE 1993	Manhattan IIE 1994	Mean over varieties and years
	(lb/a)						
Flail 3X	2262	1989	1397 bc[1]	1304	2324	1901	1863
Bale	2227	1985	1345 ab	1410	2354	1915	1873
Flail	2341	2114	1364 bc	1386	2281	1957	1907
Rake	2359	2058	1437 c	1358	2309	1919	1907
Vacuum	2348	2083	1359 bc	1433	2354	2010	1931
Propane	2356	1904	1959 a	1562	2196	2042	1887

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

Table 5. mpact of residue management on tall fescue seed yield in the southern Willamette Valley.

Treatment	Anthem 1993	Anthem 1994	Rebel Jr. 1993	Rebel Jr. 1994	Rebel II 1993	Rebel II 1994	Mean over varieties and years
	(lb/a)						
Flail 3X	1692	1544	2110 d[1]	1781	1575	1166 b	1645
Bale	1606	1425	1963 ab	1750	1434	1085 ab	1544
Flail	1662	1498	1915 a	1870	1435	1192 b	1595
Rake	1695	1489	2017 bc	1767	1547	1089 ab	1601
Vacuum	1668	1470	2078 cd	1690	1384	956 a	1541

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

Table 6. Effect of residue management on tall fescue seed yield in the northern Willamette Valley.

Treatment	Rebel Jr. 1993	Rebel Jr. 1994	Crewcut 1993	Crewcut 1994	Mean over variety and years
	(lb/a)				
Flail 3X	1890	789 a[1]	1945	1748 a	1593
Bale	1925	892 b	1897	1985 b	1675
Flail	2046	952 b	1932	1940 b	1718
Rake	1899	907 b	1887	1987 b	1670
Vacuum	1941	949 b	1738	2019 b	1662

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

Table 7. Influence of residue managment on seed yield in Elsie orchardgrass.

Treatment	1993	1994	Mean over years
	(lb/a)		
Flail 3X	921	502	712
Bale	961	448	705
Flail	926	496	711
Rake	946	446	696
Vacuum	914	458	686

Table 8. Residue management effects on fine fescue and Highland bentgrass seed yield.

Year	Treatment	Pennlawn creeping red fescue	Banner Chewings fescue	Highland bentgrass
		(lb/a)		
1993	Flail	694 a[1]	1072	594
	Rake	717 a	1075	590
	Vacuum	914 b	991	587
	Propane	876 b	1042	611
	Burn	1023 b	1057	610
1994	Flail	544 a	613	701 a
	Rake	528 a	607	734 ab
	Vacuum	498 a	670	778 b
	Propane	542 a	695	686 a
	Burn	752 b	625	763 b

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

NONTHERMAL GRASS SEED PRODUCTION SYSTEM RESEARCH STATUS REPORT

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Project Summary

Major questions exist regarding the optimum cropping practices that are required to produce grass seed economically in the absence of open field burning. Crop establishment, fertilizer, and pest management practices were developed with the assumption that post-seed-harvest residues would be removed from the system annually after each seed harvest. The purpose of this relatively long-term experiment is to obtain information to determine the cropping practices needed for optimum economic production during and after the transition period from low-residue to high-residue management. It is our intent to identify strategies that deal with any adverse system changes resulting from possible shifts in pest populations and to respond to these with new best management practices (reduced inputs where possible). Early recognition of system changes and adjustments in practices are required if consistent and optimum economic seed production is to be achieved.

Many grass-seed cropping systems in western Oregon have historically been continuous grass seed production and have not utilized the potential beneficial effects of alternative life history crops in rotation sequences. Legume and cereal crops in rotation with grasses in nonthermal seed production systems may provide critical components that increase the likelihood of production success. Both legumes and/or cereals may benefit cropping systems by: 1) breaking the life cycles of many insect, disease, and weed pests that are persistent and difficult to control under continuous grass systems; 2) providing important sources of organically bound or biologically fixed nitrogen that can substitute for fertilizer applications; 3) improving soil tilth, general soil health, and assisting with soil stabilization that reduces erosion; and 4) improving fertilizer recovery when large amounts grass straw residues are present. However, a major problem when changing the traditional production systems is how to introduce alternate rotation crops without significantly reducing net economic productivity and increasing soil erosion and air-borne dust particulates due to increased field disturbance.

The main systems portion of this project was begun in the spring of 1992. The study is being conducted at three sites representative of three different environments typical for seed production in the Willamette Valley. Each site has a single grass seed crop species representative of that region. The crops and regions are: 1) a perennial ryegrass crop on a poorly drained site in Linn County, 2) a turf-type tall fescue crop on a moderately drained soil at Hyslop Research Farm, Benton County, and 3) a fine fescue crop on a hill-land soil in the Silverton Hills, Marion County. We have now completed the first full crop sequence staging in our experiment, and in the next year be able to actually measure the effects of the non-grass seed crop rotation sequence components.

Straw residue effects.
Maximum straw residue compared to low residue management following first year seed crops did not significantly reduce seed yields for any second year crops of the three grass seed species in 1994 (Figure 1). Average seed yields for fine fescue, tall fescue, and perennial ryegrass were approximately 400, 800 and 870 pounds per acre, respectively. We will continue to compare continuous grass seed production systems with more rapid two year grass seed crop components within rotation systems.

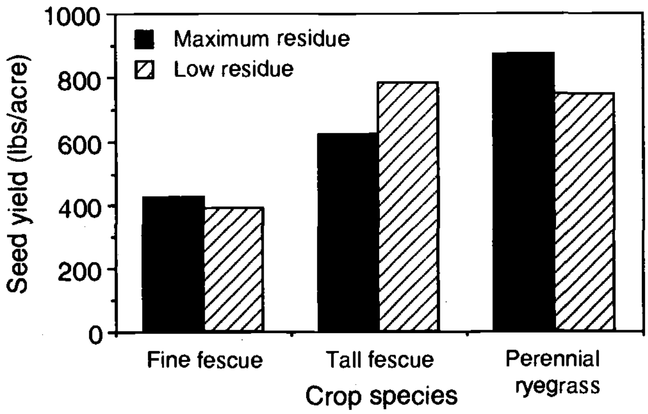

Figure 1. Straw residue effects on subsequent year grass seed yields at three locations in 1994.

Volunteer seedlings.
After the first year harvest of perennial grass seed fields, shattered seeds germinate and become established underneath established mother plants once the winter rain period begins. A greenhouse experiment was done to simulate these conditions and to determine the potential contribution of first-year volunteer seedlings to established crop seed yield in the second year of production. Seeds of perennial ryegrass, tall fescue, and fine fescue were planted and grown for 0, 7, 15, and 30 days (8 hrs @ 40° F and 16 hrs @ 60° F with lights) before being put in cold temperature conditions (35° F for 90 days with 8 hrs light). After exposure to the cold temperatures, the plants were moved to a greenhouse and grown from May 1 to July 1 at approximately 80° F with either 100 or 23% natural day light to simulate full sun or shaded conditions under established mother plants in the field. The actual measured amount of shading in the field between rows for perennial ryegrass, tall fescue, and fine fescue during this period was 84, 95, and 84% respectively.

Only perennial ryegrass plants produced reproductive tillers that flowered under any of the conditions of the experiment (Table 1). There were no reproductive tillers produced by the tall and fine fescue simulated volunteer plants. Given these results, for the cultivars used and the conditions of this experimental simulation, tall fescue and fine fescue volunteers could be expected to not produce any seeds during their first year of establishment in already established second-year seed crop fields. Perennial ryegrass, on the other hand, will produce reproductive tillers, regardless of seedling age when entering the cold temperature period, so volunteer seedlings could contribute to total seed production in second year seed fields. However, under low light conditions similar to those found to naturally occur in the field, volunteer plant contributions to total seed yield may be low due to a 96% reduction in the number of reproductive tillers produced per plant compared to no-light-limited conditions. If actual field studies can be shown to repeat these simulated results, it may be possible to reduce the need for the applications of non-selective herbicides to control volunteer seedlings in fields that are only grown for two seed crops.

Table 1. Effect of seedling age before vernalization and two levels of light during reproduction on number of reproductive tillers for perennial ryegrass, tall fescue, and fine fescue grown in the greenhouse.

Seeding age before cold treatment	Perennial ryegrass		Tall fescue		Fine fescue	
	Shading treatment†					
	without	with	without	with	without	with
(days)	--------(no. of reproductive tillers/plant) ------					
0	7.3	0.3	0	0	0	0
7	8.2	0.1	0	0	0	0
15	4.6	0.0	0	0	0	0
30	6.6	0.6	0	0	0	0
Average	6.7	0.25	0	0	0	0

†Shading treatment resulted in 79% reduction in light compared to full sunlight.

Nitrogen fertilizer management.
Reductions of N fertilization from 150 to 75 pounds per acre (50% less than standard N application amount) in second-year perennial ryegrass reduced seed yields by 22%. No fertilizer application reduced seed yield by 69%, compared to the standard application amount. For tall fescue, there was no seed yield difference between the 150 and 75 lb N/a application treatments. The no-N fertilization treatment reduced tall fescue seed yield by 27%, compared to the standard treatment amount. First-year fine fescue seed yields were unaffected by the addition of N fertilizer, and so were the same as the no-N treatment.

Reductions in seed yield in tall fescue and perennial ryegrass were associated with reductions in the number of fertile tillers and total above-ground dry matter production. The root to shoot dry weight ratio was increased under conditions of reduced N fertilization. Seed yields across the N treatments by previous season straw residue treatments (maximum straw residue vs. minimum residue) were the same for all three grass species. It may be possible to reduce the amount of N fertilizer applied and not lose seed yield if adequate nitrogen is produced by a previous season clover seed crop. We will begin to measure this possibility in 1995.

Compost effects.
Using compost as a substitute N source, perennial ryegrass seed yields were similar as those using inorganic N fertilizer (Figure 2). There was no interaction effect between the previous-year residue treatment and the amount of compost applied. These treatments are being repeated in 1995.

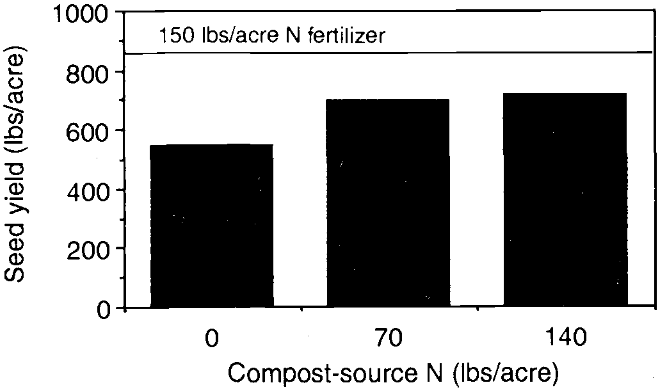

Figure 2. Effect of compost N substituted for inorganic N fertilizer on perennial ryegrass seed yield in 1994.

No-till establishment.
No-till wheat was planted into existing perennial grass seed stands at all three locations. Successful final wheat establishment was achieved at the tall fescue and fine fescue sites. Wheat yields at the tall and fine fescue sites under conventional and no-till establishment were 7475 and 5875; and 5430 and 5340 pounds per acre, respectively. Due to the poorly drained soil conditions at the perennial ryegrass site, wheat yields were highly variable between the four replications (range equals 1057 to 5634 lb/a). Red clover was planted no-till into the established wheat stands (before the wheat began to elongate) at the tall and fine fescue sites in early spring. Many of the established clover plants survived the summer dry period and have reinitiated growth this past fall. The success of this strategy will be judged by our ability to increase the rate of crop sequence. Using conventional tillage establishment methods, a loss in revenue occurs in the 16 month period between the time when the last perennial grass seed crop is harvested and the clover seed crop is planted the following spring but not harvested until the following year. We will begin to evaluate this strategy in 1995.

Legume seed production.
Highest 'Louisiana S-1' white clover seed yields for stands that did not have forage removed in spring were achieved with conventional fall establishment when compared with fall no-till and spring-broadcast seeding methods (Figure 3). The most economical method for establishment is the broadcast treatment, but high stand density resulted when compared with the row-planted methods which may have reduced flower density. These three treatments have been

repeated and will be evaluated again in 1995. The effects of stand density when using the broadcast methods will also be determined.

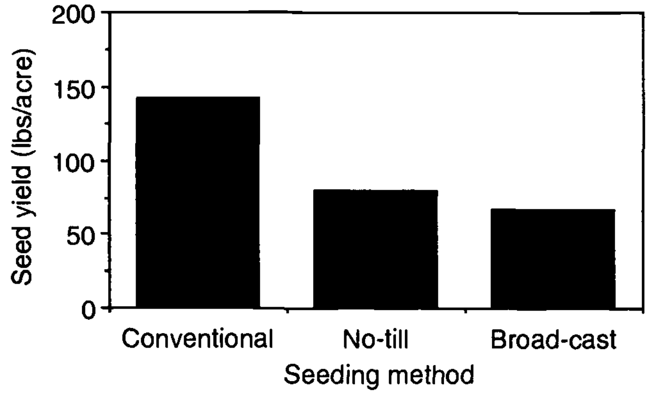

Figure 3. Effect of white clover seed establishment method of seed yield. Conventional and no-till methods were planted in the fall of 1992 and broad-cast planted in the spring of 1993.

White clover seed yield was not different when comparing the optimum forage removal time treatment with the no-forage-removal control (Figure 4). However, white clover seed yields were reduced when the forage was removed at June 3 or later, compared to the no-forage-removal treatment. If this relationship continues, then growers using Louisiana S-1 white clover will have the option to either not remove forage in spring or to graze with sheep, and not significantly reduce white clover seed yields.

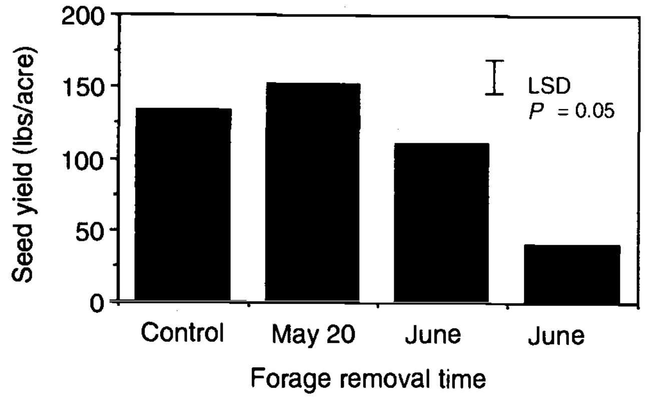

Figure 4. Effect for forage removal on white clover seed yield on poorly drained soil in 1994.

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RESIDUE MANAGEMENT PRACTICES FOR GRASS SEED CROPS GROWN IN THE GRANDE RONDE VALLEY

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Three on-farm sites were established in spring 1992 in the Grande Ronde Valley to investigate nonthermal management effects on Kentucky bluegrass and Chewings fine fescue seed production. Treatments included: (i) removal of straw by baling (bale only), (ii) baling, flailing with a rotary scythe, followed by residue removal with a needle-nose rake (rake), (iii) baling, followed by removal of residue by vacuum-sweeper (vacuum), (iv) repeatedly chopping straw and stubble (3 times) with no removal (flail 3X), and (v) open-field burning. A fourth site (Stolte) was initiated in spring 1993 to compare propane treatment to vacuum and open burn treatments in Kentucky bluegrass. The purpose of this report is to provide an update on the progress of this research.

Response of Fall Regrowth to Residue Management Strategies

Fall-formed Kentucky bluegrass tillers were consistently taller in flail 3X (stubble height reduced, no straw removal) and bale (no stubble reduction, 75% straw removal) treatments (Table 1). Total tiller number was also generally reduced in these treatments. Flail 3X and bale treatments reduced the number of large (2 mm basal diameter) fall tillers in both Kentucky bluegrass varieties in 1992 (Table 2). Untimely rainfall and late maturity of Bristol delayed both seed harvest and residue management in 1993. Because of green regrowth at the time of harvest, burning was delayed several weeks after the nonthermal treatments were conducted to allow the residue to dry. Consequently, this timing difference may have resulted in lower than expected tiller production in the burn treatment. Nevertheless, flail 3X treatment produced low numbers of large tillers in both varieties in fall 1993. Rake and vacuum treatments consistently produced numbers of large fall tillers that were equivalent to or greater than burning.

Table 1. Impact of residue management strategies on fall tiller height in Kentucky bluegrass and Chewings fescue.

	Kentucky bluegrass				Chewings fescue	
	Abbey		Bristol		Barnica	
Treatment	1992	1993	1992	1993	1992	1993
	(cm)					
Flail 3X	13 b[1]	15 c	14 c	15 d	18 c	14 c
Bale	12 b	10 b	10 b	9 c	14 b	9 ab
Rake	9 a	7 a	7 a	5 a	13 ab	10 b
Vacuum	8 a	7 a	8 ab	5 a	15 bc	7 a
Burn	9 a	7 a	7 a	7 b	10 a	10 b

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

Table 2. Influence of residue management strategies on number of large (2 mm diameter) fall tillers in Kentucky bluegrass.

	Abbey		Bristol	
Treatment	1992	1993	1992	1993
	(% of burn)			
Flail 3X	65 ab[1]	35 a	43 a	86 a
Bale	64 a	89 b	48 a	97 a
Rake	115 c	99 b	78 b	156 bc
Vacuum	108 c	101 b	92 b	168 c
Burn	100 c	100 b	100 b	100 ab

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

Residue management affected Barnica Chewings fescue regrowth differently than was observed in Kentucky bluegrass. Tiller height was typically greatest in the flail 3X treatment and burning produced shorter tillers, but the effect of management on height was not consistent for the other treatments (Table 1). For instance, the vacuum treatment produced tall regrowth in 1992 but not in 1993. Residue management practices had no impact on total tiller number or on the basal diameter of the tillers in Chewings fescue. The number of aerial tillers were reduced in proportion to the thoroughness of stubble and straw removal. Aerial tillers accounted for more than 20% of the total tiller population in bale and flail 3X treatments in 1993, whereas no aerial tillers were found when the crop was burned. It is possible that the increased presence of aerial tillers in these treatments in fall 1993 caused the reduction in seed yield observed in summer 1994 (Table 4).

Greater tiller maturity (measured by leaf number) was observed in flail 3X, vacuum, and burn treatments than in other treatments in Barnica Chewings fescue. Tillers of Abbey Kentucky bluegrass were least mature in fall 1993 when residue was managed by the flail 3X treatment. The flail 3X treatment produced the poorest seed yield in summer 1994. The greatest tiller maturity in Bristol Kentucky bluegrass was exhibited in the bale and vacuum treatments.

Effect of Residue Management Strategies on Spring Tiller Production

Fertile tillers are the primary component of seed yield in cool-season grasses. Fertile tiller number in both Kentucky bluegrass varieties was affected by residue management conducted in the previous summer. The lowest fertile tiller populations were found in the flail 3X treatment. The rake and vacuum treatments produced fertile tiller numbers that were equivalent to open burning. The numbers of vegetative tillers observed in spring in both Kentucky bluegrass varieties were not impacted by residue management conducted in the previous summer.

Barnica Chewings fescue fertile tiller numbers were greatly reduced by the flail 3X treatment. All other treatments produced fertile tiller numbers that were equivalent to those measured in the open burn treatment. Residue management did not affect spring vegetative tiller number in Chewings fescue.

Impact of Residue Management on Harvest Characteristics

Seed yields were equivalent to open-burning when Kentucky bluegrass was managed by the rake or by the vacuum methods (Table 3). These treatments reduced stubble height and removed at least 90% of the straw remaining in the field after harvest. Unacceptable low seed yields were measured in the flail 3X treatment. In the 1993 trial, the bale treatment produced yields equivalent to rake and vacuum treatments, but yields were lower in the 1994 trial. Harvest index tended to be lower when stubble and straw was not removed. Percent cleanout was increased in flail 3X and bale treatments in Abbey, but not in Bristol. Kentucky bluegrass seed yields was not affected by propane burning. Yields at the Stolte site in summer 1994 under thermal residue management were 483 lbs/acre and 497 lbs/acre for the propane and open burn treatments, respectively. The vacuum treatment produced 578 lbs/acre seed yield.

Table 3. Effect of residue management on Kentucky bluegrass seed yield.

Treatment	Abbey 1992	Abbey 1993	Bristol 1992	Bristol 1993
	(lb/a)			
Flail 3X	836 a	245 a	431 a	226 a
Bale	1100 b	490 b	600 b	356 b
Rake	1242 b	766 c	642 bc	452 c
Vacuum	1170 b	661 c	627 bc	442 c
Burn	1224 b	749 c	674 c	434 bc

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

The vacuum treatment consistently produced seed yields that were equivalent to burning in Barnica Chewings fescue (Table 4). The rake treatment produced yields that were also statistically equivalent to burning, but had a marked tendency to be lower. Seed yields were not reduced by the bale treatment in 1993, but were lower in 1994. Flail 3X treatment consistently produced low seed yields. Cleanout was increased by the flail 3X treatment.

Table 4. Residue management effects on Barnica Chewings fescue seed yield.

Treatment	1993	1994
	(lb/a)	
Flail 3X	801 a	335 a
Bale	931 ab	599 b
Rake	965 b	639 bc
Vacuum	1032 b	745 c
Burn	1021 b	749 c

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

Thoroughness of residue removal had no effect on seed germination or purity in Kentucky bluegrass and Chewings fescue in 1993. Seed germination was highest in flail 3X, vacuum, and burn treatments in Abbey Kentucky bluegrass in 1994. Purity and germination were low in Bristol Kentucky bluegrass in 1994 regardless of residue treatment. Seed purity and germination were reduced by the flail 3X treatment in Barnica Chewings fescue in 1994. No weed seed were observed in seed harvested at any of the sites.

Our research clearly demonstrates that seed yield can be maintained in Kentucky bluegrass and Chewings fescue without burning provided that straw removal is thorough and stubble height is reduced prior to regrowth of the crop. Residue management operations in Grande Ronde Valley seed crops must reduce stubble height and remove 90% of the straw to ensure optimum crop regrowth and development. But maintenance of seed yield without fire does not come without increased costs to the producer. Residue management costs in rake or vacuum-based systems are certainly increased compared to burning and it is likely that weed management costs will also be greater than when the field is managed by burning.

EVALUATION OF POST-HARVEST RESIDUE REMOVAL EQUIPMENT ON KENTUCKY BLUEGRASS GROWN FOR SEED IN CENTRAL OREGON

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Introduction

This report updates the 1993 Seed Production Research report for this project. Post-harvest open-field burning on Kentucky bluegrass has been responsible for maintenance of yield and high quality seed production in the Pacific Northwest. However, increased concern for air quality has pressured growers to find alternative ways of removing debris after harvest

With new technology in equipment available, this study's objectives is to: 1) demonstrate different mechanical residue management practices; 2) determine crop growth and development of Kentucky bluegrass with reduced smoke impact management treatments; and 3) compare the mechanical treatments to open-field burning for seed yield and seed quality.

Materials and Methods

Two on-farm sites were established in 1991 in central Oregon to evaluate the full compliment of the latest technology for mechanical post-harvest residue removal on Kentucky bluegrass seed production. Two more fields were added in 1992 and in 1993 (for a total of six fields) for a comparison over time. Each year, one field was planted with an aggressive variety (highly rhizomatous) and the other field with a non-aggressive variety. Aggressive varieties include those that are highly rhizomatous (Bristol and Rugby) and fill-in between a 12" row spacing within a year or two; non-aggressive varieties (Abbey and Merit) are less rhizomatous.

Because the primary focus for the study was to evaluate the most advanced technology in post-harvest residue equipment, we needed to identify what extent of residue removal was desired. The most common practice of open field burning leaves the field absent of any non-combustible debris and also eliminates debris around the crown of the plant. This cleansing of the soil surface allows maximum light penetration as well as allowing maximum efficiency for pesticide applications. Mechanical residue removal can be accomplished by using various methods. Each method varies in the amount and efficiency of soil cleansing. New equipment used in this study included a wheel rake, which has stiff tines to scratch the residue and thatch, and remove debris from around the crowns; and a Grass Vac, both developed by Rear's Manufacturing in Eugene, Oregon. The Grass Vac machine enabled us to clip and vacuum remove the stubble to a 1 inch height. With the wheel rake, the bulk of the residue is windrowed, which is baled or otherwise disposed of. Other equipment tested included a flail mower and a propane flamer. Propane flaming was tested because it produced relatively little smoke after vacuum sweep or wheel rake treatments.

Commercial grass seed fields in central Oregon normally have a large portion of the crop residue removed as baled straw, followed by open-burning of stubble, propane burning or both. Thus, this "field treatment" was compared with several alternative methods of stubble management. Treatments included (1) field treatment; (2) bale-only (no subsequent stubble management); (3) flail chop (flailing all the stubble back on the ground); (4) wheel rake; (5) rake plus propane (6) vacuum-sweep (mechanical removal of stubble after baling with a Grass Vac); and (7) vacuum sweep plus propane. The treatment plot size was 100 x 22 ft.

Data were collected for vegetative tiller development, fertile tiller development, seed yield, and seed quality. All other management practices such as fertilizing, irrigating, and pest control were done as the normal grower practices for the individual fields. Harvest was completed with the use of conventional equipment and sub-samples were collected to obtain a percent clean out. Clean seed yield, 1,000 seed weight and percents germination were determined.

Results and Discussion

Significant differences in seed yield resulted from the various management treatments. The highest yields consistently were produced where the residue was removed completely either by mechanical means or by burning. Bale-only treatment resulted in the least seed yield as well as the lowest number of fertile tillers. Tables 1-3 shows clean seed yields (lb/a) for 1992 thru 1994. When averaged over all test sites, seed yield and fertile tiller numbers were highest with the open-field burning treatment. In comparison, for plots in which residue was removed by vacuum-sweep followed by propaning, vacuum-sweep alone, flail-only and bale-only, mean seed yields were 85, 85, 79, and 67%, respectively, per two fields in 1992; were 94, 90, 90, and 83%, respectively, per four fields in 1993; and were 94, 86, 80, and 75%, respectfully, per six fields in 1994. Wheel rake treatments were harvested in 1993 and 1994 with mean seed yields of 91 and 86% compared to open-field burning. Seed yields were lowest for fields in the fourth year of harvest when compared to third and second year harvest. Fertile tiller numbers followed the same trend as seed yields. Thousand seed weight and seed germination percentages were comparable among all treatments for each field ($P \leq 0.05$), and were unaffected by residue management. This study will continue through 1996.

Differences in seed yield by variety type were observed in our study. In 1992 the aggressive variety showed a significant need for a more complete residue removal. However, in 1993 the aggressive variety did not need complete residue removal. The winter of 1992 was dryer than the winter of 1993, which may have effected the need for completeness of residue removal. In 1994 there were harvests from a second, third, and fourth year fields. The second year did not require as intense post-harvest residue removal as the third and second years. An obvious need for more intense residue management as the stands age.

Tiller development: The general trend of fertile tiller numbers was the same as for seed yield. Fall and spring vegetative tiller numbers showed no differences among treatments, with the exception that in the bale-only treatment there were fewer tillers.

Seed quality: Seed quality was determined by observing germination percentage and by measuring 1,000 seed weight. Seed quality was not affected by different residue management treatments.

In general, mechanical removal performed much better in our studies compared to bale-only treatment. However, compared to open-field burning, removal of residue with vacuum-sweep or vacuum-sweep followed by propane flaming were not quite as reliable. It is likely that mechanical means of straw removal will elevate the cost of production over the cost of open-field burning, both by requiring additional equipment purchase and usage, and by depressing yield. For non-aggressive varieties, these mechanical means of residue removal may prove adequate. The rake plus propane treatment showed promise in the first year of use as a cheaper more efficient mechanical stubble removal technique.

Table 1. Effect of residue management on seed yield (clean weight) in Kentucky bluegrass in Madras, Oregon for 1994.

Treatment	2nd year Abbey	2nd year Bristol	3rd year Merit	3rd year Rugby	4th year Abbey	4th year Rugby
	(lb/a)					
Rake + Prop	851 b*	802 a	1015 bc	NA	NA	NA
Field Burn	943 a	824 a	1257 a	958 a	1133 a	831 a
Vac + Prop	919 ab	857 a	1059 ab	922 a	1021 ab	783 a
Vac	1078 a	836 a	927 bcd	856 ab	911 bc	604 b
Flail + Rake	1003 a	958 a	880 cd	843 ab	814 cd	578 b
Flail	823 ab	839 a	887 cd	699 ab	721 d	593 b
Bale only	890 ab	842 a	806 d	621 b	793 cd	403 c

*Means followed by the same letter are not statistically different by Duncans multiple range test at 5% level.

Table 2. Effect of residue management on seed yield (clean weight) in Kentucky bluegrass in Madras, Oregon for 1993.

Residue treatment	2nd year Merit	2nd year Rugby	3rd year Abbey	3rd year Rugby
	(lb/a)			
Flail + Rake + Prop	1768 a*	NA	NA	NA
Field Burn	1671 a	1066 a	1170 a	978 a
Vac + Prop	1619 abc	962 a	1009 ab	1003 a
Vacuum Sweep	1684 ab	987 a	931 ab	860 ab
Flail + Rake	1529 abc	992 a	1064 ab	848 ab
Flail	1475 c	988 a	983 ab	919 ab
Bale only	1573 bc	912 a	815 b	798 b

*Means followed by the same letter are not statistically different by Duncans multiple range test at 5% level.

Table 3. Effect of residue management on seed yield (clean weight) in Kentucky bluegrass in Madras, Oregon for 1992.

Residue treatment	2nd year Abbey	2nd year Rugby
	(lb/a)	
Field Burn	1996 a*	1262 a
Vac + Prop	1842 ab	983 b
Vacuum Sweep	2010 a	863 b
Flail + Rake	NA	829 b
Flail	1676 b	915 b
Bale only	1752 b	570 c

*Means followed by the same letter are not statistically different by Duncans multiple range test at 5% level.

EVALUATION OF MECHANICAL REMOVAL OF POST-HARVEST RESIDUE AND ENHANCED AMMONIUM NUTRITION OF KENTUCKY BLUEGRASS

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Introduction

The Pacific Northwest Pollution Prevention Research Center (PNWPPRC) awarded a grant to the Department of Plant, Soil, and Entomological Sciences of the University of Idaho and the National Forage Seed Production Research Center of the USDA-ARS at Corvallis, OR in 1992 to conduct a study evaluating mechanical residue removal of post-harvest residue and enhanced ammonia nutrition in Kentucky bluegrass produced for seed. The current practices of open-field burning of post-harvest residue from Kentucky bluegrass seed fields and potential ground water contamination from nitrate nitrogen application are environmental concerns. Alternative mechanical residue removal practices may have potential to reduce acreage burned. Use of ammonia nitrogen fertilizers, which are less likely to leach, may decrease nitrate leaching into groundwater.

Findings

Residue Management: Idaho. First- and second-year seed yields were obtained from sixteen Kentucky bluegrass cultivars established at Worley, Moscow, and Rathdrum Prairie, Idaho in 1992 (Table 1). In the establishment year the first seed crop (1993) was produced without either burning or crewcutting. Unusually dry conditions reduced establishment on the dryland sites at Worley and Moscow, but acceptable yields were obtained. Prolonged snow cover at the Rathdrum Prairie location reduced seed yields to less than 30% of normal.

Previous data has shown that the second seed crop usually responds more favorably to mechanical residue removal than subsequent seed crops. However, in 1994 the second seed crop yields (first crop following crewcutting) showed interactions between varieties within a location and variety by location interactions (Table 1). All varieties showed better second year seed yields with crewcutting at Rathdrum. Poor yields in year one and improved stand establishment probably accounted for the dramatic yield increase. These data also suggest that reduced plant density in the year of establishment and during production of the first-year seed crop may be advantageous to subsequent crops produced with crewcutting.

At Worley, varieties Adelphi, Baron, Eclipse, Glade, and Julia, showed second-year seed yield decline, but at Moscow, these same varieties showed improved second year seed yields (Table 1). The basis for these and many other interactions apparent in these data is not completely known. Cultivars with long fall floral induction requirements appear to respond less favorably to mechanical removal of residue than cultivars with short fall floral induction requirements. Although one notable exception existed with Glade, which has a very long floral induction requirement. Detailed micro-climatic data and floral induction responses are being collected at Moscow to further examine these interactions.

Table 1. First year, 1993, and second year, 1994, seed yield[1] of Kentucky bluegrass cultivars established in 1992.

	Location					
	Worley		Rathdrum		Moscow	
	1993	1994	1993	1994	1993	1994
	(lb/a)					
Adelphi	765	661	149	770	596	1328
Argyle	792	994	-----	-----	1171	1239
Baron	943	816	202	862	948	1203
Cheri	529	752	145	649	742	1590
Eclipse	931	640	302	558	578	916
Glade	742	692	138	500	695	1189
Huntsville	801	1027	244	496	1358	1296
Julia	1084	521	132	580	1009	1167
Ken Blue	852	740	222	526	696	1221
Liberty	798	664	174	734	776	1185
Midnight	1105	624	162	943	1037	1300
Newport	932	904	212	711	677	646
Ram I	527	696	93	574	590	918
Shamrock	----	-----	212	760	----	----
South Dakota	996	740	67	608	871	691
Suffolk	797	816	265	707	501	924
Wabash	669	304	47	350	501	367
LSD*	358	225	96	186	433	390

[1] No burning or crewcutting is required for the first seed crop. The second seed crop was produced following removal of post harvest seed residue by crewcutting.

* Mean differences within a column that equal or exceed the LSD value are significantly different at the 0.05 level of probability

Further evidence of the interaction of stand density, yield, and residue removal method was shown by the harvest of seed from a 1994 row spacing study with Glade Kentucky bluegrass on the Rathdrum Prairie. Glade is an aggressive variety that covers the soil surface quickly. When planted on 21-inch row spacing, seed yield following crewcutting was 865 pounds per acre, while the 14 inch row spacing produced only 638 pounds per acre. Seed yield following burning was 608 pounds per acre on the 21 inch row spacing and 744 pounds per acre on the 14-inch row spacing. These data suggest that bluegrass could benefit from lower planting densities if mechanical residue removal is used.

Cooperative Variety Trial: Jacklin Seed Co. Rathdrum Prairie. Crewcutting did not rejuvenate seed yields from the previously mowed areas to the level of the burned areas for any variety. However, the yields were improved over mowing alone for all varieties but Touchdown. Crewcutting in plot areas that had been previously burned for three years produced lower yields for all varieties than burning except for Georgetown. Yields for Georgetown with crewcutting was 531 pounds per acre compared to 516 pounds per acre with burning. Crewcut areas in previously burned areas of Sydsport, Limousine, Ram I, and Entopper produced yields that were one half to two thirds that of the continuously burned areas. The remaining four varieties had seed yields with crewcutting that were less than one-half that obtained with burning. Grass that had been mowed after every seed harvest for five years often had yields of 20 pounds per acre or less.

These data show that crewcutting will not renovate areas that were previously mowed. Crewcutting after previously burning was successful for only one variety. The differential variety response will be useful as part of a needed management system with mechanical residue removal. Crewcutting is a better treatment than mowing for sustaining or rejuvenating seed yield. Mowing does not remove enough residue for sustained seed production.

Commercial On-farm Trials. Plant samples collected December 2, 1992 from the crewcut area and placed in the greenhouse showed 9.8 panicles per four-inch core while plants from the burned portion of the field had 5.3 panicles per four-inch core, eight weeks after transfer to the greenhouse This indicated that the crewcut site may have equal or greater seed yield than the open-field burned site. At Worley, Idaho, seed yield of 'Banff' Kentucky bluegrass in July, 1993 was 682 pounds per acre for the crewcut area. The burned portion of this field averaged 547 pounds per acre. These yields verified the plant response observed from plants collected in December.

In 1994 at Worley, third-year seed yields, second-year with crewcutting, were 354 pounds per acre, equal to yields of 366 pounds per acre obtained with two years of burning. Seed yield from an area burned the first-year and crewcut the second year was 305 pounds per acre, not significantly different from the other yields.

At Nezperce, Idaho in 1993, the second seed crop of the variety Classic, first seed crop following crewcutting, produced 720 pounds per acre and 563 pounds per acre after burning. The panicle numbers from plants collected in November also reflected this trend. Both of these fields were in the second year of seed production, the first year with mechanical removal of residue.

In 1994, at Nezperce, third-year seed yields following crewcutting, 439 pounds per acre, were not significantly different from seed yields after burning, 521 pounds per acre. Unlike at Worley, seed yield from an area burned the first year and crewcut the second year was 277 pounds per acre, significantly lower than from the other treatments.

Panicle density measured on plants growing in the greenhouse after collection from the field at periodic intervals from late October through March and seed yields from field plots in 1994 were significantly correlated at Worley, r=0.41, and Rathdrum, Idaho, r=0.60, but not at Moscow, r=0.18.

Nitrogen, Plant Growth and Seed Yield Components
For the Kentucky bluegrass varieties Liberty, Adelphi, Glade, Suffolk, Classic, Merit, and South Dakota nitrogen form did not significantly (p=0.05) affect final above and below ground biomass accumulation, vegetative tiller and panicle number, or seed yield (Table 2 and 3). Generally, variability due to position in the field (replications) was generally greater than variability attributable to variety or form.

Table 2. The effect of nitrogen form on panicle number. Values are means of five Kentucky bluegrass cultivars which were harvested from Worley, and Rathdrum, ID and Madras and La Grande, OR.

Form of Nitrogen	Location Worley	Rathdrum	Madras/ LaGrande
	(no./ft² row)		
Ammonium nitrate	258	85	154 236
Ammonium sulfate	247	83	132 225

There is some indication that fall tiller number may be enhanced with enriched ammonium nutrition. Tiller and panicle production was estimated on plant samples taken on March 10, 1993 by transplanting plant cores into the greenhouse to speed up development. Vegetative tiller number was 64 and 69 per 4 inch core for urea and ammonium nitrate treatments, respectively. Panicle number was equal for both treatments. Plants grown with urea (enhanced ammonium nutrition) showed earlier panicle development than those grown with ammonium nitrate.

The results of an experiment at Alicel, Oregon examining the effect of N- source on Kentucky Bluegrass growth and components of seed yield are shown in Table 4. Calcium nitrate and ammonium nitrate treated plots produced higher

Table 3. The effect of nitrogen form on seed yield. Values are means of five Kentucky bluegrass cultivars which were harvest from Worley, and Rathdrum, ID and Madras and La Grande, OR.

Form of Nitrogen	Location			
	Worley	Rathdrum	Madras	Moscow LaGrande
	(lb/a)			
1993 Ammonium nitrate	655	129	---	---
Ammonium sulfate	670	113	---	---
1994 Ammonium nitrate	697	498	25	---
Ammonium sulfate	636	524	25	---

Table 4. Effect of calcium nitrate, ammonium nitrate, ammonium sulfate, and urea-DCD fertilization on components of seed yield in Kentucky bluegrass (cv. Conventry). Fertilizer was applied in the fall to plots in an existing two-year crop located on the De Lint Farm, Alicel (LaGrande area), OR. Plots measured 129 ft². Means followed by the same letter are not significantly different by Newmans-Keuls test ($P < 0.1$).

N-source	Panicle Number	Shoot Biomass	Seed Yield	Harvest Index
	(no./ft²)	(lb/a)	(lb/a)	(%)
Calcium nitrate	582 a	20,510 a	1,398 a	6.8 a
Ammonium nitrate	558 a.	19,667 a.	1,345 a	6.7 a
Ammonium sulfate	546 b	17,987 b	1,060 b	5.9 b
Urea-DCD	451 b	14,696 b	1,229 b	8.4 c

seed yields, tillers per unit area, and total final shoot dry mass per unit area than ammonium sulfate and urea-DCD treated plots (Table 4). Seed yield of plots treated with calcium nitrate or ammonium nitrate were not significantly different. Seed yield harvest from the grower's field 1,309 pound per acre (determined from a 10.8 ft² sampling). Ammonium sulfate and urea-DCD fertilization reduced seed yield by 23% and 10%, respectively and total shoot mass was reduced by 11% and 27%, respectively, compared to both nitrate-N treated plots. Changes in shoot mass and seed yield reflected changes in harvest index (HI) for each treatment. Urea-DCD fertilization increased HI by 24% over nitrate treated plots, whereas ammonium sulfate reduced HI by 13%. Urea-DCD increased total cleaned seed mass per tiller.

Data support laboratory hydroponic findings that generally Kentucky bluegrass growth and tillering is greater under high nitrate conditions opposed to high ammonium (Griffith, unpublished). Kentucky bluegrass therefore may be an excellent scavenger of soil residual nitrate. Data also indicate the potential of N management to alter the HI in favor of reducing total post-harvest straw residue while still maintaining high seed yields. Ammonium based fertilizers can result in more efficient N utilization resulting in greater N conservation and lower fertilizer cost than nitrate fertilizers.

Potential Implications

1) Our results indicate that mechanical residue removal could be an alternative to burning in the second year of seed production if economic methods of removal are found.
2) Ammonia nutrition can be used without adversely affecting seed yield in Idaho and Oregon, thus reducing potential nitrogen losses to underground water supplies. A cost saving may also be realized if ammonium based fertilizers are used.
3) Prolong use of ammonium fertilizers may lower soil pH. With the higher pH soils at Madras this may not be as critical as it would be in the acid soils of northeastern Oregon or northern Idaho and eastern Washington.

Recommendations

1) Kentucky bluegrass cultivars should be classified for persistence of seed yield with repeated mechanical residue removal treatments.
2) Classify fall floral induction requirements of Kentucky bluegrass to shorten the time required for cultivar classification from five years to two years.
3) Test new needle nose (Rears) rake and flail technology as an effective, economical means of mechanical residue removal.
4) More information is needed concerning the timing of fertilizer nitrogen application. It should be determined if growing degree days might serve as a timeline for fertilizer timing, especially for irrigated Kentucky bluegrass.

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WEED CONTROL IN ESTABLISHED PERENNIAL RYEGRASS: RESULTS FROM SECOND YEAR TREATMENTS

G.W. Mueller-Warrant

Residue management and herbicide treatments at three perennial ryegrass sites were reapplied to the same plots in the 1993-94 growing season as used in the previous one, with the exception of the untreated checks and a few other minor modifications. Untreated checks were located on "fresh" plots that had been treated in the first year with a duplicate set of what had been anticipated to be the best treatments. Weed populations were counted in late winter, and data are expressed as percent of available space between the rows occupied by volunteer perennial ryegrass seedlings (ground cover). The presence of other weeds was also monitored, but there were generally too few annual bluegrass or Italian ryegrass plants in the test areas for meaningful data. Crops were swathed July 10-15, and combined in early August. Samples were then bagged and subsequently cleaned over an air-screen cleaner.

Volunteer perennial ryegrass seedling density for the same treatments was somewhat higher in spring 1994 than in the first year. One possible reason for the slightly poorer control in the second year was timing of pre-emergence herbicide applications in October 1993 relative to the arrival of fall rains. Because approximately 1 inch of rain fell at all three sites about a week prior to "pre-emergence" applications on October 21-22, volunteer perennial ryegrass was beginning to emerge when Prowl, Goal, and Dual were applied. The Prowl "raked-in" treatment for vacuum-sweep and bale/flail/rake was applied and lightly incorporated on October 1-4, and was truly pre-emergence to the seedlings. The incorporated granular Prowl treatment (or Treflan at Klopfenstein's) for full straw load was applied Oct. 13-14, and was pre-emergence to seedlings, although rain had just begun at Klopfenstein's and the straw was wet.

Volunteer perennial seedling density was 81, 107, and 212% higher, on average, in bale/flail/rake than in vacuum-sweep plots (Table 1). Incorporated Prowl (raked-in) was superior to normal surface-applied Prowl at all three sites. Under vacuum-sweep conditions, raked-in Prowl by itself provided adequate control of volunteer perennial ryegrass. Under bale/flail/rake conditions, raked-in Prowl had to be followed by post-emergence Goal + Diuron to provide adequate control. Goal was the least effective "pre-emergence" treatment, while Dual and Prowl provided similar control.

Seed yield in vacuum-sweep and bale/flail/rake treatments was strongly related to effectiveness of weed control. Highest yields occurred in the Prowl raked-in followed by Goal + Diuron treatment, while lowest yields occurred in the weediest plots, such as the untreated checks and the Goal + Diuron post-emergence-only treatment (Table 2). None of the treatments caused serious crop injury in the vacuum-sweep and bale/flail/rake conditions, and the value of controlling volunteer seedlings was clearly evident.

Results in the full straw load tests were quite different from those in the vacuum-sweep and bale/flail/rake conditions. The late post-emergence (Dec. 20-22) applications of Diuron and Goal + Diuron in the full straw tests were extremely phytotoxic, controlling remaining seedlings very well but also destroying much of the established crop. This effect was most extreme in the incorporated Treflan plots at Klopfenstein's, where five of the treatments provided 100% control (0% ground cover), and even incorporated Treflan by itself (with no post-emergence treatment) reduced volunteer perennial ryegrass ground cover from 94 to 28% (Table 3). In the full straw load tests, yields were responding to both crop injury from the herbicides and competition from the volunteer seedlings. At Lindsay's, for example, yields were higher for incorporated Prowl treatments than they were without any pre-emergence herbicide for all plots that received post-emergence treatment, but not for the no post-emergence checks (Table 4). Incorporated Prowl had also dramatically improved weed control for the same group of post-emergence treatments, but not for the checks. At Klopfenstein's, the incorporated Treflan treatments tended to be lower yielding than treatments without pre-emergence herbicide, despite reduced competition from weeds in the Treflan plots, due to the severity of crop injury in the Treflan plots. Intermediate results were obtained at Scharf's, with incorporated Prowl improving weed control but not changing yield. Overall, yields in full straw compared favorably with those in vacuum-sweep and bale/flail/rake. However, crop tolerance and weed control efficacy were more erratic in full straw conditions, and further research will be needed to refine herbicide application practices for that environment.

Table 1. Effects of herbicide treatments on volunteer perennial ryegrass seedling ground cover in spring 1994, averaged over vacuum-sweep and bale/flail chop/needle-nose rake residue management.

Herbicide treatments[1]		On-farm grower co-operator		
Pre-emergence	Post-emergence	Bob Lindsay	Wilbur Klopfenstein	Scharf Bros.
-------------------- (lb a.i./acre) --------------------------		---------------------(% ground cover) -----------------------		
2.0 Prowl	None	46 c	32 d	24 d
2.0 Prowl raked-in	None	12 a	14 b	11 b
2.0 Prowl	0.12 Goal+1.2 Diuron	43 c	18 bc	12 b
1.0 Prowl raked-in	0.12 Goal+1.2 Diuron	19 b	18 bc	13 bc
2.0 Prowl raked-in	0.12 Goal+1.2 Diuron	9 a	8 a	6 a
2.0 Prowl raked-in[2]	0.12 Goal+1.2 Diuron[2]	12 a	6 a	5 a
0.25 Goal	0.12 Goal+1.2 Diuron	47 c	31 d	19 cd
1.5 Dual	1.6 Diuron	38 c	21 c	17 bcd
2.0 Prowl	0.12 Goal+0.56 Sencor/Lexone	46 c	23 cd	14 bc
None	0.25 Goal+1.6 Diuron	74 d	53 e	38 e
None	None	90 d	89 f	72 f
Residue management main effects				
Vacuum-sweep		21 a	14 a	8 a
Bale/flail chop/needle-nose rake		38 b	29 b	25 b

[1] Application dates for 1993-94 growing season: Bob Lindsay: Surface-applied Prowl raked-in = Oct. 4, other PRE = Oct. 21, all POST = Nov. 22; Wilbur Klopfenstein: Surface-applied Prowl raked-in = Oct. 1, other PRE = Oct. 22, all POST = Nov. 23; Scharf Bros.: Surface-applied Prowl raked in = Oct. 1, other PRE = Oct. 22, all POST = Nov. 22.
[2] Treatment applied to plots used as untreated post-emergence checks for the 1993 harvest. All other treatments were applied to the same plots in both years.

Table 2. Effects of herbicide treatments on perennial ryegrass seed yield in summer 1994, averaged over vacuum-sweep and bale/flail chop/needle-nose rake residue management.

Herbicide treatments[1]		On-farm grower co-operator		
Pre-emergence	Post-emergence	Bob Lindsay	Wilbur Klopfenstein	Scharf Bros.
(lb a.i./acre)		(lb/acre)		
2.0 Prowl	None	868 def	1266 bcd	990 e
2.0 Prowl raked-in	None	1111 ab	1308 a-d	997 de
2.0 Prowl	0.12 Goal+1.2 Diuron	922 cd	1372 ab	1102 abc
1.0 Prowl raked-in	0.12 Goal+1.2 Diuron	1092 ab	1168 cd	997 de
2.0 Prowl raked-in	0.12 Goal+1.2 Diuron	1128 a	1426 a	1119 a
2.0 Prowl raked-in[2]	0.12 Goal+1.2 Diuron[2]	1027 bc	1157 d	1082 a-e
0.25 Goal	0.12 Goal+1.2 Diuron	885 de	1218 bcd	1121 ab
1.5 Dual	1.6 Diuron	762 f	1331 a-d	1020 bc
2.0 Prowl	0.12 Goal+0.56 Sencor/Lexone	811 ef	1346 abc	1086 a-e
None	0.25 Goal+1.6 Diuron	630 g	1185 cd	1093 a-d
None	None	503 h	1157 d	1010 cde
Residue management main effects				
Vacuum-sweep		954 a	1315 a	1083 a
Bale/flail chop/needle-nose rake		857 a	1282 a	1040 b

[1] Application dates for 1993-94 growing season: Bob Lindsay: Surface-applied Prowl raked-in = Oct. 4, other PRE = Oct. 21, all POST = Nov. 22; Wilbur Klopfenstein: Surface-applied Prowl raked-in = Oct. 1, other PRE = Oct. 22, all POST = Nov. 23; Scharf Bros.: Surface-applied Prowl raked in = Oct. 1, other PRE = Oct. 22, all POST = Nov. 22.
[2] Treatment applied to plots used as untreated post-emergence checks for the 1993 harvest. All other treatments were applied to the same plots in both years.

Table 3. Effects of herbicide treatments on perennial ryegrass volunteer seedling ground cover in spring 1994, two years full straw load chop in place management.

Herbicide treatments[1]		Lindsay PRE-E herbicide			Klopfenstein PRE-E herbicide			Scharf Bros. PRE-E herbicide		
Early post-emergence	Late post-emergence	None		Inc. Prowl	None		Inc.Treflan	None		Inc. Prowl
(lb a.i./acre)		(% ground cover)								
0.25 Goal+1.5 Dual	1.6 Diuron	26 a	*	9 a	6 a	*	0 a	10 a	*	1 a
0.25 Goal+1.5 Dual[2]	1.6 Diuron[2]	50 b	*	14 b	11 ab	*	0 a	23 bc	*	4 b
0.25 Goal+0.25 Sencor/Lexone	0.12 Goal+1.2 Diuron	59 bcd	*	25 c	12 b	*	0 a	24 c	*	3 b
0.25 Goal+0.5 Sinbar	0.12 Goal+1.2 Diuron	52 bc	*	32 c	17 b	*	0 a	23 bc	*	4 b
0.25 Goal+0.8 Diuron	0.12 Goal+1.2 Diuron	49 b	*	22 c	12 ab	*	0 a	14 ab	*	5 b
None	0.38 Goal+1.6 Diuron	75 cd		62 d	67 c	*	8 b	51 d		24 c
None	None	80 d		88 d	94 c	*	28 c	87 d		54 d

* PRE-E None and PRE-E Incorporated granular Prowl (or Treflan) treatments differ significantly.
[1] Application dates for 1993-94 growing season: Bob Lindsay: Incorporated granular Prowl = Oct. 13, Early POST-E = Nov. 9, Late POST-E = Dec. 20; Wilbur Klopfenstein: Incorporated granular Treflan = Oct. 14, Early POST-E = Nov. 10, Late POST-E = Dec. 22; Scharf Bros.: Incorporated granular Prowl = Oct. 14, Early POST-E = Nov. 10, Late POST-E = Dec. 22, except 0.38 Goal+1.6 Diuron applied Dec. 6.
[2] Treatment applied to plots used as untreated post-emergence checks for the 1993 harvest. All other treatments were applied to the same plots in both years.

Table 4. Effects of herbicide treatments on perennial ryegrass seed yield in summer 1994, two-years full straw load chop in place management.

Herbicide treatments[1]		Lindsay PRE-E herbicide		Klopfenstein PRE-E herbicide		Scharf Bros. PRE-E herbicide	
Early post-emergence	Late post-emergence	None	Inc. Prowl	None	Inc. Treflan	None	Inc. Prowl
(lb a.i./acre)		(lb/acre)					
0.25 Goal+1.5 Dual	1.6 Diuron	985 ab	*1111 b	1341 a	1139 ab	1198 a	1290 a
0.25 Goal+1.5 Dual[2]	1.6 Diuron[2]	1037 a	*1217 ab	1347 a	1107 ab	1090 abc	1110 bc
0.25 Goal+0.25 Sencor/Lexone	0.12 Goal+1.2 Diuron	893 bc	*1246 a	1246 ab	*1027 b	1088 ab	1155 b
0.25 Goal+0.5 Sinbar	0.12 Goal+1.2 Diuron	852 c	*1123 b	1297 ab	1125 ab	1052 bc	1106 bc
0.25 Goal+0.8 Diuron	0.12 Goal+1.2 Diuron	901 bc	*1192 ab	1318 a	*1056 b	1026 bc	1139 bc
None	0.38 Goal+1.6 Diuron	654 d	* 951 c	1232 ab	1335 a	1010 bc	1064 bc
None	None	576 d	693 d	1051 b	1167 ab	958 c	1031 c

* PRE-E None and PRE-E Incorporated granular Prowl (or Treflan) treatments differ significantly.

[1] Application dates for 1993-94 growing season: Bob Lindsay: Incorporated granular Prowl = Oct. 13, Early POST-E = Nov. 9, Late POST-E = Dec. 20; Wilbur Klopfenstein: Incorporated granular Treflan = Oct. 14, Early POST-E = Nov. 10, Late POST-E = Dec. 22; Scharf Bros.: Incorporated granular Prowl = Oct. 14, Early POST-E = Nov. 10, Late POST-E = Dec. 22, except 0.38 Goal+1.6 Diuron applied Dec. 6.

[2] Treatment applied to plots used as untreated post-emergence checks for the 1993 harvest. All other treatments were applied to the same plots in both years.

REDUCING GRASS SEED FIELD VOLUNTEER POPULATIONS WITH COMBINE-MOUNTED SEED GLEANERS OR RECOVERY SYSTEMS AND BY SELECTIVE HARVEST TIMING

L.R. Schweitzer

Introduction

Shattered crop seed and weed seed constitute major problems for Oregon grass seed growers. The phase-out of field burning to control these problems necessitates development of new practical methods for reducing the resultant volunteer and weed populations in grass seed fields. Reducing these problems would help certified seed growers meet certification standards for their fields, as well as reduce costs for chemical or cultural control.

The extent of the shattered crop and weed seed problem in current grass seed production is not fully known, so one of the goals of this project was to assess the actual shattered seed losses in commercial production situations.

Since total elimination of grass and weed seed shatter is not likely, a practical device for picking up shattered seed may help alleviate the problem. Smucker Manufacturing, Harrisburg, has developed a prototype shattered seed gleaner that may provide significant potential for reducing the volunteer populations in seed production fields. And Roy A. Bowers & Sons Farm have developed a combine modification to remove sieve-passed small seed that would normally be returned to the ground. A goal of this research was to evaluate efficacy of both inventions .

Grass seed is well known to shatter more easily with advanced maturity and the concomitant reduction in moisture content. However, harvesting too early reduces seed yield and seed quality because the seeds have not fully developed (filled) and matured. Previous researchers have worked at determining optimal harvest times and methods for indicating when to harvest. Most studies on grass crop harvest timing, however, used hand harvesting and/or small plots without addressing the potential limitations in transposition to farm scale applications. Furthermore, it is not known whether previous harvest time indicators apply adequately to current grass seed varieties or to early and late maturing types.

Objectives

1. Assess shattered crop seed and weed seed occurrences in commercial production fields of several current varieties of perennial ryegrass and tall fescue.

2. Evaluate efficacy of: a) Prototype combine-mounted shattered seed recovery system (Smucker Manufacturing, Inc.) for retrieving shattered seed, and b) Prototype combine modification for removing sieve-passed small seed (Roy A. Bowers & Sons Farm) for reducing potential volunteers.
3. Measure the effects of earlier and later swathing dates on shattered seed losses and seed quality, and determine optimal harvest time.

Procedures

Seed Fields - All research was conducted in commercial seed production fields in the Southern Willamette Valley. Primary fields included early and later maturing varieties of perennial ryegrass and tall fescue in the Albany and Harrisburg areas. Additional evaluations of the Smucker Seed Gleaners were conducted in two annual ryegrass fields.

Shattered Seed Sampling - Shattered seed was collected by vacuuming all seed and debris from within a 2 x 6 ft. area (six replications). Samples were collected a) directly after swathing, b) from under the combine header at threshing time, and c) after the combine had passed and returned straw and chaff to the field.

The effective sampling area was positioned perpendicular to the windrow, but halfway in the windrow area and halfway in the area beside the windrow. Therefore, shattered seed amounts represent shattered seed on a total field area basis, i.e., even though almost all shattered seed was directly under the windrow, it is expressed as average seeds per square foot or pounds per acre for the total field area.

Swathing Date Treatments - Target dates were two and four days before and after commercial swathing date as estimated by the grower. Weather uncertainties and scheduling difficulties caused some adjustments in actual cutting dates.

Relative seed yield from different swathing dates within a field was determined by collecting combine seed output for a set time period (typically 20 or 30 seconds, replicated 6 times) and calculating yield based on combine ground speed.

Gleaner efficacy was determined by collecting samples of actual gleaner pickup from a measured combine travel distance (typically 100 or 200 feet, replicated 6 times). Similarly, the Bowers' cross-auger output was determined by measuring and sampling the chaff collected from a given distance of ground travel (700 to 900 feet, not replicated).

Vacuum samples of shattered seed were obtained from side-by-side windrows threshed with or without the respective seed gleaner operating.

Results and Discussion

The 1993 crop year was not an ideal year for shattered seed studies in Willamette Valley grass seed crops. The extended cool rainy weather delayed crop maturity, interfered with timely harvest, and increased seed shatter in the windrow. As threshing was delayed by periodic rains, shattered seed began sprouting under the windrow, especially in the perennial ryegrass fields. Therefore, vacuum samples at harvest time (under the header and after the combine) did not recover all the seed that had actually shattered onto the ground. Several counts of sprouted seeds under perennial ryegrass windrows in the Albany field indicated from 100 to 400+ seedlings per square foot.

The continually wet soil surface under the windrows caused shattered seed to adhere to the soil surface, thus reducing efficacy of the Smucker Manufacturing Seed Gleaners. A soil moisture test of the top 1 inch layer of soil under the windrow of the annual ryegrass field near Albany harvested August 5, 1993, indicated over 25% moisture content.

Total Shattered Seed Extent - Table 1 summarizes the amounts of shattered seed measured after commercial harvest of each field. Quantities are expressed as both viable seeds per square foot and pounds per acre (total field basis). Wet weather-induced pre-harvest sprouting of shattered seed reduced the recovery of shattered seed, especially for perennial ryegrass. And not all viable seeds were recovered from the vacuum samples collected. Some of the light chaff removed during seed cleaning contained potentially viable seeds.

Seed Gleaner Efficacy - Table 2 summarizes the amount of shattered seed actually recovered (Smucker Seed Gleaner) or the amount of viable seed from the combine discharge prevented from reaching the ground (Bowers' Cross-Auger system). Based on these values, efficacy in reducing potential seedling volunteers ranged from less than 1% for most cases to 8.2% for Bowers' cross-auger elimination of viable seed from perennial ryegrass fields.

Table 1. Shattered seed assessments in several Willamette Valley grass seed crops (1993 harvest).

Species and Variety	Total shattered seed Viable seeds.	Yield loss
	(no./sq.ft.)	(lb/a)
Tall Fescue		
Arid	839	208
Fawn	583	156
Vegas	660	136
Average	694	167
Perennial Ryegrass		
Nova	576	103
Pebble Beach	713	118
Repel	682	122
Average	657	114
Annual Ryegrass		
Field 1	1554	435
Field 2	962	233
Average	1258	334

Table 2. Shattered seed recovery or elimination using prototype combine attachments or modifications.

Gleaner Type, Seed Crop, and Variety	Total shattered seed	Gleaner pickup	Gleaner efficacy
	--- (lb/a) -----		(%)
Smucker Mfg. Prototype 1			
Annual Ryegrass	233	0.2	0.1
Smucker Mfg. Prototype 2			
Annual Ryegrass	435	7.6	1.7
Per. Ryegrass (Nova)	103	0.5	0.5
Tall Fescue (Vegas)	136	1.1	0.8
Bowers Combine Cross-Auger			
Per. Ryegrass (Repel II)	122	10.0	8.2
Tall Fescue (Arid)	208	1.2	0.6

Because of minimal gleaner recovery and high variation among replications, vacuum sampling did not detect statistically significant benefit of the gleaner operations.

However, the Bowers' cross-auger actually removed more viable seeds than these reported values indicate. Sprouting tests conducted on cross-auger output samples without first trying to separate inert matter from the seed indicated there may be up to three or four times more viable seeds than were actually salvaged. These unreported seeds would be very small, light crop or weed seeds, but are potential volunteer or weed contaminants.

Even though most of these efficacy ratings were quite low, after considering wet weather complications discussed earlier there seems to be at least some potential for further development of systems to recover shattered seed from the ground and/or prevent combine-passed small light seeds from being added to the shattered seed problem.

Germination Potential of Shattered Seed - Germination tests of the recovered shattered seed proved viability nearly equal to that of the commercially harvested seed in almost every field (Table 3).

Table 3. Percent germination of shattered seed compared to harvested crop seed.

Crop and Variety	Crop sample	Shattered seed	Gleaner pickup
	--------------	(%)	--------------
Annual ryegrass (Field 1)	93	95	97
Annual ryegrass (Field 2)	96	95	94
Per. ryegrass (Nova)	97	98	97
Per. ryegrass (Pebble Beach)	97	97	--
Tall fescue (Fawn)	95	94	--
Tall fescue (Vegas)	93	87	82

Date of Swathing Effects on Seed Shatter - The graphs in Figure 1 summarize the effects of swathing date on seed shatter for perennial ryegrass and tall fescue. Data are shown for vacuum samples from three stages of the harvest process for each crop: a) directly after the swather, b) under the combine header after windrow pickup but before straw/chaff return, and c) after complete combine passage and discharge.

The swather vacuum samples should quite reliably indicate seed shatter levels. The vacuum samples taken later at harvest time may not indicate the full extent of seed shatter because some of the shattered seed sprouted before threshing or adhered to the damp soil surface and was not recovered.

Most shatter probably occurs at swathing. Additional shatter occurs in the windrow and at the combine pickup.

Then the combine returns smaller, lighter seed through the machine in the straw and chaff.

Swathing date effects on seed shatter confirm expected patterns except for a couple exceptions. Seed shatter increased nearly linearly with later swathing in most cases. The steep increase for Fawn tall fescue reflects a dramatic weather change from light rain on the day of the first cutting to more favorable conditions. The decline in shattered seed (swather sample) for the last Fawn tall fescue cutting and the uncharacteristic low values for the after-combine samples for both tall fescue fields are not readily explainable. The lower values observed for all samples at the later harvests for Pebble Beach perennial ryegrass probably result from these two delayed harvests being located in a different location in the field about 30 windrows away from the early and commercial harvest treatments.

Date of Swathing Effects on Seed Yield and Quality (Figure 2) - Relative seed yields at the different dates of swathing indicate that swathing could have been completed at least two days earlier for these crops without sacrificing yield. Delayed swathing, however, reduced seed yields for the two fields where data was available (Vegas tall fescue and Nova perennial ryegrass). These yield reductions correlate with increased seed shatter observed for the delayed harvest dates. Seed germination quality was nearly constant over all dates of swathing, both earlier and later than the selected date for commercial cutting.

Optimal Seed Moisture and Harvest Timing - Comparisons of seed moisture, seed yield, seed quality, and seed shatter data for each crop of tall fescue and perennial ryegrass in this study (Figures. 1, 2) indicate an optimal seed moisture range of 45±4% for swathing. Harvesting earlier at even higher moisture levels reduced seed shatter but sacrificed seed yield. Harvesting at 40% or lower moisture risked serious seed shatter losses. The data affirm grower judgment of harvest timing, but also indicate that each field may have been swathed one or two days earlier to reduce seed shatter without sacrificing yield or quality.

These results also generally confirm published literature on harvest timing. The recent study by Andrade (1993) reported tall fescue reaches physiological maturity at 40-48% moisture content. He recommended windrowing at 35-41% moisture for maximum seed yield. Andrade compiled an excellent review of literature covering methods of determining harvest time for cool season grasses, seed moisture as a harvest indicator and related subjects.

Conclusions:

1. A large amount of grass seed is lost on the ground in commercial production fields. Seed shatter losses ranged from 103 lb/a for perennial ryegrass, to 140-200 lb/a for tall fescue, and up to 435 lb/a for annual ryegrass.

   A major proportion of the shatter losses occur at swathing. Additional shatter occurs in the windrow and during combine pickup. The combine straw discharge returns still more seed to the field.

2. The Smucker Manufacturing Co. combine-mounted Prototype 2 seed gleaner (blower system) was able to retrieve only 0.5-1.7% of the shattered seed. However, the abnormally wet weather during 1993 harvest seriously interfered with gleaner performance by causing seed adherence to the damp soil or causing them to sprout before harvest. The Prototype 2 concept appears to have potential for further development.

3. The Bowers' system of removing combine sieve output from the field reduced the potential volunteer and weed seed problem more than 8% in perennial ryegrass harvest, but was less effective in tall fescue. This system appears to have significant merit for perennial ryegrass.

4. Optimal timing for swathing of perennial ryegrass and tall fescue in these studies occurred in the seed moisture content range of about 45±4%. Swathing at moistures of 50% or above reduced seed yields, while swathing at lower moistures increased seed shatter losses.

5. There were no definitive performance or response differences between earlier or later maturing varieties of either perennial ryegrass or tall fescue in this limited study.

Reference

Andrade, R.P. 1993. Flowering, seed maturation, and harvest timing of turf-type tall fescue. Ph.D. Thesis. Oregon State University. 105 pgs.

Acknowledgment: This research was supported by a grant from the Oregon Department of Agriculture.

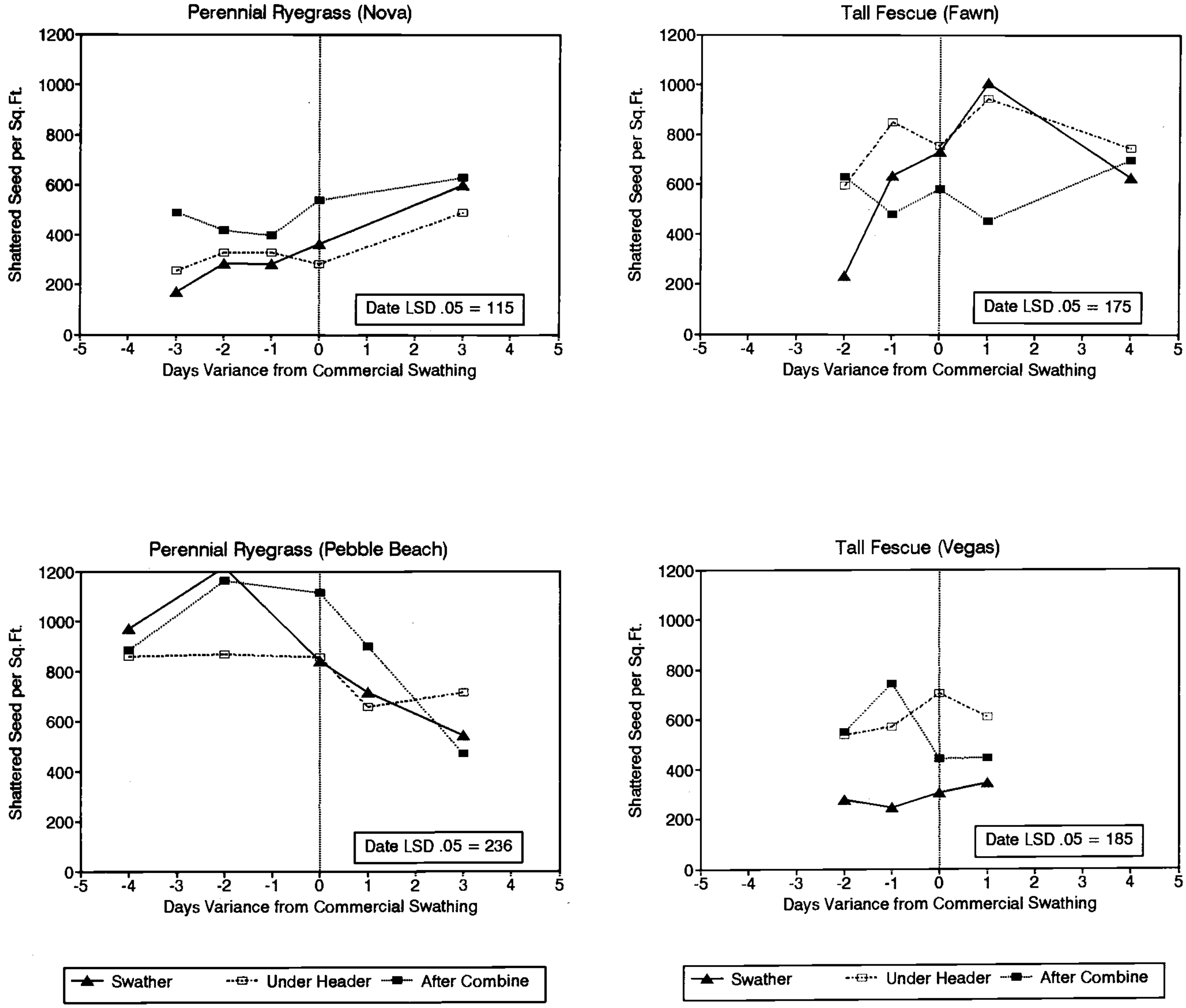

Figure 1. Swathing date effects on perennial ryegrass and tall fescue seed shattering, 1993.

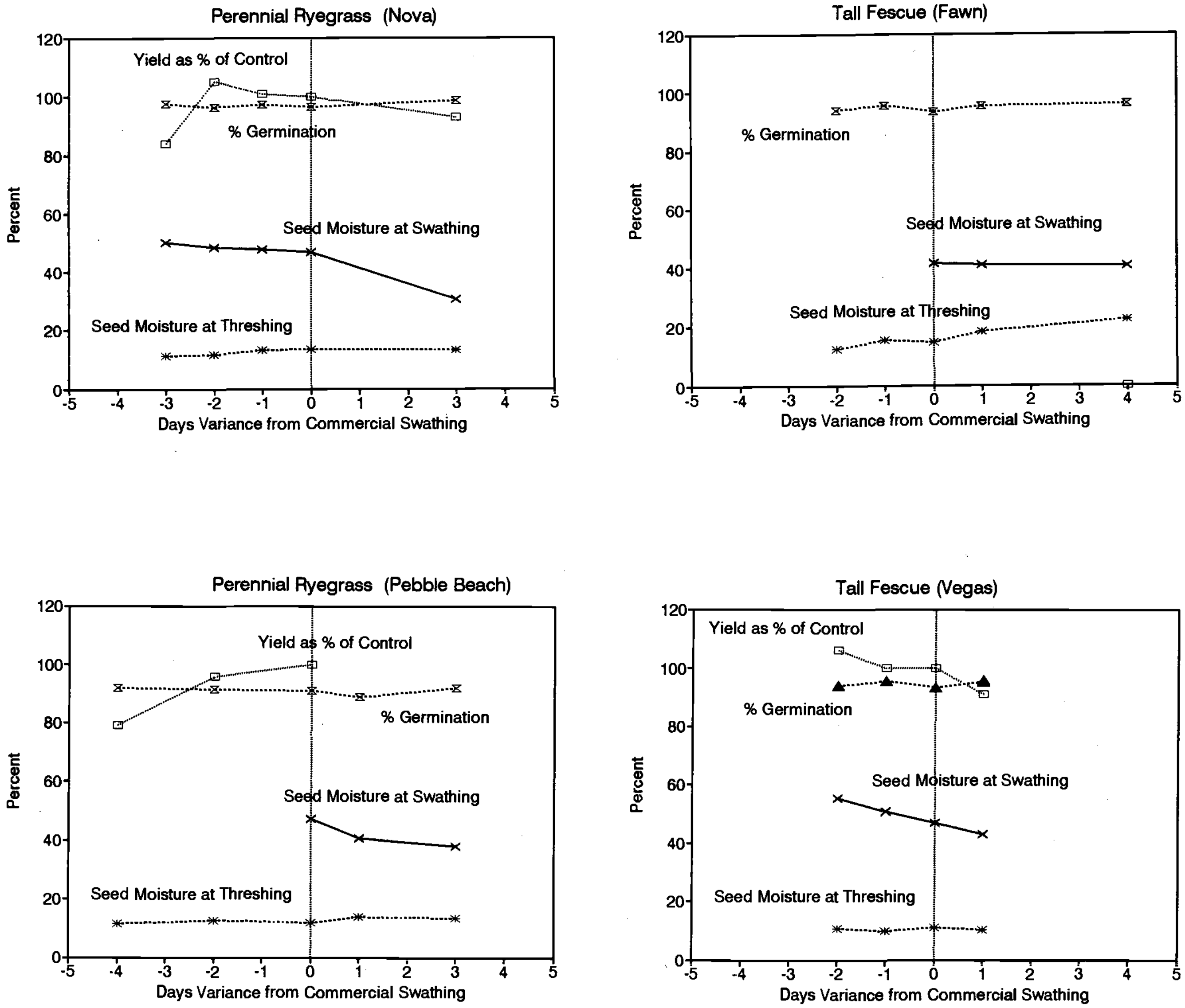

Figure 2. Swathing date effects on perennial ryegrass and tall fescue seed moisture, yield and quality, 1993.

EFFECT OF FUMIGATION AND VARIETY ON DIE-OUT IN PERENNIAL RYEGRASS.

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

Perennial ryegrass seed fields often decline prematurely in the third or fourth year of production, and sometimes as early as the second year. Stand loss can be severe. The problem has most commonly been referred to as die-out or die-back. Starting in 1989, USDA and OSU plant disease and insect scientists have investigated fields showing die-out. High nematode numbers have been found in some fields, but no other pathogenic disease or insect problems have been found to date. Some investigators concluded a complex of factors was involved.

In 1991, we established a fumigation and variety trial in Linn County in a field that had shown die-out in previous stands of perennial ryegrass. One objective of the trial was to determine if fumigation would prolong stand life by reducing nematode levels or other potential soil pests at the time of planting. A second objective was to find out if there were differences between varieties. We included varieties that were low and high in endophyte to see if the fungus helped prevent die-out.

The trial was a split-plot design with fumigation as main plots and varieties as subplots. The site was pre-irrigated with about 1.5 inches of water in early October. Fumigation was accomplished with commercial equipment applying 60 GPA Sectagon II (metam sodium) on October 17, 1991. Unfumigated blocks were treated with application equipment the same as fumigated areas (i.e., the entire trial area underwent the rotovate and power roll incorporation treatment). Varieties chosen for the study were Linn and six fine-leaf turf selections, including three with high endophyte levels (78-90%) and three with low endophyte levels (0-10%). The trial was carbon seeded on November 11, 1991 with a small plot drill. Varieties were planted across fumigated and unfumigated blocks in 6 x 30 foot plots with 5 rows on 12 inches spacings, and each treatment was replicated four times. After planting, all chemical and fertilizer applications were performed by the grower as part of their normal field operations. The trial was maintained through three seed crops (1992-1994). The stand was evaluated in the spring of each year for die-out by making a visual estimate of the percent of plants remaining in each plot. Soil and root samples were taken the final year of the study on April 22, 1994 and tested for nematodes at the OSU Plant Disease Clinic.

Stand decline was first observed in this trial in the spring prior to the second seed crop, and approached 50% die-out in some plots by the third year of production (Table 1). There was some benefit to fumigation in maintaining plant stands, but differences in varieties were more striking. For example, the variety Linn without fumigation had a stand rating at the end of the trial that was as good or better than any of the fine-leaf varieties, even those planted on fumigated ground. Farmers and field reps have observed that some varieties decline sooner than others in commercial production. The side-by-side comparisons in this trial confirmed that some varieties are indeed more prone to die-out than others, indicating there is a genetic component to the problem.

Fumigation reduced the levels of root-lesion nematodes in the soil and root samples. The mean level of nematodes from unfumigated plots, averaged across all the varieties, was 10,841 per quart of soil (Table 1). This is a high level compared to thresholds established for crops such as peppermint. In the fumigated plots, nematode counts were comparatively very low, averaging 179 per quart of soil. These samples were taken two and one half years after planting, and showed that the fumigation method used was effective in reducing nematode levels for the life of the stand. The effect of reducing nematodes counts on die-out, however, was much less dramatic. In fact, regression analysis showed no relationship between the final stand ratings and nematode numbers (analysis provided by Steve Alderman, research pathologist at the USDA-NFSPRC). This suggested that nematodes did not contribute to die-out in this trial. Nematode sampling, however, was limited. More detailed studies are needed to understand the biology and role nematodes play in grass seed fields.

Table 1. Effect of variety and fumigation on stand decline and nematode levels in perennial ryegrass. Varieties ranked in descending order based on 1994 stand rating.

Variety	Endophyte infection level	Pre-plant Fumigation	Stand Ratings[1] 5/5 1992	Stand Ratings[1] 4/20 1993	Stand Ratings[1] 3/14 1994	Root-lesion nematodes[2]
	(%)	(+/-)		(%)		(no./qt)
Linn	0	+	100	88	84	320
Linn	0	-	100	85	75	18,600
Lindsay	10	+	100	85	75	53
Dandy	78	+	100	80	75	0
Lindsay	90	+	100	78	72	80
Gator	0	+	100	78	66	80
Regal	90	+	100	70	66	320
Lindsay	90	-	100	75	59	6,390
Dandy	78	-	100	75	58	14,400
Gator	0	-	100	78	58	3,840
Lindsay	10	-	100	78	56	6,370
Delray	0	+	100	70	54	400
Delray	0	-	100	60	51	1,570
Regal	90	-	100	78	50	24,720
LSD 0.05			NS	10.3	12.7	---

[1]Stand rating is the percent stand remaining at each date observed.
[2]Final samples collected on April 22, 1994.

Fumigation did show a positive effect on stand rating at the end of the trial. The benefit to fumigation could have been related to some effect other than nematode control. For instance, there was a growth response the first year on the fumigated plots (seedling plants were taller and greener through winter and early spring). While this did not produce a higher stand count the first year, it could have resulted in deeper rooted plants more tolerant of drought and herbicide stress, enabling them to persist better in the final years of the trial.

Endophyte level had no effect on stand decline in this trial. The variety Lindsay, for example, was included in this trial twice. Once with a high endophyte level of 90% and again with a low level of 10% (provided by International Seeds, Inc.). Stand ratings were basically the same during the course of the trial for these genetically identical Lindsay varieties. Variety differences were more important than endophyte level.

In summary, this trial demonstrated that some varieties are more likely to experience die-out than others. Endophyte level had little or no effect on die-out. Soil samples showed that nematode levels can get relatively high in perennial ryegrass seed fields, but reducing nematode levels through fumigation did not prevent stand loss over time. These results suggested that nematodes may only play a small role in die-out. Variety and stand age appear to be the most consistent and perhaps most important factors in die-out. Field observations have shown that herbicide injury and fall drought are major factors that contribute to stand decline, especially after the second year of production. Heavy rust infection, slug pressure, soil properties that restrict rooting, and other factors may also contribute to die-out in perennial ryegrass.

SLUG OBSERVATIONS IN DIFFERENT GRASS SEED CROPPING SYSTEMS

G.C. Fisher and J.J. Steiner

A question often asked is "How can I control slugs in my fields?" There are no easy answers, but observations are being made that will start to give insight into how slug populations can be managed to help avoid crop damage. The number of slugs in the different rotation treatment plots of the USDA-ARS Nonthermal Grass Seed Production Systems project have been monitored for the past two years. Presented below is a summary of these findings for the Hyslop Farm site using a tall fescue seed production system. Some mention is given of observations at sites near Silverton and Shedd where fine fescue and perennial ryegrass are being grown. Also shown are the results of an efficacy trial for registered slug baits used in a white clover seed field near Tangent. These are only preliminary findings and should be considered in reference to your own observations and field conditions.

When do slug populations begin to increase?

Significant numbers of slugs were observed during winter/spring 1994 at the Hyslop Farm site. However, very few slugs were observed at the Silverton and Shedd sites during this same period. Large numbers of slugs were observed at all three sites in the fall of 1994 and winter/spring of 1995. The timing of the slug number increase was similar at all three sites this past year. In the winter/spring of both 1994 and 1995 (Figures 1 and 2, respectively), slug populations began to increase in early February which coincided with an increase in day and night temperatures. Soil moisture conditions at that time were also favorable for slug activity because of recent precipitation. Slug populations did not increase in the fall of 1994 until significant precipitation fell in late October, regardless of the warm temperatures during that time (Figure 2). Because we monitored the plots two to three times per week, we found that the slug populations began to increase in the tall fescue and wheat following tall fescue treatments after each bait treatment in early and late February. Without consistent monitoring, we would not have known when the slugs were active and the populations increasing during these separate periods.

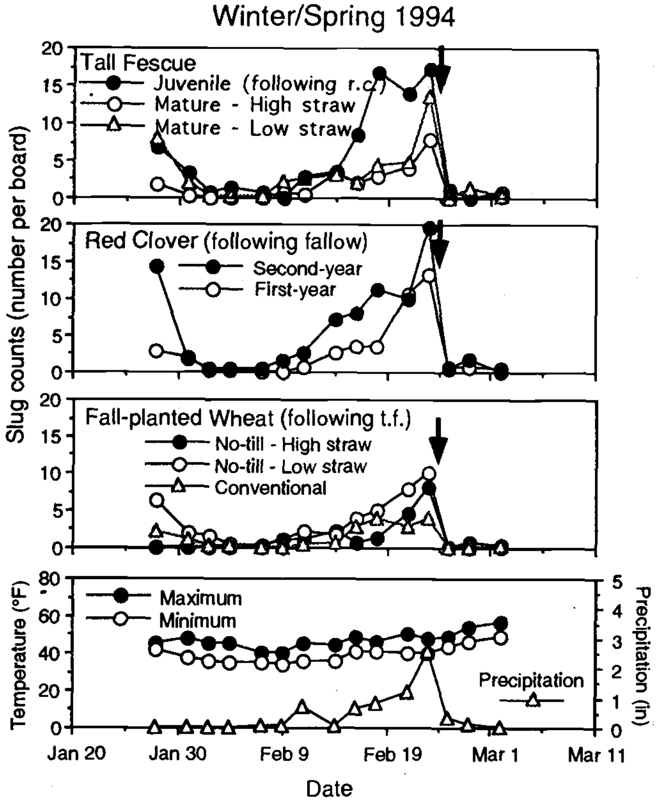

Figure 1. The number of slugs observed during winter/spring 1994 in tall fescue, red clover, and wheat grown under different cropping system practices at Hyslop Farm, Corvallis. Arrows indicate time of metaldehyde bait application.

How and when should the slugs be treated?

We treated the slugs in the Grass Seed Production Systems plots with approximately 20 lb/a of commercially available 4% metaldehyde bait. The bait was applied as slug populations were increasing to levels that appeared to be starting

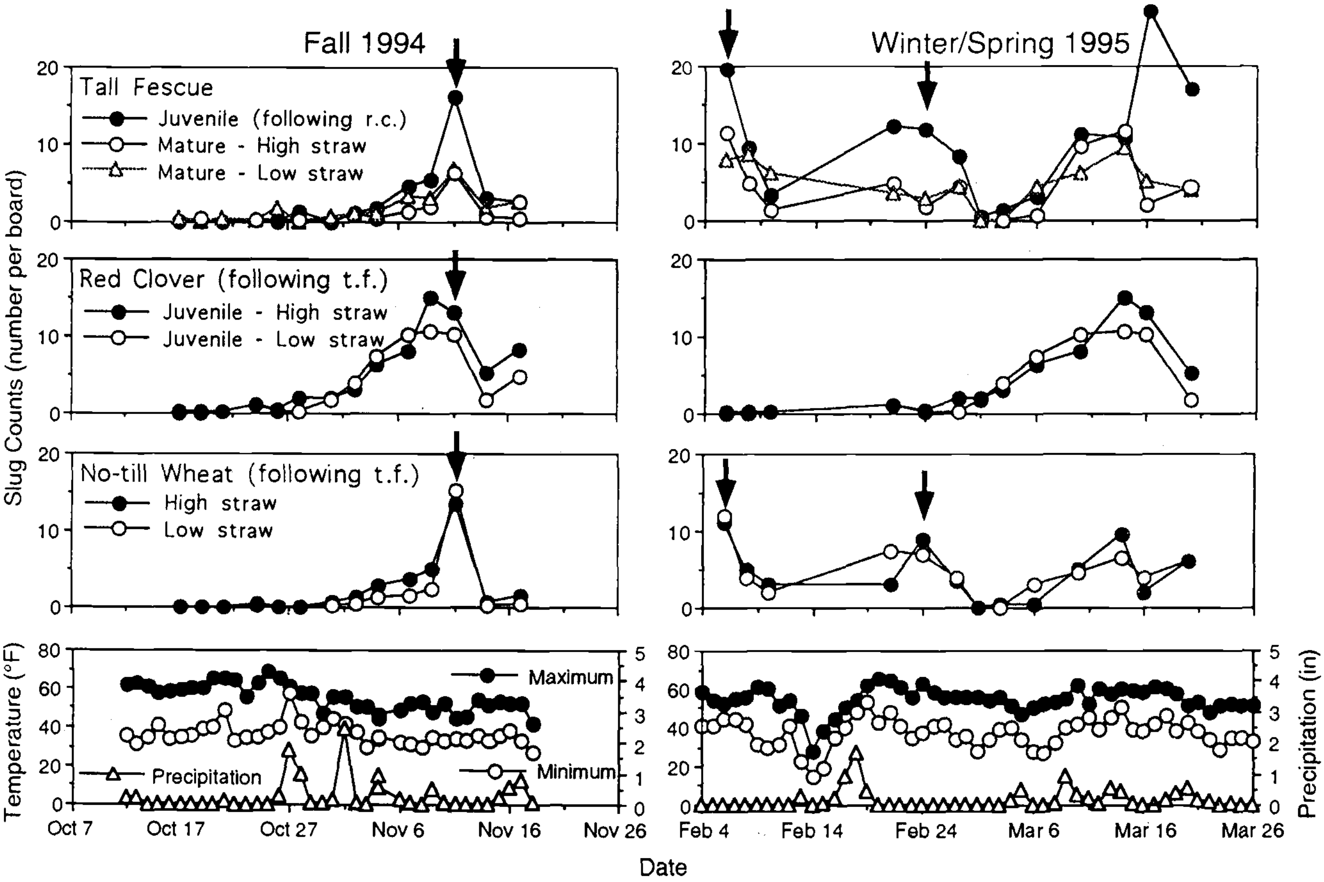

Figure 2. The number of slugs observed during fall 1994 and winter/spring 1995 in tall fescue, red clover, and wheat grown under different cropping system practices at Hyslop Farm, Corvallis. Arrows indicate time of metaldehyde bait application.

to show crop damage and when we anticipated that there would be no rain for two days following the bait application and when water was not standing in the field (note the arrows that mark treatment times in the figures). If bait is applied in the rain or when water is standing in the field, it will break down rapidly. Additionally, poisoned slugs have a higher rate of recovery when the soil surface is close to saturation. There are no economic thresholds established for slugs in the United States as have been established for some insect pests.

Single applications of bait greatly reduced the number of slugs in the treated plots. A single well-timed, fall application sufficiently reduced the slug population for the following fall/winter period. This is the optimum time to control egg production. Under non-irrigated conditions, slugs mature in late summer and begin to mate and lay eggs as the weather becomes cool and wet and as the days shorten. Baiting in the fall greatly reduces the egg load and slug populations occurring in winter and spring.

Single winter/spring applications also effectively reduced the number of slugs that were monitored, however, the slug populations began to increase again after each bait application. This is to be expected due to population recruitment from hatching eggs and also because slugs become more active on the soil surface as temperatures warm. Continuous monitoring is necessary to know when bait applications are needed or if multiple spring treatments should be applied. An increase in slug numbers has also been observed during March 1995 following the second bait application. This increase is still being monitored and appears to be declining without treatment. Monitoring will continue to determine if this decline is due to temporary drying conditions of the soil surface, or if it is a natural phenomenon. If the weather turns cool and wet again, slowing grass growth, another baiting may be necessary.

There are few chemical control options for slugs in seed fields. In a white clover seed field near Tangent, both 4% metaldehyde and 5% carbaryl applied in the fall significantly reduced slug populations compared to an untreated control (Figure 3). Large populations of slugs were present and actively feeding at night on the clover even though daytime temperatures were above the normal 80° F and precipitation to date had been slight. Large cracks throughout the field can provide excellent harborages when conditions on the soil surface are not favorable for slugs. Moisture from a heavy dew can be adequate to make slugs active at night. At this site 95% of the population was gray garden slug and 5% were marsh slug. Both the metaldehyde and carbaryl treatments are registered for agricultural purposes in Oregon. See the Pacific Northwest Insect Control Handbook for details.

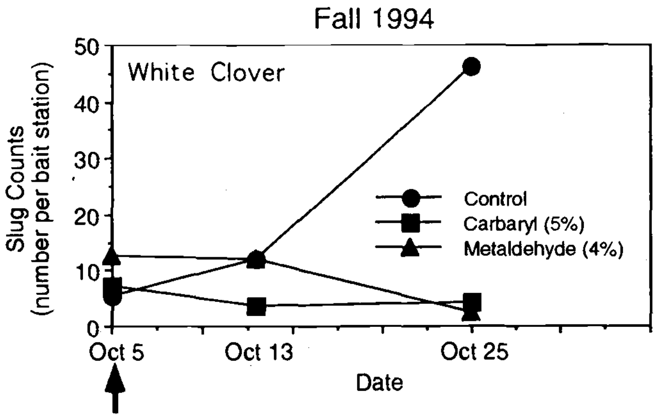

Figure 3. The number of slugs observed in October 1994 in a white clover seed field near Tangent after treating with metaldehyde and carbaryl baits. The arrow indicates the time of bait applications.

What effect does crop history and stand age have on slug populations?

The number of slugs is greater in juvenile tall fescue that was planted after red clover than in second-year stands of tall fescue. Fewer slugs were found in wheat following tall fescue than in all other treatments. It appears that once a tall fescue crop is established, slug populations do not increase as rapidly as in other crops. At the Silverton site, the number of slugs that were counted in winter/spring 1995 are greatest in plots that had wheat no-till planted into established stands of fine fescue in December of 1993 and which had the wheat harvested this past summer 1994. The slugs were observed to feed on shattered wheat kernels and volunteer wheat seedlings. The number of slugs counted were three times greater than any other treatment at all three locations. Wheat kernels are excellent for slug nutrition and reproduction, so reducing shatter losses should make the field less hospitable for slugs. More years of observations are needed before a clearer picture of crop and rotation sequence effects on slug populations are known.

Does grass straw residue have an affect on slug populations?

Our limited observations indicate that there was very little effect due to the amount of residue that was left on the tall fescue plots or carried over to plots of the next crop in the rotation sequence. Similar findings were observed on the perennial ryegrass and fine fescue at the Shedd and Silver ton plots, respectively. This is interesting because there is usually a good correlation between the amount of soil organic matter and slug population size. More data need to be collected from a broader range of sites to verify these observations, but this may be an encouraging finding for those who choose to use high residue post-harvest management practices.

How should the slug populations be monitored?

The slugs can be monitored by putting approximately 1 tablespoon of Mesurol bait under a 0.5" x 8" x 30" fir board. Commercial metaldehyde bait can also be used, but it is not as effective as mesurol for monitoring purposes. Unfortunately, mesurol is no longer registered for commercial agriculture uses.

The sampling board provides cover for the slugs and protects the bait from breaking down rapidly. Once a slug has ingested the poison, it usually stays under the board and dies. The slugs are counted during each site visit and removed with long-handled tongs. The board should be checked four or five times in a two week period and moved occasionally when the bait is replaced. It is best to use several boards to monitor a field, but we do not have a scientific sampling scheme to recommend at this time.

The slug populations have only been monitored the past two years during the periods from the beginning of October until mid-November, and from late January until the end of March when the slugs are most active. We will begin to monitor the entire winter period beginning this next fall/winter period. We have found that it is necessary to check the boards at least twice a week. It appears that when conditions are conducive to slug activity, populations will increase rapidly and crop damage may result before you know what is happening.

Summary

Please remember that these are only preliminary observations. Slugs were found at all three experimental sites and it is probably reasonable to assume that slugs can be found anywhere grass seed is produced in the Willamette Valley. For a field to exhibit slug activity, adequate soil moisture and warm temperatures must be present. Slugs were inactive in the fall of 1994 until significant precipitation built up soil moisture. Late September and October are periods when mating and most egg laying occur. In the late winter and spring, if the soil is moist, slugs become active with periods of warm weather. For the slug bait to be effective, it needs to be applied when the slugs are active and weather and field conditions are such that the bait will not break down. A single application of bait in the fall adequately reduced slug populations so that no crop damage was observed through the mid-winter 1994/95 period. Slug populations began to increase again in late winter and early spring as temperatures increased and eggs hatched. Only one application of bait was required to control the slugs in the winter/spring of 1994, but at least two applications were needed in winter/spring 1995. This was probably due to the warm and moist field conditions that occurred in 1995. Slug populations were greater in juvenile tall fescue that was planted after red clover than in mature tall fescue stands. The greatest slug populations were found in plots that were harvested for wheat the previous summer. More observations are needed to determine the effects of crop and rotation sequences on slug populations. The amount of post-harvest straw residue appeared to have no affect on slug counts made in tall fescue, perennial ryegrass, and fine fescue plots of this study.

For more information, contact Glenn Fisher, Extension Entomologist, Dept. of Entomology, Oregon State University, Corvallis, OR 97331, 503 737-5502; or Jeffrey Steiner, National Forage Seed Production Research Center, USDA-ARS, 3450 SW Campus Way, Corvallis, OR 97331, 503 750-8734.

SEEDLING CONTAMINATION IN PERENNIAL RYEGRASS WHEN CHANGING FROM ONE CULTIVAR TO ANOTHER

R.E. Barker, G.W. Mueller-Warrant, W.C. Young III and R.L. Cook

Seedlings that grow from shattered seed of a previous crop or year are considered serious weeds and require control. Volunteer seedlings compete with original plants in the field and contaminate its seed crop. Early developed cultivars were synthetics with few parental clones and cultivars could change genetically during seed production generations because of seed from volunteer plants. This change is called genetic shift, or genetic drift. To minimize deleterious effects, restricted generation seed production rules for certification (Breeder, Foundation, Certified classes) were developed. In recent years, cultivars have been released that have large numbers of parents. These cultivars are sometimes referred to as advanced generation synthetics, but they should be more correctly classified as open pollinated populations. Genetic integrity of open pollinated cultivars is maintained during seed increase by the frequency of desirable genes (alleles) remaining constant. Alleles from volunteer plants of the same cultivar should not change the original cultivar if environmental selection is absent. Genetic shifts in advanced generation synthetics, however, is largely unknown because grasses have few identified genetic markers that allow study of contamination effects.

A closely associated problem of volunteer seedlings in the same cultivar is volunteer plants from another cultivar grown on the same land in a previous year. Oregon Seed Certification rules allow perennial ryegrass seed growers to change certified cultivars within a field by three crop rotation options: stay out of perennial ryegrass production for two years, establish crop history, or modify land history. In the establishing of crop history option, after a final seed harvest of an "old" cultivar, the stand is destroyed by herbicide application and tillage. Certified seed of a "new" cultivar is carbon-band planted in the fall in conjunction with a broadcast application of diuron. If there is a "sprout" up before the seeded crop emerges, it is killed with Roundup or Gramoxone. Areas between crop rows are examined for volunteer seedlings during the first growing season. Two non-certified seed crops are taken from the field, after which certified seed of the new cultivar is again carbon-band planted into a destroyed stand. After emergence, the field is again examined for presence of volunteer seedlings between seeded rows. The decision to certify the final crop is based on calculations using between row seedling counts obtained during the two inspections.

Two questions arose that became objectives to a field study in 1994, and a laboratory study in 1994 to 1995. First, how many volunteer seedlings from the previous cultivar are "hidden" under the carbon band in a seeded row? And, second, can contaminating seedlings be recognized?

Field seedling counts

Two fields of perennial ryegrass converted from one cultivar to another in 1993-94 were located and used in this study. After a final crop of 'Pennfine' in 1992 on the Sayer farm near Brownsville, OR, the field was plowed and planted to arrowleaf clover for one year. In 1993, the field was plowed and 'Aquarius II' was seeded. At the Hyslop Crop Research Farm near Corvallis, OR, a field of 'Citation' was disked and plowed in 1993 in preparation to change to 'Pleasure'. At the Hyslop site, treatments were arranged in a randomized complete block design with three replications. A sprout up spray was applied to both fields before seeding the new cultivars.

During planting in each field, drill rows in the seed boxes were blocked with duct-tape and metal plates, and an identifiable strip was planted without seed. Bands of carbon (activated charcoal) were sprayed as normal over the plugged drill rows as well as over the planted rows. Plugged rows were located far enough from the edge of the field to avoid problems typical of weedy borders or alternative management practices on field borders. The balance of the field was planted normally. Care was taken to avoid overdrilling through the entire "plug-row" area. The plug-row area was clearly flagged after planting, marking the unplanted rows that were used in our studies.

Seedling density was measured at several places in the seeded crop row, in the non-planted carbon bands, and between rows of both plugged and seeded rows. Seedling density was determined by counting plants in replicated sites in each plug-row at the Sayer farm and in each replication and treatment at the Hyslop site.

Number of seedlings were excessive in all zones, including within the plug-row, between plug-rows, between seeded rows, and within the tarped-off area (Table 1). A higher number of seedlings were found between seeded rows than between plug-rows (1.93 vs 1.09 seedlings per foot row), possibly indicating that some seed was misapplied by the drill, falling between rather than within rows. Seedling numbers at Hyslop were even higher than those at the Sayer farm. The primary reason for the high number of seedlings at both sites was the absence of significant early fall rains, which prevented effective use of Roundup or Gramoxone in "sprout-spray" programs. Perennial ryegrass seedling numbers in the carbon-band plug-rows were higher than would be expected based on seedling counts between the rows. This represents the combined safening effects within the row of activated charcoal, starter-fertilizer, and the planter's furrow-closing, press-wheel mechanism on volunteer seed present within the soil. In fields where effective sprout-spray treatments reduce the between row population, hidden seedlings within the row could represent a population about as large as that seen between rows, possibly doubling the total contamination. Conversely, higher populations found between seeded rows than between plug-rows may imply that planters are sometimes "leaky" enough that seedlings found between rows and presumed to be volunteers are really just newly planted seed that have bounced, blown, or washed out of place. Bird feeding and scratching may also contribute to the problem of out-of-place seed.

Table 1. Perennial ryegrass seedling counts in various zones.

	Sayer Farm	Hyslop Farm
	(Seedlings per foot of row in each zone)	
Within plug-rows (1 in.)	0.76	4.81
Within seeded rows (1 in.)	12.42	--
Between plug-rows (11 in.)	1.09	--
Between seeded rows (11 in.)	1.93	22.3
Between seeded rows, under tarp (11 in.)	6.30	--

The best predictor of plug-row populations was seedling density in the traditional tarped-off area. In the tarped zone, an average of 6.3 seedings were found per foot of row in the 11-inch wide area between each row, leading us to expect 0.57 seedlings per foot of row in a 1-inch wide area (6.3/11). Because only one tarped-off area existed near the plug-rows, our estimate of volunteer seedlings under the tarp is not as precise as our estimates in the plug-rows and between the rows. Therefore, the 33% increase in seedlings within the plug-rows relative to seedlings under the tarp (0.76 vs 0.57) may or may not be meaningful.

Without genetic tests able to identify cultivars, procedures for certifying new stands of perennial ryegrass will continue to rely upon a series of assumptions concerning the origin of seedlings found between rows, within planted and unplanted rows, and under tarps.

Management practices at the Sayer farm resulted in fewer seedlings than the Hyslop site. It was recognized that probably neither site would qualify for seed certification purposes, but there was sufficient contamination at each site to provide good conditions for our study. Clearly there was a higher plant density within rows at both sites than between rows. These results indicate the possibility of considerable undetected volunteer seedling contamination within rows. A larger question remained to determine from which cultivar the contaminating seedlings originated. Definite genetic tests to identify varieties would better protect both seed producers and buyers.

Laboratory tests for cultivar identification

Molecular technologies have advanced in recent years, making it possible to "DNA fingerprint" cultivars and characterize genetic changes. Using both classical and molecular technologies, we know that each individual in a open-pollinated grass field is different from every other individual. A cultivar is identified by grouping individuals that are closely related, or have characteristics in common such as disease resistance.

A wide variety of Mendelizing units (alleles or "genes") identified as bands on random amplified polymorphic DNA (RAPD) gels have been identified and can be used to characterize populations of individuals. Each plant in an outcrossed germplasm line has a different pattern of banding, but a characteristic allelic frequency difference among lines can usually be found. The number of alleles in common between two cultivars define genetic distance and can be determined by specialized computer programs.

The first step was to develop a database of each known cultivar to which the unknown seedlings could be compared. Seed from the last seed crop of 'Citation' produced at Hyslop and the seed source to produce 'Pennfine' on the Sayer farm was used to represent the "old" cultivars. Seed used to establish the new fields of 'Aquarius II' and 'Pleasure' were used for the "new" cultivars. Seeds were planted in the greenhouse, and when large enough, leaf tissue was harvested from individual plants. Tissues were prepared for arbitrarily primed polymerase chain reaction (AP-PCR) analysis using standard procedures for this technique. (These procedures will not be explained here.) Bulk tissue was also harvested from remnant germinated seedlings and used to screen for primers that produce polymorphic patterns between the two cultivars used at each field site.

Banding patterns on random amplified polymorphic DNA (RAPD) gels for seven primers were identified. While polymorphisms were present in bulked tissue samples, clear morphological or genetic markers did not appear to exist to distinguish between the old cultivars and the new ones for these studies. Thus, DNA from individual plants was extracted and allelic frequency (band pattern) is being used to characterize each cultivar (Figure 1).

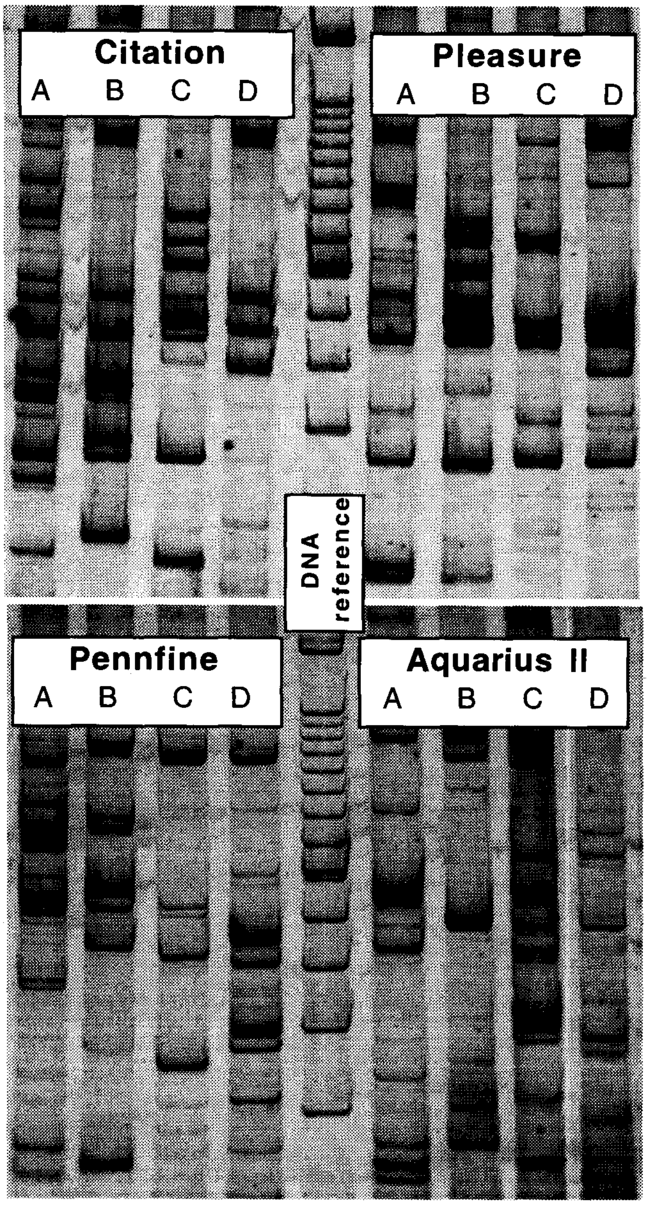

Figure 1. Images of RAPD electrophoretic gels run on individuals with known cultivar origin.

Band profiles of four individuals from each cultivar are presented in Figure 1. Each individual is different from the others, but after computer analysis, individuals within a cultivar can be grouped. Band profiles from plants harvested from the field with unknown origin will be compared with the individuals with known parentage using a matrix mixture analysis. This analysis will reveal cultivar origin.

Acknowledgments: Partial support for this research was provided by the CSREES Special Grant Grass Cropping System program.

ROW SPRAYING VOLUNTEER ANNUAL RYEGRASS SEED CROPS

W.C. Young III, B.M. Quebbeman, M.E. Mellbye and C.J. Garbacik

Historically, seed growers have used no-till establishment methods to direct-seed annual ryegrass (*Lolium multiflorum*) crops into the unplowed soil following open-field burning. Typically, growers would use conventional tillage and planting methods one year, and then annual ryegrass seed crops would be replanted for three to five years using no-till management. This was a low input and low cost approach to growing annual ryegrass that was dependent upon annual burning. However, political pressures resulting from reduction in air quality caused by open-field burning of all seed crop residues has led to a legislative agreement to phase-down the practice. Of the 123,300 acres of annual ryegrass seed harvested in 1994 only 36,185 acre were burned, less than 30 percent.

The most common nonthermal residue management strategy used by annual ryegrass growers is flail chopping and plowing under the crop residue before conventional preparation of a seedbed for the next crop. The practice of "volunteering" a crop (allowing seedlings to germinate from shattered seed lost during harvest of the previous crop), is another strategy growers are experimenting with as a possible method of nonthermal management in annual ryegrass. The producer's objective in choosing this establishment option is to cut the production costs over standard seed bed preparation. Growers using the volunteer system have reported yield reductions of 100 to 400 lb/a, thought to result from increased interplant competition. As no rows are present in a volunteer stand of annual ryegrass, the idea of creating rows by banding herbicides (row spraying) is being considered. Data reported last year (Young et al., 1994) on the effect of a band sprayed herbicide treatment, which resulting in 6 inch "rows" with a 14 inch inter-row spacing, showed no significant difference in total harvest dry weight, clean seed yield, harvest index, or 1000 seed weight when compared to an unsprayed volunteer stand.

In the 1993-94 crop year, we took another look at row-spraying annual ryegrass seed fields established by volunteer seedlings. Row-spray treatment this year was one month earlier and done with equipment that resulted in 5 inch "rows" with a 5 inch inter-row spacing. In addition, this year's trial was arranged so comparisons could be made with a conventionally-prepared seedbed that was drill seeded.

On January 14, 1994, a herbicide tank mix of Karmex 80W (diuron) and Roundup (glyphosate) at 1.0 lb/a and 1 pt/a, respectively, was band sprayed to a volunteer-established stand of annual ryegrass in the Halsey, OR area. Row-spray treatments were arranged within the volunteer stand, which comprised about 10 acres of a 160 acre field—the balance of which was plowed and drill-seeded, such that data could be analyzed as a completely randomized design experiment.

The field area that was plowed and drilled had 245 lb/a of 10-20-20 fertilizer at planting (24 lb N/a) on October 9, 1993, that the volunteer stand did not receive. Spring N management was uniform across all treatments with 200 lb/a 21-0-0 (42 lb N/a) on March 28 and 250 lb/a 46-0-0 (115 lb N/a) on May 10, 1994. The field was stocked with sheep from late December to early March, with the initial grazing pressure being more intense in the volunteer stand as greater growth had resulted from volunteer seedlings established one month earlier than the drilled area of the field.

Clear evidence "rows" in the row-sprayed areas did not become apparent until mid-February, but became increasingly obvious in the early spring weeks following the March nitrogen application. Plant samples taken on April 27 were timed with canopy closure in the row-sprayed area; the objective was to assess the vegetative tiller population. Total number of vegetative tillers in the row-sprayed area was about half that found in the drill planted area, and two thirds of the volunteer stand (Table 1). Average tiller stem base diameter was larger in the row-sprayed plots; 88% of the tillers in the row-sprayed area had a stem base diameter of 3 to 4mm (Table 1). Thus, the tiller population in the row-sprayed area was comprised of a smaller number total tillers, but a greater proportion of them were larger in size.

Table 1. Vegetative tiller data collected April 27, 1994, at canopy closure in the row-sprayed treatments.

	Total tillers	Avg. tiller stem base diameter	Tiller size 2mm	Tiller size 3mm	Tiller size 4mm
	(no./ft^2)	(mm)	-------- (%) -------		
Volunteer	288	2.8	22	77	1
Row-spray	193	3.1	13	68	20
Plow/Drill	375	2.7	34	58	9
LSD 0.05	123	0.2	13	8	11

A second sampling on June 7 coincided with peak anthesis and quantified both reproductive and vegetative tiller numbers. No difference in the proportion of fertile to vegetative tillers was present in the stand (data not shown), however, there were significantly fewer total tillers and fertile tillers in the row-sprayed plots at maturity (Table 2). In addition, there was no statistically significant difference in total dry weight, suggesting that a fewer number of larger size tillers maintained total crop biomass. Additional information on seed yield components determined at peak anthesis found significantly larger spikes (seed heads) in the row-sprayed area (Table 3). Although number of spikelets per spike was unchanged there was a significantly greater number of florets (seeds) per spikelet.

Table 2. Vegetative and reproductive tiller data collected June 7, 1994, at about peak anthesis.

	Total tillers	Fertile tillers	Vegetative tillers	Total tiller dry weight
	--------- (no./ft^2) -----------			(ton/a)
Volunteer	259	146	112	5.05
Row-spray	201	99	101	4.14
Plow/Drill	338	168	170	5.40
LSD 0.05	75	53	NS[1]	NS

[1]Significant at P<0.1 probability level (LSD 0.1=46)

Table 3. Inflorescence yield component data from reproductive tillers collected June 7, 1994, at about peak anthesis.

	Spike length	Spikelets per spike	Florets per spikelet
	(cm)	------------ (no.) ---------	
Volunteer	19.2	20.4	6.8
Row-spray	28.4	22.2	9.8
Plow/Drill	25.2	22.4	8.7
LSD 0.05	3.2	NS	1.3

Final harvest data was attained in cooperation with the grower by weighing four combine harvested swaths (12 x 200 ft.) from each treatment in the field. Sub-samples of combine-run seed were collected for a purity analysis at the Oregon State University Seed Laboratory. Clean seed yield and 1000 seed weight was determined following purity analysis. Seed yield was significantly reduced in the volunteer stand, however, there was no difference between the volunteer stand that was row-sprayed and the conventionally seeded area (Table 4). Inert matter was significantly higher in the volunteer area, and weed seed content was greatest in the plowed and drilled section.

Partial budget analysis on this grower's operation found a significant economic advantage to the system of row-spraying a volunteer established stand. Seedbed preparation costs and planting expenses were avoided entirely, and seed yield was maintained at a level equal to conventional seeding for a minimum expense of row-spraying (less than $10.00/a). Not row-spraying the volunteer established stand resulted in over 300 lb/a reduction in seed yield.

Table 4. Seed yield and seed quality characteristics from combine harvest data collected on July 20, 1994.

	Clean seed yield	1000 seed weight	Pure seed	Inert matter	Weed seed
	(lb/a)	(g)	----------	(%)	---------
Volunteer	2128	2.75	94.8	4.3	0.01
Row-spray	2448	2.59	96.7	2.3	0.00
Plow/Drill	2401	2.68	95.7	2.9	0.12
LSD 0.05	192	NS[1]	1.5	1.3	0.03

[1]Significant at P<0.1 probability level (LSD 0.1=0.11)

Reference

Young, W.C., P.K. Boren, M.E. Mellbye and B.M. Quebbeman. 1994. Row spraying volunteer annual ryegrass seed crops. *In* W.C. Young III (ed.), 1993 Seed Production Research an Oregon State University and USDA-ARS Cooperating. Dept. of Crop and Soil Science, Ext/CrS 98.

WHITE HEAD SYMPTOM IN ANNUAL RYEGRASS AND THE CEREAL STEM MOTH

G.C. Fisher, S. Panashatham and M.E. Mellbye

Introduction

In the late 1980s fieldmen noticed many early-appearing white heads in a few fields of annual ryegrass near Harrisburg. These heads were without seed and were associated with a small white stem boring caterpillar. Significant damage in a few fields of annual ryegrass prompted the following study with objectives to identify the pest, determine its life history, identify other possible economic host plants and evaluate certain controls.

The field biology and host range of the cereal stem moth (CSM) was the subject of a thesis for the Master of Science degree at OSU by the second author from 1992 through 1994. Financial support was provided by the Department of Entomology.

Distribution and Life History

The CSM (*Ochsenheimeria vacculella*) is native to Europe. In the U.S. it has been documented only in the Northeast and the Willamette Valley, OR. The few scientific reports from European literature indicate it can be a serious pest of wheat and cereal rye. In OR, field populations of the larvae have thus far been restricted to commercial fields of annual ryegrass. The life cycle of CSM is quite interesting. In 1992 and 1993 eggs by the tens of thousands overwintered in outbuildings next to infested ryegrass fields. From February through April these eggs hatched and the small caterpillars "ballooned" from the buildings by thin silk threads to land on seedling grasses. The few larvae successfully reaching a grass host became leafminers for the first week to 12 days. They then emerged and entered a stem boring phase that lasted for a couple of months. Up to a dozen stems can be damaged by a single larva. The larvae pupate between the stem and leaf sheath. The very small adults fly during the afternoon in June and July, coinciding with harvest.

Whiteheads, the result of CSM injury, easily pull free from the stem sheath. Separation usually occurs near the last node. The stem will show signs of chewing. Sometimes the larva is found, but more often a very small exit hole is seen near where the stem separated from the sheath. Larval droppings can be seen within the sheath under magnification.

Adults congregate sometimes by the thousands in old barns and buildings, particularly those with a history of grass straw or seed storage. Eggs are massed on the walls, ceilings and other objects. A portion of these eggs may hatch soon after being laid in June and July. The rest will not begin to hatch until late February or March. The summer hatch amounts to a "suicide emergence" as suitable stages of green annual ryegrass are not generally present.

Hosts

Field, greenhouse and laboratory studies confirmed that annual ryegrass was the most suitable host for larval development, even though overall survivorship was low (about 20%). Very few larvae produced adults when raised on perennial ryegrass, orchardgrass, tall fescue and winter wheat (10% or fewer).

Management
In 1994 parasitism of CSM larvae by two species of parasitic wasps resulted in nearly 100% control by harvest at one study site. Very likely these wasps are native to the area and general parasites that use many different species of caterpillar hosts.

The practice of "sheeping" annual ryegrass fields in the late winter/early spring, reduced larval infestations by 75% or more in field trials.

Previous field trials indicated that insecticides timed during the period when larvae drift into fields also can reduce damage from CSM.

Conclusions
Annual ryegrass appears to be the favored host of CSM, even though survival rate of larvae is fairly low. CSM larvae did not survive on several varieties of winter wheat exposed to larvae in the field.

Economic impact of this pest on annual ryegrass has not been determined. Its occurrence thus far is restricted to a few fields in the south Willamette Valley. Localized damage in areas of these fields may possibly have approached 10% in one or two previous seasons. Parasitization and "sheeping" may keep this pest in check. It is felt that field burning would not contribute to control as most adults would have migrated from the seed field to outbuildings by the time fields were burned in the summer. Although not confirmed, field burning may actually be more harmful to the wasp parasites.

To date, larvae have been only collected in annual and perennial ryegrass seed fields. They have reached damaging numbers only in fields of annual ryegrass in south Linn County.

ANNUAL RYEGRASS N FERTILIZATION AND GROWTH AS RELATED TO GROWING DEGREE DAYS IN TWO CONTRASTING CLIMATIC YEARS

S.M. Griffith, S.C. Alderman and D.J. Streeter

Introduction
Concern for potential environmental N pollution and conservation of energy and resources, and increased economic return has continued the need to improve nitrogen (N) fertilizer management practices to achieve greater N use efficiency without limiting economic return. Potential strides in N conservation can arise from improved fertilizer timing, application levels, use of more economical or efficient N-sources, or improved plant germplasm.

Nitrogen is the most critical mineral element affecting ryegrass seed yield (Youngberg, 1980). If nitrogen timing, level, or N-source is incorrectly managed reduced grass seed yields may result. For example, applying excess nitrogen to ryegrass seed crops increases vegetative tiller production and reduces seed yield (Young, 1988). This occurs in part, because floral tiller sinks compete poorly with vegetative tillers for plant assimilates (Griffith, 1992).

In a survey of grass seed growers in western Oregon's Willamette Valley, Horneck and Hart (1988) showed that average N application rates were 29% greater than the Oregon State University Extension Fertilizer Guide recommended rate. This practice may have arisen from a lack of reliable basic and applied information about local ryegrass N nutrition parameters. Hence, there is a critical need to advance knowledge of N nutrition in western Oregon grass seed crops. Significant advances in improved N use efficiency and growth regulation by N may be achieved by identifying optimum levels, timing, and how different N-forms (ammonium and nitrate) affect plant growth. Further, by relating this knowledge to environmental parameters, such as units of heat accumulation (growing degree days) and stages of plant ontogeny, one could plan for optimum N use efficiency.

Soil nitrate and ammonium levels are regulated by numerous factors, such as soil temperate, pH, soil microbiology, fertilizer form, and moisture. In cool, low pH soils (e.g., western Oregon), ammonium is likely to be the dominate N-form. Thus, ammonium nutrition maybe important to ryegrass when the major portion of growth, and hence N uptake, occurs in the cool early spring months. Understanding the role that ammonium and nitrate play, with respect to plant growth and seed yield, may be a means to maximize harvest index by enhancing primary fertile tiller production over vegetative growth. Griffith and Streeter (1994) showed vegetative growth rate of plants receiving lower ratios of nitrate/ammonium was as much as twice those plants receiving total nitrate or 75/25 nitrate/ammonium. In addition, floral tiller number increased as much as 55% with increasing ammonium-N to nitrate-N, while vegetative tiller number was not significantly affected.

A field study was initiated as a follow-up to previous work which examined physiological aspects of ammonium and nitrate nutrition on ryegrass growth and development under controlled hydroponic conditions (Griffith and Streeter, 1994). The research objectives were: (1) to manipulate soil ammonium and nitrate ratios by using calcium nitrate, ammonium nitrate, ammonium sulfate, ammonium chloride, and urea + dicyandiamide (cyanoguanidine, $CH_2H_4N_4$) (DCD) fertilizer applications; and (2) to examine N fertilizer source effect on ryegrass growth and seed yield as a function of plant ontogeny and accumulated heat units (growing degree days, GGD). Soil N dynamics and plant N uptake data will be reported at a later time.

Materials and Methods

Field Plots: Field plots (20 ft. x 20 ft.) of Italian ryegrass (*Lolium multiflorum* Lam. cv. Marshall) were established at Hyslop Experimental Research Farm near Corvallis, Oregon during September of 1991 and 1992. The soil was a Woodburn silt loam (fine-silty, mixed, mesic Aquultic Arigixerolls). The plots were arranged in a randomized block design with four replications. Treatments included calcium nitrate (CN) (($Ca(NO_3)_2$),ammonium nitrate (AN) (NH_4NO_3), ammonium sulfate (AS) (NH_4SO_4), ammonium chloride (AC) (NH_4Cl), and urea + DCD (urea+dicyandiamide) (UD) ((cyanoguanidine, $CH_2H_4N_4$) contains 5% N)). Fertilizer was surface boardcast in the fall at 30 lb N/a and a split application in the spring of 45 lb N/a each. The spring application was applied at 541 GGD (March 25) and 759 GGD (April 18) in 1991 and 502 GGD (March 6) and 945 GGD (April 16) for 1992.

Data Collection and Analyses: Shoot (above ground biomass), roots, and soil were collected from each plot on March 22, April 11, 22, May 6, 20, June 5, 19 in 1991 and January 22, February 19, March 17, April 2, 16, May 1, 14, 18 in 1992. At seed harvest, the plot's center 10 ft. x 10 ft. area was cut by hand and threshed. Meteorological data were collected at the OSU Hyslop Farm weather station near the experimental site. Accumulated GGD was calculated by the formula Σ {$[T_{max}+T_{min}) /2]-T_{base}$. T_{base} was 0° C.)

Results

Climatic Conditions: The 1992 crop year was warmer and drier than 1991. Maximum and minimum temperatures from January through May in 1991 and 1992 were 6.3 and 2.9° C higher during 1992 than 1991. Total precipitation between January 1 and the date of seed harvest was 20.7 in. and 13.4 in. for 1991 and 1992, respectively. Total precipitation between the first and second spring N application was 9.1 in. and 3.1 in. for 1991 and 1992, respectively. Total precipitation between the second spring N application and the date of seed harvest was 9.1 in. and 2.3 in. for 1991 and 1992, respectively.

Plant Growth: There was no evidence that the N-source treatments had an effect on the rate of developmental expression. The relative relationship between plant stage of development and GGD was as follows: 5-6 leaf stage (107 GGD on Jan. 22, 1991 and 1992); beginning of tiller elongation (805 GGD on Apr. 22, 1991 and 792 GGD on Apr. 2, 1992); late-boot to early-heading (945 GGD on May 6, 1991 and April 16, 1992); mid-head emergence (1105 GGD on May 21, 1991 and 1133 GGD on May 1, 1992); and mid-anthesis (1327 GGD on June 8, 1991 and 1332 on May 1, 1992). Seed harvest occurred at 1832 GGD (Jul. 10, 1991) and 1783 GGD (Jun. 10, 1992).

There was no significant difference between root and shoot dry mass accumulation over time and N-source treatment by year, but there was between years across N treatments. Therefore, data have been averaged across N treatments by year. In 1992, root growth increased until 600 GGD, remained constant until 1100 GGD, then increased again. In 1991, root growth declined until 700 GGD then increased up to 1000 GGD followed by a latter decline. This was dramatically different from 1992.

Following winter dormancy, 1991 and 1992 shoot growth resumed between 300 and 700 GGD. Maximum shoot growth was achieved by 700 GGD in 1991, but not until after 1500 GGD in 1992. Unlike 1992, 1991 shoot DMA remained constant from 700 to 1000 then gradually declined. Maximum DMA for 1991 was only 35% of that measured for 1992.

In 1991, ammonium-source fertilization following 700 GGD resulted in greater tiller number per unit area compared to all nitrate. In 1992, N-source treatment did not affect tiller number. In 1991, tiller number remained constant after 700 GGD for CN treated plots and 900 GGD for ammonium treated plots. In 1992, tiller number gradually increased up to 1600 GGD.

Seed Yield: Although there were no significant seed yield differences among N treatments in 1991, AN, AS, AC, and UD had higher numerical seed yield than CN treated plots (Table 1). In 1991, plots receiving no added N had similar seed yields as plots receiving added N. Seed yield was greatest with addition of AN fertilizer followed by AC and UD fertilizers in 1992 while CN and AS treatments had the lowest seed yields of all N treatments. Minus-N check plot data were not available for 1992. Percent germination of harvested seed was not affected by N-source treatments in either year.

Table 1. Effect of N-source fertilization on Italian ryegrass seed yield (lb/a) for 1991 and 1992. Seed yield among N treatments in 1991 was not significantly different.

N-Source	Seed Yield 1991	Seed Yield 1992	
	------------- (lb/a) ------------		
No Added N	1042	---	
$Ca(NO_3)_2$	953	2289	a
NH_4NO_3	1283	3563	c
NH_4SO_4	1060	1772	a
NH_4Cl	1105	2939	b
Urea-DCD	1113	3100	bc

N and Phytomass Accumulation: Maximum total (above and below ground) phytomass accumulation and plant N uptake occurred during a short duration in the early season of 1991 just prior to tiller elongation (500 and 700 GGD; March 19 and April 13, 1991, respectively) (Figure 1). Following 700 GGD (March 26, 1991) phytomass accumulation remained constant, whereas total plant N declined sharply following the beginning of tiller elongation (800 GGD; April 2, 1991).

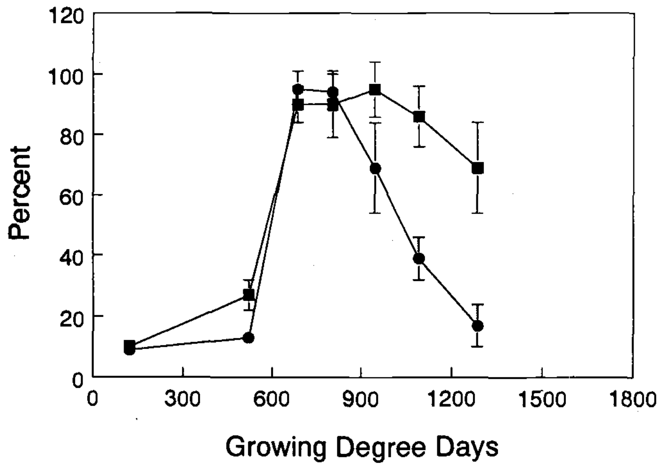

Figure 1. The percent of maximum total N (●) and phytomass (■) accumulation of annual ryegrass *(Lolium multiflorum* Lam.) as a function of growing degree days for 1991. Growing degree days were calculated from January 1 and a base temperature of 0° C was used.

In 1992, phytomass accumulation and N uptake followed a characteristic growth pattern (Figure 2). In 1992, nitrogen uptake preceded phytomass accumulation by 200 to 300 GGD throughout most of the growing season. Nitrogen uptake remained constant following spike emergence (1100 GGD; April 28). A decline in net N uptake occurred prior to maximum phytomass accumulation.

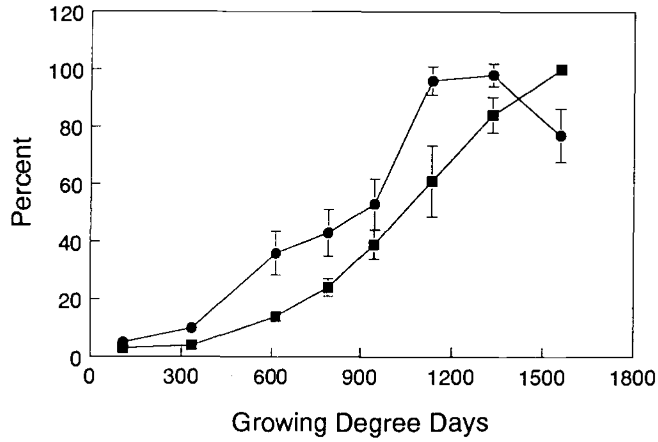

Figure 2. The percent of maximum total N (●) and phytomass (■) accumulation of annual ryegrass *(Lolium multiflorum* Lam.) as a function of growing degree days for 1992. Growing degree days were calculated from January 1 and a base temperature of 0° C was used.

Discussion

Although there were differences in tillering and seed yield among plants that received all nitrate, mixed nitrate-ammonium, and all ammonium fertilizer sources, the greatest differences appeared to be related to soil N availability rather than to differences related to ammonium or nitrate nutrition. Further, these affects appeared to be related to environmental conditions (e.g., temperature and precipitation).

Plant growth and seed yield in the high precipitation year of 1991, resulted in the greatest reduction in growth and final seed yield compared to the warmer drier 1992 growing season. It is hypothesized that this affect resulted from an apparent N deficiency in 1991 caused by high precipitation that year. This was evidenced by the commencement of early season root growth at a time when shoot growth subsided. When soil N level is growth limiting, plants expend more energy and partition more biomass to their roots and less to shoots. Further evidence in support of N deficiency in 1991 was the fact that check plot control (no added N fertilizer) had similar seed yield to N applied plots. Lastly, the all nitrate fertilizer application in 1991 resulted in lower tiller number per unit area compared to the ammonium N-source treatments for that same year. This suggests that greater N loss through nitrate leaching may have been a factor, whereas possibly ammonium treated plots had more N available in less mobile ammonium-N form.

Greater loss of N from nitrate applications, compared to ammonium forms, in a wetter than a drier year may be expected because of the greater potential for soil nitrate-N mobility. If in fact N deficiency occurred in 1991 it was not evident from visual field observations, since at no time did the crop appear chlorotic or stunted. Even though ammonium is more immobile in soils, ammonium applications in 1991 did not over come possible N deficiencies incurred by plants.

In the warmer drier season of 1992 seed yield was reduced with CN and AS applications without an apparent reduction in growth or tiller number. The nitrate response observed in 1992 was predicable based on the notion that ryegrass performs better under ammonium enriched conditions, although one would have also expected a reduction in growth also. Inconsistent, is the lower seed yield due to AS application. There is no evidence at this time that can explain this response.

Climatic conditions, temperature and precipitation, play a major role determining final grass seed yield. Since temperature is a major regulator of growth and development, growth data as a function of accumulated GGD, allowed for growth comparisons between years of contrasting weather. Little information is available concerning the relationship of different grass species and cultivars grown for seed in western Oregon with respect to climate, plant development, and nitrogen uptake. Such information would increase the accuracy of any crop model predicting timing and level of fertilizer use in addition to crop growth which considers the impact of climatic conditions on crop growth.

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DEVELOPMENT OF RYEGRASS IDENTIFICATION METHODOLOGY TO REPLACE FLUORESCENCE TEST

S.M. Griffith and G.M. Banowetz

Findings

In 1979, Nakmura was able to distinguish between seed of Italian (annual) ryegrass (*Lolium multiflorum* Lam.) and perennial ryegrass (*L. perenne* L.) by using a test that detected the enzyme activity of a unique Italian ryegrass esterase isozyme protein (Est-1). This finding was later confirmed by work of Payne et al. (1980).

More evidence for a unique protein in Italian ryegrass was supported by findings of Griffith and Banowetz (1992) after screening 18 cultivars of Italian ryegrass and 74 cultivars of perennial ryegrass. They prepared protein extracts from seeds of each cultivar, electrophoresed these protein extracts through isoelectric focusing gels, and stained the gels for esterase activity. They found that all protein extracts prepared from Italian ryegrass cultivars contained an esterase protein with unique electrophoretic mobility. Protein extracts from perennial ryegrass did not contain this protein. They named this esterase protein Est-1. Other esterase proteins were found that were common to both Italian and perennial ryegrass, but Est-1 enzyme activity was only present in Italian ryegrass seed. A similar Est-1, with respect to a common pI, was also found in *Lolium remotum* (Schrank) seed but not in other *Lolium* species examined (Griffith and Banowetz, 1992). The isoelectric focusing procedure utilized to examine these grasses was highly effective in identification of Est-1, but was not a practical procedure for use in routine screening large numbers of seed lots for certification purposes.

The unique electrophoretic mobility of Est-1 indicated that Est-1 was structurally different from the other esterases that occurred in the seed extracts, although no estimate of the extent of the structural differences was possible without further protein characterization. If structural differences in proteins are of sufficient magnitude, antibodies can be produced against the proteins which will differentiate that protein from other similar molecules. Consequently, antibodies have been prepared and used for specific identification of a wide variety of proteins. Many of these proteins serve as unique biochemical markers and antibodies that recognize these proteins are used in immunoassays to identify particular species. In each case, however, sufficient structural differences in the protein must be present to stimulate production of antibodies that do not cross-react with similar molecules. Because Est-1 appeared to be unique to Italian ryegrass, work was initiated to determine if the structural differences between Est-1 and the other esterases were adequate to develop an antibody probe to be used to identify Est-1 in future purity seed tests.

In 1992, Est-1 was purified to homogeneity (Griffith and Banowetz, unpublished). Purified protein was then used for Est-1 monoclonal antibody production. The results at first were discouraging because of faulty myeloma cells used in the procedure. Once procedures were corrected, both polyclonal and monoclonal antibodies to Est-1 were developed. Initial screening of the antibodies continued to indicate that Est-1 was unique to Italian ryegrass, but other proteins in extracts from both Italian and perennial ryegrass also reacted with the antibodies. An enzyme-linked immunsorbent assay (ELISA) was devised to compare the reactivity of the antibodies with four protein extracts which included one Italian and three perennial ryegrass cultivars. One polyclonal serum, 43 different monoclonal antibodies, and 23 antibodies produced by cloned cell lines were tested for reactivity in these ELISA immunoassays. All antibodies reacted with both the Italian ryegrass protein extract and the three perennial ryegrass protein extracts. These antibodies were developed as the result of seven separate attempts to prepare specific monoclonal antibodies and represented screening of over 2500 hybridoma cultures for an Est-1 specific antibody. These results suggest that the structural differences between Est-1 and the other esterases present in ryegrass protein extracts are not sufficient to permit differentiation of the two species by an anti-Est-1 antibody-based test. As of the date of this final report, the antibodies that we have will not distinguish Italian from perennial ryegrass in an ELISA immunoassay. They may be useful in further characterization of Est-1. If future efforts are made to develop of a gene-based probe, these antibodies may be useful in screening expression libraries to clone the gene that codes for Est-1.

Summary

This investigation was initiated to determine if an Italian ryegrass seed esterase (Est-1) could be used as a biochemical marker to develop a reliable method for detecting Italian ryegrass seed contamination in perennial ryegrass seed lots. One possible procedure would be by directly screening for the presence of the specific Italian ryegrass seed esterase protein, Est-1. If developed, this procedure could be easily performed in a few days by a trained seed technician as compared to the currently used fluorescence test which requires at least 21 days.

We have concluded that Est-1 will not serve as a marker in an immunoassay for Italian ryegrass seed identification. Although Est-1 enzyme activity was only detected in Italian ryegrass seed, immunological evidence using a collection of different anti-Est-1 antibodies suggests that the molecular protein composition of Est-1 is greatly conserved in other perennial ryegrass esterase proteins. Because of the apparent extensive structural similarity of the esterases, all the anti-Est-1 antibodies were cross reactive with similar proteins present in perennial ryegrass protein extracts. Our original hypothesis that Est-1 enzyme activity is present in Italian ryegrass seed and not in perennial ryegrass is not voided by these results. However, more structural information that compares Est-1 with other seed esterases is needed to conclusively evaluate whether Est-1 can serve as a marker using a gene-based probe.

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SULFORIX APPLICATIONS FOR SUPPRESSION OF STEM RUST IN PERENNIAL RYEGRASS

M.E. Mellbye and G.A. Gingrich

Stem rust is a serious disease that reduces seed yields of perennial ryegrass in Western Oregon. Fungicide applications are made on fields each spring to provide rust control and optimize seed yields. Tilt and Bayleton are the most widely used fungicides and are classified as sterol inhibitors. With only one mode of action and with multiple annual applications over many years of production the potential for developing resistant strains of rust is a concern for long term disease management programs.

Lime sulfur is a product that has been used for many years to control foliar diseases of various crops. Based on field trials we conducted in 1993, a formulation of lime sulfur plus surfactants called Sulforix (originally Orthorix) received a 24(c) label for use on perennial ryegrass in Oregon. Trials were continued in 1994 to further evaluate the effect that Sulforix, applied alone or in combination with Tilt, had on the control of stem rust in perennial ryegrass.

Trial plots were established in four commercial fields of perennial ryegrass in the Willamette Valley. Sulphorix and Tilt were applied alone or in combination according to the treatment schedule shown in Table 1. Treatments began prior to the appearance of stem rust, with the first fungicides applied during early head emergence in May. Second and third applications were made on about 21 day intervals. Each trial was a randomized block design with three replications. Individual plot size was 8 x 30 ft. Fungicides were applied in water at 20 GPA using a hand-held, CO2 backpack sprayer. No surfactants were added. The varieties of perennial ryegrass were: Accolade, Regal, and APM. Fertilizers and herbicides were applied according to normal field practice.

Table 1. Product rates and application dates for stem rust control trials on perennial ryegrass in Linn and Marion Counties, 1994.

	Treatments (product/acre)		
	5/13/94	5/30/94	6/20/94
1.	0 (Check)	0	0
2.	Sulforix .5G	Sulforix .5G	Sulforix .5G
3.	Sulforix .5G	Sulforix .5G + Tilt 4 oz.	Tilt 6 oz.
4.	Sulforix .5G + Tilt 4 oz.	Sulforix .5G + Tilt 4 oz.	Tilt 6 oz.
5.	Sulforix .5G	Tilt 4 oz.	Tilt 6 oz.
6.	Tilt 4 oz.	Tilt 4 oz.	Tilt 6 oz.
7.	0	Tilt 4 oz.	Tilt 6 oz.
8.	Sulforix .5G	Sulforix .5G	Tilt 6 oz.
9.	Tilt 4 oz.	Tilt 4 oz.	Sulforix .5G + Tilt 6 oz.

Evaluation of rust infection level was determined by using the Modified Cobb Scale to rate each treatment for rust control. Evaluations were made on three dates between application and harvest. Tables 2 and 3 show the level of rust infection for the treatments at two of the four locations. Seed yields were not taken from the plots.

Table 2. Stem rust infection in perennial ryegrass. Variety Accolade. Ron DeConinck Farm, Marion County, Oregon, 1994.

	Rust evaluation date			
Treatments	5/5	5/30	6/21	6/25
	-----------(% infected)--------			
1. CHECK	2	19	83	92
2. Sulforix (3x)	0	14	42	50
3. Sulforix/Sulf + Tilt 4 oz./Tilt 6 oz.	0	6	18	14
4. Sulf + Tilt 4 oz./ Sulf + Tilt 4 oz./ Tilt 6 oz.	0	4	13	8
5. Sulf/Tilt 4 oz./ Tilt 6 oz.	0	8	25	20
6. Tilt 4 oz./Tilt 4 oz./ Tilt 6 oz.	0	6	18	15
7. 0/Tilt 4 oz./ Tilt 6 oz.	0	14	23	20
8. Sulf/Sulf/Tilt 6 oz.	0	15	30	21
9. Tilt 4 oz./Tilt 4 oz./ Sul + Tilt 6 oz.	0	3	12	11
LSD (0.05)	NS	NS	15	10
LSD (0.01)	NS	NS	20	14

Results of the treatments were similar across the four field locations, and consistent with our observations in 1993. Application of Sulforix alone provided some rust control. While the level of control was not adequate for commercial use by itself, the results showed that this formulation of lime sulfur had activity against stem rust. Making an early application of Sulforix and following with two Tilt treatments or combining the Sulforix with Tilt provided good rust control. Adding the highly alkaline Sulforix product to Tilt in the spray tank did not reduce the effectiveness of Tilt. In fact, a tank mix of Sulforix and Tilt performed as well or better than Tilt alone. Overall, our results show that Tilt will continue to be an essential component of the rust control program for Willamette Valley seed producers. Sulforix may contribute to stem rust control, but should not be considered as a replacement or substitute for Tilt.

Table 3. Stem rust infection in perennial ryegrass. Variety Regal. Steve Glaser Farm, Linn County, Oregon, 1994.

Treatments	Rust evaluation date			
	5/5	5/30	6/21	6/25
	-----------(% infected) --------			
1. CHECK	0	5	60	80
2. Sulforix (3x)	0	0	35	57
3. Sulforix/Sulf + Tilt 4 oz./Tilt 6 oz.	0	0	9	17
4. Sulf + Tilt 4 oz./ Sulf + Tilt 4 oz./ Tilt 6 oz.	0	0	2	4
5. Sulf/Tilt 4 oz./ Tilt 6 oz.	0	0	9	15
6. Tilt 4 oz./Tilt 4 oz./ Tilt 6 oz.	0	0	7	6
7. 0/Tilt 4 oz./ Tilt 6 oz.	0	0	22	35
8. Sulf/Sulf/Tilt 6 oz.	0	0	26	52
9. Tilt 4 oz./Tilt 4 oz./ Sulf + Tilt 6 oz.	0	0	8	7
LSD (0.05)	NS	NS	15	10
LSD (0.01)	NS	NS	20	14

Sulforix provides only contact disease control and is not systemic within the plant. It must be used in conjunction with other fungicides to effectively provide acceptable levels of disease control during the growing season. The inclusion of Sulforix in the rust control program may reduce the potential for the development of resistant strains of stem rust. Additional trial work is planned for the 1995 season.

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EFFECT OF FUNGICIDE APPLICATIONS ON SEED YIELDS OF FINE FESCUE

G.A. Gingrich, M.E. Mellbye and R.J. Burr

Fine fescue seed crops are grown on approximately 25,000 acres in the Willamette Valley. Historically fine fescue has not had serious disease problems as have many other grass species. However, since the late 1980's growers have reported an increase in the presence of various foliar diseases. Mildew, rust and other leaf and stem spots now regularly infect many fields. Fine fescue growers are making fungicide applications to some of their fields but little research data is available to confirm a consistent benefit for such treatments. This study was initiated to quantify the benefit of controlling rust on fine fescue seed yields. In addition the proper timing and number of applications that provide rust control and increase seed yields was evaluated. Rusts that have been identified on fine fescue plants include stem (*Puccinia graminis*), leaf (*P. coronata*) and Fine Fescue rust (*P. crandallii*).

Rust infections on spring seedings of fine fescue have also been increasing during the late summer period. Growers have become concerned that this summer developing rust may be contributing to increased rust pressure and seed losses the following year. In an effort to determine the impact of summer rust on subsequent level of spring rust infections a fall fungicide treatment was applied at two sites. The fields selected were all Chewings fescue with two located on spring seedings, no seed crop yet harvested, and two on established fields that had been in production for at least two years. The established fields had serious rust infections during the spring of 1993. The new seedings were severely infected with rust during the summer of establishment.

Tilt was the fungicide used to control rust at all sites. The initial Tilt application was made in early fall followed by from 1 to 3 additional applications in the spring. Each application consisted of Tilt at 6 oz/a plus the surfactant Agridex at 1 pt/a. Each trial was arranged in a complete randomized block design with either three or four replications. Fungicide applications were made with a tractor mounted boom sprayer. Water was used as the carrier at a rate of 20 GPA at 25 PSI, nozzles used were XR 8003 flat fan. Plot size was 23 ft X 200 ft. At harvest a 12 x 100 ft. swath was taken from the center of each plot to determine for seed yield. All field operations were done by the grower and his equipment was used to harvest the plot area. Seed was collected in plastic garbage cans during combining and yield per acre calculated (Tables 1, 2 and 3).

Table 1. Effect of Tilt on Seed Yield in an established Cascade Chewings Fescue field. Tony Silbernagel Farm, 1994.

Treatment (6 oz Tilt/ application)	Application dates Fall '93	Spring '94	Seed yield (Dirt wgt.)
			(lb/a)
1. Tilt 3x	--	4/20, 5/7, 5/27	508
2. Tilt 2x	--	4/20, 5/7	551
3. Tilt 1x	--	4/20	546
4. Check			437
LSD (0.05)			71

Table 2. Effect of Tilt on Seed Yield in a Shadow Chewings Fescue first year field. IOKA Farms, 1994.

Treatment (6 oz Tilt/ application)	Application dates Fall '93	Spring '94	Seed yield (Dirt wgt.)
			(lb/a)
1. Tilt 4x	10/22	4/28, 5/18, 6/9	1380
2. Tilt 3x	--	4/28, 5/18, 6/9	1310
3. Tilt 2x	--	4/28, 5/18	1398
4. Tilt 1x	--	5/18	1256
5. Check			1281
LSD (0.05)			95

Table 3. Effect of Tilt on Seed Yield in an established Shadow Chewings Fescue field. IOKA Farms, 1994.

Treatment (6 oz Tilt/ application)	Application dates Fall '93	Spring '94	Seed yield (Dirt wgt.)
			(lb/a)
1. Tilt 4x	10/22	4/28, 5/18, 6/9	688
2. Tilt 3x	--	4/28, 5/18, 6/9	719
3. Tilt 2x	--	4/28, 5/18	668
4. Check			557
LSD (0.05)			64

Four sites were initially established and treatments were to be the same at each location. However due to poor fall regrowth in one field, no rust infection at one location and an over-spray of one site changed the final treatment schedule as shown in the tables.

However on the three locations where rust was present we were able to get good rust control and seed yield comparisons. The first spring applications were made prior to rust pustule emergence or as soon thereafter as possible and at approximately 20% head emergence on the fine fescue. Tables 1, 2 and 3 show the application dates and yield comparisons for the three trials that were harvested.

At all sites rust caused significant yield reductions when compared to the best Tilt application sequence. There was no seed yield benefit from the fall treatments. The fall application did not appear to influence the amount of rust present the following spring. At none of the locations was there a significant seed yield advantage from making more than two Tilt applications in the spring. In most cases a single spring application at early head emergence provided adequate rust control and seed yield increases.

At each of the locations where rust was a problem significant seed yield increases were obtained by controlling the rust. Trial work conducted in previous years did not provide consistent and significant seed yield increases. This may have been due to the fungicide applications being made too late in the season. Based on the seed yield data obtained from these trials in 1994 we were able to significantly increase seed yield from one or two, properly timed, applications of Tilt when compared to the untreated check plots.

SEED YIELD OF FIVE GENOTYPES OF TALL FESCUE SUSCEPTIBLE OR RESISTANT TO STEM RUST

R.E. Welty and M.D. Azevedo

Stem rust susceptible (SRS) and stem rust resistant (SRR) genotypes of tall fescue were selected from a greenhouse/field study started in 1990 with 20 cultivars and 1,400 plants. The susceptible or resistant reaction of a genotype was based on two disease scores in the greenhouse and two disease scores in the field in 1990, a year when stem rust was severe and susceptible cultivars were scored as high as 91% using the Modified Cobb scale of scoring. (See: Welty, R.E. and R.E. Barker. 1993. Reaction of twenty cultivars of tall fescue to stem rust in controlled and field environments. Crop Sci. 33:963-967.)

In August, 1990, ramets (tillers) were removed from SRS and SRR genotypes from each of five cultivars, three forage and two turf-type, and grown about 5 wks in a greenhouse and transplanted into field plots on 1 October 1990. Paired ramets for each SRS or SRR genotype were planted side-by-side within each plot; each plot contained 20 plants (5 SRS and 5 SRR genotypes x 2). Twelve plots were established in the study and were divided into six replications of two plots each. The experiment contained 240 plants.

In each of four years, one plot in each replication was treated with propiconazole (Tilt) at the 4 oz/acre rate; the other plot served as the nontreated control. Fungicide treatments in each replication was assigned at random each year. Tilt was applied to provide thorough coverage in early spring before stem rust developed and continued at 14-21 day intervals until flowering. In some years, weather delayed applications beyond 21 days and traces of stem rust developed in some Tilt- treated SRS genotypes.

When seeds matured (about 44% moisture content), 100 panicles were harvested from each plant and seed were cleaned. Seed weight, seed per tiller, and thousand seed weight were determined for each plant. For this report, only the seed weight (grams) per 100 tillers is provided.

Results

Seed yield. Seed weights for Tilt treated v. nontreated controls among the five SRS genotypes in 1991 and 1993 (Figure 1) were not statistically different (P = 0.05). However, seed yields from the Tilt treated v. nontreated plants among SRS genotypes in Arid, Forager and Kentucky 31 were significantly larger in 1992 (P = 0.001) and significantly larger for Arid and Kentucky 31 (P = 0.001) and Shortstop (P = 0.01) in 1994. Seed weights for the SRS genotype of Rebel II treated v. nontreated was not statistically different (P = 0.05) in any year. The response of this genotype to stem rust (as cited earlier, Welty and Barker, 1993) was reconfirmed as susceptible by review of field notes. As 5- and 10-wk-old seedlings, the infection type score of this genotype was 4 (on a scale of 0-4, with 0 being immune and 4 highly susceptible). In field plots, the Modified Cobb scale stem rust score of this genotype was 100% on 23 July 1990, 40% on 11 July 1991 (a light stem rust year), and 100% on 29 May 1992 (a severe stem rust year). Obviously, more research is needed to explain why a plant consistently scored susceptible to stem rust in greenhouse and field conditions does not respond to fungicide control of stem rust with a seed yield response.

Seed yield among the Tilt treated SRR genotypes were not significantly different (P = 0.05) from nontreated controls in any of the four years of testing (Figure 2). When seed yield differences are compared between fungicide treatments within a SRR genotype, 10 instances occurred where each treatment was higher than the other, indicating the yield responses to be a chance occurrence.

Seed yield comparisons between SRS v. SRR genotypes, or the interaction between genotype and fungicide treatment are illegitimate comparisons because seed yield data are confounded by an unknown genotype interaction.

Stem rust. During the study, stem rust developed in each of the SRS genotypes each year. A mean stem rust score for the head, culm, and flag leaf of 10 tillers of each genotype of Arid, Forager, Kentucky 31, Rebel II and Shortstop was 78, 58, 66, 6 and 29%, respectively, in 1991; 100, 70, 100, 38, and 37%, respectively, in 1992; 87, 33, 87, 6, and 43%, respectively, in 1993; and 97, 23, 100, 1, and 69%, respectively, in 1994.

The study provides more questions to be answered. Additional research is needed to explain how stem rust and stem rust yields are affected by each of the four independent factors that "drive" an epidemic, namely the host, pathogen, environment, and time. The interaction of these four factors is complex and more study is needed to understand how they fit together to influence seed yields. More data are needed also in order to develop models that successfully predict stem rust occurrence and its rate of development.

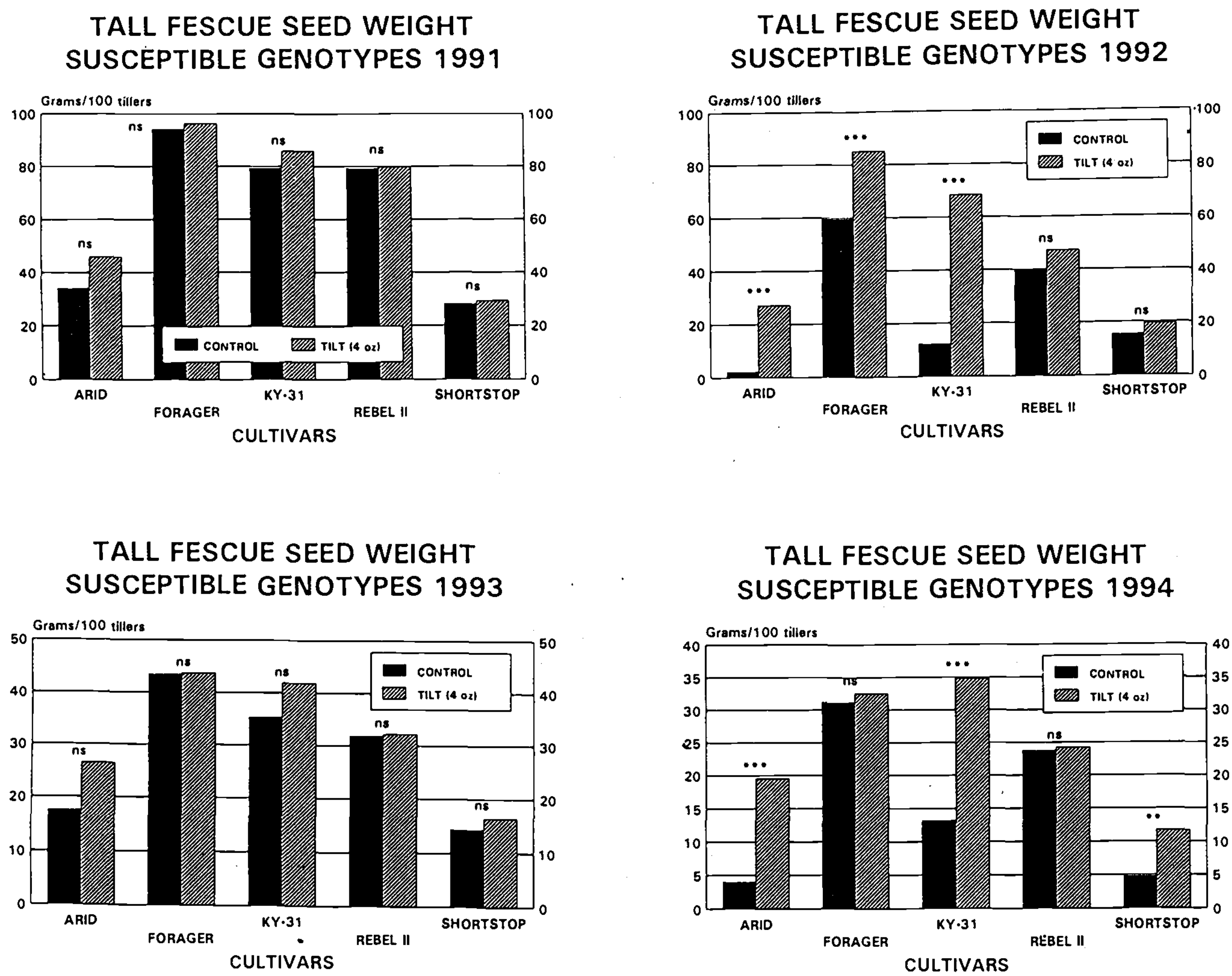

Figure 1. Seed yield (grams per 100 tillers) of five stem rust susceptible genotypes of tall fescue treated with 4 oz./acre of Tilt versus nontreated controls in 1991-1994.

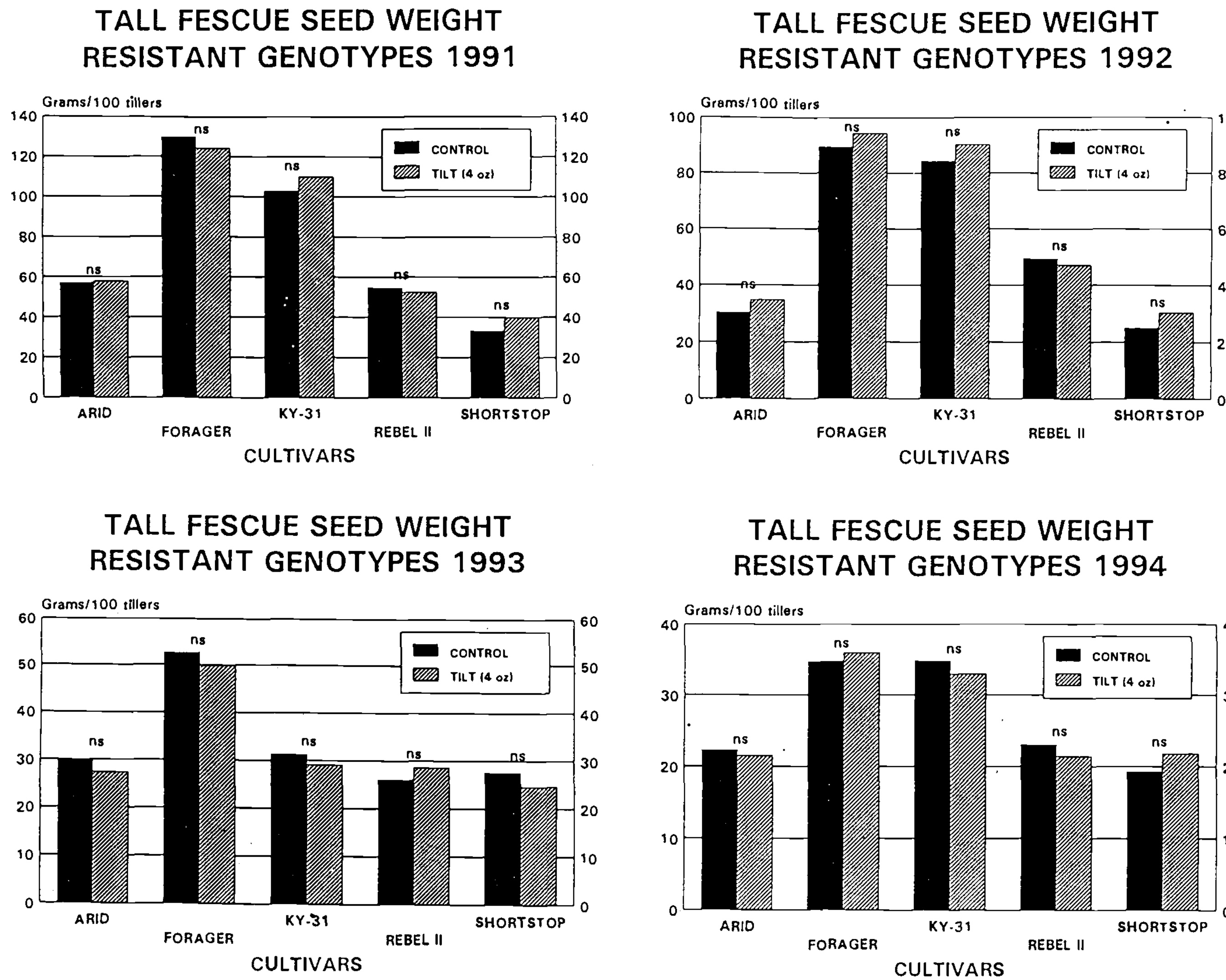

Figure 2. Seed yield (grams per 100 tillers) of five stem rust resistant genotypes of tall fescue treated with 4 oz./acre of Tilt versus nontreated controls in 1991-1994.

FUNGICIDE EVALUATIONS FOR POWDERY MILDEW CONTROL ON KENTUCKY BLUEGRASS, 1994

M. D. Butler

Powdery mildew is an important disease on Kentucky bluegrass seed grown in central Oregon. The diseases is weather dependent, but usually appears during April and May. Materials commonly used are Bayleton and Tilt, with Bayleton generally being the product of choice. The objective of this research was to evaluate Orthorix (calcium polysulfide) applied alone and in combination with Tilt, and a new material, Folicur, against the industry standards, Bayleton and Tilt.

Fungicides were evaluated for powdery mildew control in Kentucky bluegrass seed fields near Madras (cv. Rugby) and Culver, Oregon (cv. Gnome). Fungicides were applied with 8002 TwinJet nozzles on a 9 ft CO_2 pressurized boom sprayer at 40 psi and 20 gal of water/acre to 10 ft x 20 ft plots replicated three (cv. Rugby) or four (cv. Gnome) times in a randomized complete block design. Treatments were initiated on May 2 and were completed on June 11, with biweekly application of Orthorix and three weeks between application of Bayleton, Tilt and Folicur. Application rates were Tilt, Folicur and Bayleton at 4 oz/a and Orthorix at 64 oz/a. Silwet-77 surfactant was applied at 8 oz/100 gals and R-56 at 1 pt/100 gals in combination with non-Orthorix treatments. There were a maximum of 4 Orthorix applications, three applications of the other fungicides, and various combinations thereof. Fields were evaluated for severity of disease by rating 20 observations per plot on a scale from 0 (none) to 5 (throughout) on May 7 and 8.

Tilt, Bayleton, and the combination of the two provided significant protection from powdery mildew compared to the non-treated control plots. Folicur and Orthorix treatments provided significant control on the Gnome field, but not on the Rugby field where incidence of the disease was higher. Orthorix alone did not significantly reduce powdery mildew when compared to the untreated plots, however the trend showed reduced incidence of the disease at both locations. From informal observation, the Orthorix appears to provide better control when plants are small and good coverage can be achieved, with severity of the disease increasing as penetration of the material becomes more difficult.

Table 1. Results of fungicide treatments for powdery mildew on Kentucky bluegrass grown for seed near Madras (cv. Rugby) and Culver, Oregon (cv. Gnome) 1994.

	Disease Rating[1]	
Fungicide Treatments	Rugby	Gnome
Orthorix, Orthorix, Orthorix, Orthorix	1.1 ab[2]	0.6 ab
Orthorix, Orthorix, Orthorix, Tilt 3.6E	1.4 ab	0.2 a
Orthorix, Orthorix + Tilt 3.6E, Tilt 3.6E	0.2 ab	0.1 a
Orthorix, Tilt 3.6E, Tilt 3.6E	0.1 ab	0 a
Tilt 3.6E, Tilt 3.6E, Tilt 3.6E	0 a	0 a
Folicur 3.6F, Folicur 3.6F, Folicur 3.6F	0.6 ab	0 a
Bayleton 50%DF, Bayleton 50% DF, Bayleton 50% DF	0 a	0 a
Bayleton 50% DF + Tilt 3.6E, Bayleton 50% DF + Tilt 3.6E, Bayleton 50% DF + Tilt 3.6E	0 a	0 a
Untreated	1.8 b	1.1 b

[1] Rating scale from 0 to 5, 0=none, 1=isolated spots, 2=light, 3=moderate, 4=heavy, 5=throughout
[2] Mean separation with T-method at $P \leq 0.05$

OCCURRENCE AND SEVERITY OF ERGOT AMONG CULTIVARS OF KENTUCKY BLUEGRASS GROWN FOR SEED IN EASTERN OREGON

S.C. Alderman and D.D. Coats

The occurrence and severity of ergot among fields of Kentucky bluegrass grown for seed in eastern Oregon was evaluated in 1991-1993. A Combine-run (precleaned) sample was obtained from fields of Abbey, Baron, Chateau, Coventry, Merit, and Victa. All subsamples were obtained with a riffle divider to provide a random selection of material. Seed was cleaned on a air column adjusted to remove lightweight materials but retain seed and ergot sclerotia. Straw pieces were removed with hand screens to provide standardized clean samples for comparisons. Ergot assessment was based on a random subsample of 10 grams from each field. A single sample was used for comparison because preliminary studies indicated variation among subsamples was not significantly different. Ergot sclerotia from each sample were identified and removed under 5X magnification and counted.

The occurrence of ergot among cultivars of Kentucky bluegrass was variable among years and among cultivars within years (Table 1). Presence of ergot among fields and ergot sclerotia/gram seed within fields of Abbey, Baron, Merit, and Victa were consistently lower than in Chateau or Coventry (Table 2). This suggests a greater susceptibility of Chateau and Coventry to ergot. This was especially apparent in the upper range of ergot as high as 92.4 sclerotia/gram seed for Chateau in 1991 and 50.8 for Coventry in 1993. The lowest range of ergot values were found in Abbey and Victa.

Table 1. Fields with ergot/fields examined among Kentucky bluegrass cultivars in 1991-1993 in eastern Oregon. Evaluations were based on the presence of ergot in a combine-run sample from each field.

Cultivar	1991	1992	1993
Abbey	6/16	1/10	9/18
Baron	14/21	6/17	15/16
Chateau	8/8	3/3	1/1
Coventry	3/3	2/5	4/4
Merit	0/3	4/7	8/10
Victa	4/6	2/4	3/4

In surveying ergot among fields of Kentucky bluegrass, ergot can be expressed as incidence (fields with ergot/total fields) (Table 1) or as severity (sclerotia/gram of seed) within a field. Severity values can be calculated from only fields with ergot (Table 2) or include infected and noninfected fields (Table 3). Mean values as presented in Table 1 and 2 will vary, depending on the number of fields infected. In Table 2, the range of infection and mean level infection occurring in infected fields is expressed. In Table 3, which incorporates information from table one and two, the general impact of ergot within each cultivar is expressed. Table 3 presents a convenient means of assessing the general impact of ergot among cultivars within a region.

Table 2. Severity of ergot (ergot per gram of seed) among various cultivars of Kentucky bluegrass. Means and standard deviations based on fields with ergot.

	1991		1992		1993	
Cultivar	range	mean±s.d.	range	mean±s.d.	range	mean±s.d.
Abbey	0.1-0.8	0.35±0.29	0.12*	0.20	0.1-1.2	0.44±0.42
Baron	0.1-9.9	1.89±3.04	0.1-8.8	3.05±3.52	0.1-11.0	1.43±2.72
Chateau	3.2-92.4	24.0±28.7	1.0-13.5	4.63±6.04	2.5**	2.50*
Coventry	6.0-32.9	18.1±13.7	1.2-5.0	3.30±2.97	0.3-50.8	13.3±25.0
Merit	0.0-0.0	0±0	0.1-0.2	1.25±0.05	0.1-2.1	0.46±0.68
Victa	0.1-0.7	0.38±0.25	0.2-0.6	0.39±0.33	0.4-0.6	0.47±0.12

*only one field with ergot
**only one field

Table 3. Severity of ergot (ergot per gram of seed) among various cultivars of Kentucky bluegrass. Means and standard deviations based on fields with and without ergot.

Cultivar	1991	1992	1993
Abbey	0.13±0.24	0.01±0.04	0.22±0.37
Baron	1.26±2.17	1.08±2.48	1.34±2.66
Chateau	24.0±28.7	4.63±6.04	2.5*
Coventry	18.1±13.7	1.23±2.17	13.3±25.0
Merit	0±0	0.07±0.08	0.38±0.63
Victa	0.25±0.27	0.20±0.30	0.35±2.25

*only one field

Ergot infection during 1991-1993 in Abbey, Baron, Merit and Victa were stable at a low level of ergot (Table 3). Ergot severity among Chateau and Coventry varied greatly among years but were generally infected to a much greater extent than the other cultivars. This indicates that yearly variation in ergot within a region may occur from variation in a proportionally small number of fields. In years when ergot is high in these fields, the severity value expressed for a region may be biased upward and not fairly represent the overall impact of ergot within the region. This study suggests that survey data for ergot should be expressed for individual cultivars rather than as a single value averaged over all cultivars.

Acknowledgment: We acknowledge the generous support of Blue Mountain Seed Co. in providing seed samples for this study.

DEVELOPMENT OF CONTROL PROGRAM FOR *CLAVICEPS PURPUREA* IN KENTUCKY BLUEGRASS SEED PRODUCTION

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

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

Fungicide evaluations in central Oregon during the 1992-93 seasons indicated excellent ergot control with Punch, while Tilt and Folicur provided moderate to good control. Tilt is currently registered for powdery mildew and rust control on grass seed crops. Registration of Punch in the United States is not being pursued, and Folicur has been under evaluation at EPA for several years.

During the 1994 season fungicides were evaluated for control of ergot in a Kentucky bluegrass seed field (cv. Coventry) at Trail Crossing near Culver, Oregon. A second field of Coventry located at the Central Oregon Agricultural Research Center (Powell Butte site) was infested with ergot at 1 sclerotia/ft^2 on January 28, 1994. Fusilazole (Punch, Dupont), propiconazole (Tilt, Ciba), tebuconazole (Folicur, Miles) and Orthorix (Best Sulfur Products) were evaluated during the 1994 season, with an emphasis on Tilt since it is currently registered for grass seed. Surfactants Silwet-77 and Penaturf were evaluated as the second of two applications following Tilt. Orthorix and chlorine were included in the trial as multiple applications, with chlorine applied weekly to simulate application during irrigation.

Materials were applied to 10 ft x 20 ft plots replicated four times in a randomized complete block design with 8003 TwinJet nozzles on a 9 foot CO_2 pressurized boom sprayer at 40 psi and 30 gals of water/a. Silwet-77 at 8 oz/100 gals and R-56 at 1 pt/100 gals were applied in combination with all fungicides except Orthorix and chlorine.

Table 1. Evaluation of fungicides applied for ergot control to Kentucky bluegrass (cv. Coventry) in the Trail Crossing area of central Oregon on May 30 and June 10, 1994.

Fungicide Treatments	Rate May 30	Rate June 10	Panicles with sclerotia	Total sclerotia per sample	Weight per sample	1000 seed weight
	(fl oz/a)		(%)	(no.)	(g)	(mg)
Punch 25E	28		0.3	0.3	5.61	0.34
Tilt 3.6E	4[1]		0.3	0.3	5.57	0.35
Tilt 3.6E + Tilt 3.6E	4[1]	4[1]	1.3	2.5	6.20	0.35
Tilt 3.6E	4		1.0	1.5	5.48	0.34
Tilt 3.6E	4[2]		1.5	4.5	5.40	0.33
Tilt 3.6E + Tilt 3.6E	4	4	0.3	0.5	5.84	0.34
Tilt 3.6E + Orthorix	4	64	0.3	0.3	5.68	0.33
Tilt 3.6E + Silwet-77	4	8[3]	1.0	1.3	6.03	0.35
Tilt 3.6E + Penaturf	4	42	1.3	2.0	5.24	0.36
Tilt 3.6E	8		0.5	1.0	5.34	0.36
Tilt 3.6E + Tilt 3.6E	8	8	0	0	5.63	0.33
Folicur 3.6F	4		0.5	0.8	6.38	0.35
Folicur 3.6F	8		3.0	9.0	5.45	0.34
Orthorix	64		1.0	1.8	4.92	0.35
Chlorine (applied weekly)	4[4]		4.0	9.5	5.15	0.35
Untreated			1.5	4.5	5.80	0.35
			n.s.	n.s.	n.s.	n.s.

[1] Aerial application
[2] Application with Penaturf at 42 fl oz rather than standard surfactants
[3] Silwet-77 applied at 8 oz per 100 gals
[4] Applied weekly from May 30 to June 17
Mean separation with T-method at $P \leq 0.05$

Table 2. Evaluation of fungicides applied for ergot control to Kentucky bluegrass (cv. Coventry) at the COARC Powell Butte site in central Oregon on May 31 and June 10, 1994.

Fungicide Treatments	Rate May 31	Rate June 10	Panicles with sclerotia	Total sclerotia per sample	Weight per sample	1000 seed weight
	(fl oz/a)		(%)	(no.)	(g)	(mg)
Punch 25E	28		53 c	148 d	1.80	0.38
Tilt 3.6E	4[1]		88 ab	665 abc	1.65	0.40
Tilt 3.6E	4		90 a	800 ab	1.67	0.39
Tilt 3.6E	4[2]		76 ab	348 bcd	1.53	0.38
Tilt 3.6E + Tilt 3.6E	4	4	87 ab	412 abcd	1.83	0.38
Tilt 3.6E + Orthorix	4	64	80 ab	596 abcd	1.90	0.41
Tilt 3.6E + Silwet-77	4	8[3]	88 ab	655 abc	1.86	0.40
Tilt 3.6E + Penaturf	4	42	89 ab	595 abcd	1.64	0.38
Tilt 3.6E	8		74 abc	381 abcd	2.03	0.38
Tilt 3.6E + Tilt 3.6E	8	8	66 bc	250 cd	2.06	0.38
Folicur 3.6F	4		80 ab	628 abcd	1.59	0.39
Folicur 3.6F	8		87 ab	584 abcd	1.81	0.39
Orthorix	64		88 ab	633 abcd	1.78	0.39
Chlorine (applied weekly)	4[4]		92 a	813 ab	1.54	0.40
Untreated			92 a	858 a	1.59	0.38
					n.s.	n.s.

[1] Application at 20 gals/a with TeeJet nozzles rather than 30 gals/a with TwinJet nozzles
[2] Application with Penaturf at 42 fl oz rather than standard surfactants
[3] Silwet-77 applied at 8 oz per 100 gals
[4] Applied weekly from May 30 to June 17
Mean separation with T-method at $P \leq 0.05$

Treatments were applied at the Trail Crossing location on May 30 and June 10 and at the Powell Butte site on May 31 and June 10, with the exception of weekly applications of chlorine. The first treatments were applied at the initiation of anthesis at the Trail Crossing location and mid anthesis at the Powell Butte site.

One hundred panicles were collected from each plot on June 30 at the Trail Crossing location and July 6 at the Powell Butte site. Number of panicles with sclerotia, and total sclerotia per sample were determined for each plot. Seed weight per sample and weight per 1,000 seed was determined following standard separation procedures.

Incidence of ergot at the Powell Butte site was extremely high, with the infection level at Trail Crossing location relatively low. At the Trail Crossing location, there were no significant differences between treatments (Table 1) when comparing either panicles with sclerotia or sclerotia per sample. Comparison of the total number of sclerotia per sample at the Powell Butte site (Table 2) indicates a single application of Punch providing the most effective control of ergot. A single Punch application or a double application of Tilt at 8 oz/a statistically out performed a single application of Tilt at 4 oz/a with standard surfactants, chlorine treatments, and the nontreated plots. Orthorix provided similar control to a single application of Tilt at 4 oz/a.

Seed weight per sample or weight per 1,000 seed were not significantly different at either location, but seed weight per sample was substantially lower at Powell Butte due to the severe level of ergot infection, and possibly cultural practices during the growing season.

ROUGHSTALK BLUEGRASS CONTROL IN KENTUCKY BLUEGRASS, 1993-1994

M. D. Butler

Central Oregon has historically been a Kentucky bluegrass seed production area, but production of roughstalk bluegrass (*Poa trivialis*) increased to 3,800 acres in 1994, comprising over 30 percent of grass seed production in the area. Contamination of Kentucky bluegrass seed with roughstalk bluegrass is an increasing problem for the central Oregon grass seed industry. Herbicide trials were conducted during the 1993-1994 season to determine methods of controlling roughstalk bluegrass in Kentucky bluegrass fields.

Two sets of plots were placed in roughstalk bluegrass fields (cv. Colt and Laser) to determine herbicide efficacy, and in two sets on Kentucky bluegrass fields (cv. Merit) to evaluated crop safety.

Eight herbicides were fall-applied in a grid pattern on October 16, 1993 to 10 ft x 10 ft plots with a CO_2 pressurized boom sprayer at 40 psi and 20 gal/a of water. Application rates were Horizon at 1½ pts, Assert at 1½ pts, Goal at 10 and 20 oz, Diuron at 1 and 2 lb, and Lexone at 2⅔ and 5⅓ oz per acre. Horizon and Assert were spring applied to untreated plots on March 24. There was no precipitation following fall application of materials; however, the Laser site was sprinkle irrigated from a water tank three weeks after application. Evaluations were made on February 16, April 15, and June 3, 1994. Crop injury and volunteer control were determine by rating biomass reduction, not reduction in plant population.

The February evaluation of crop injury to Kentucky bluegrass was highest for Horizon at 75 percent, lowest for Assert at 6 percent, with other materials and combinations in the 8 to 20 percent range. The Diuron-Lexone, Goal-Lexone, and Lexone-Lexone combinations produced 15-20 percent injury. Spring application of Assert and Horizon produced 5 percent and 15 percent injury, respectively.

The percent control of roughstalk bluegrass at the Colt site was 100 percent for Goal and Diuron applied alone. Goal provided 30 percent control at 20 oz and 60 percent control at 30 oz, while Diuron at 2 lb provided 80 percent control. Fall application of Assert provided good control of roughstalk bluegrass. Spring applied Assert caused 60 percent injury to roughstalk bluegrass, while Horizon resulted in a 20 percent injury. The poor performance of Goal is not unexpected since there was no precipitation following application. The high level of control at the Colt site is thought to be the result of crop stress, while the Laser location did not show any result of the fall herbicide applications.

Later evaluation of volunteer control in Kentucky bluegrass indicated 88 percent control for Horizon, which also continued to produced the greatest crop injury. Assert, Lexone-Lexone, Lexone-Diuron, and Diuron-Diuron provided 75 percent control, Goal combinations were in the 60 to 65 percent range, and Goal, Diuron, and Lexone alone provided 50 to 55 percent control. There was a pattern of slight stunting where Lexone had been applied, but this disappeared later in the spring.

Seed set on Kentucky bluegrass was significantly reduced by the fall application of Horizon. Lexone also appears to reduce seed set, although to a lesser degree.

Table 1. Effect of fall-applied herbicides at the two Kentucky bluegrass (cv. Merit) locations and one roughstalk (cv. Colt) location. There were no observable effects from herbicide treatments at the other roughstalk (cv. Laser) location.

	Kentucky bluegrass		Roughstalk bluegrass
Treatment and rate of product/a	Crop Injury[1]	Volunteer Control	Crop Control
	(%)		
Assert 1½ pts	6	68	100
Horizon 1EC 1½ pts	75	88	95
Goal 1.6E 20 oz	8	55	30
Goal 1.6E 30 oz	10	60	60
Diuron DF 80 2 lbs	7	50	80
Diuron DF 80 3 lbs	10	70	100
Lexone DF 5-1/3 oz	10	50	100
Lexone DF 8 oz	20	70	100
Goal 1.6E 20 oz + Diuron DF 80 1 lb	12	65	100
Goal 1.6E 10 oz + Diuron DF 80 2 lbs	10	65	100
Goal 1.6E 20 oz + Lexone DF 2⅔ oz	12	65	100
Goal 1.6E 10 oz + Lexone DF 5⅓ oz	15	65	100
Diuron DF 80 2 lbs + Lexone DF 2⅔ oz	15	70	100
Diuron DF 80 1 lb + Lexone DF 5⅓ oz	17	65	100

[1] Crop injury and volunteer control were evaluated as biomass reduction

WEED SUPPRESSION WITH FALL-PLANTED CEREALS IN THE ESTABLISHMENT YEAR OF PERENNIAL RYEGRASS

R.D. William and R.E. Peachey

Introduction

Weed control options are changing for many Willamette Valley crops. One strategy with potential to manage weed populations is use of non-crop vegetation for weed suppression. Cereals such as spring barley establish very quickly in the fall with the potential of winter kill, thus modifying seed bed ecology through changes in both light quality and quantity, reduced soil temperature, and possible allelopathic effects on weed seed germination and growth.

This project focused on interplanted barley as a tool to reduce weed biomass in perennial ryegrass through competition, the physical mulch, or toxin release with selective removal of the barley with fenoxaprop to optimize weed suppression and minimize competition with the perennial ryegrass. Side benefits to this approach include reduced soil erosion, improved water infiltration, and nutrient recycling. Project objectives included: 1) evaluate weed suppression during establishment of perennial ryegrass seed crops using specific cereal cultivars and management practices that reduce or minimize competition and crop loss from small-seeded, annual weeds, including grasses and the cereal itself; 2) evaluate the effect of barley interplanting on perennial ryegrass growth; and 3) determine the optimum growth stage at which to kill barley to maximize weed suppression and minimize interference with perennial ryegrass seedling establishment and seed yield.

Methods

Spring barley seed (cvs. *Micah* and *Steptoe*; 45 seeds/sq ft) and fertilizer (30 lbs N, 20 lb P/acre) was broadcast on 30 X 12 ft plots and incorporated into the soil at last tillage on October 10, 1993 at the Hyslop Research Farm. Immediately following, perennial ryegrass (cv. *Citation II*) was drilled into the plots in 12 inch rows at 12 lbs acre. Annual ryegrass, California brome, and Roughstalk bluegrass were seeded in strips perpendicular to the main plots and incorporated at last tillage. However, only the Annual ryegrass emerged. Annual bluegrass was indigenous to the research area.

Treatments were based on timing and method of selectively removing the cereal. Fenoxaprop was applied on November 18, January 19, and March 1 to selectively remove the barley in Trs. 1, 2, and 3 respectively (See Table 1). Perennial ryegrass growth stages were 2.7, 4.8 and 6.0 respectively on the dates listed above (Haun system adapted for perennial grasses; Chastain, pers.comm). Fenoxaprop was applied at 0.2 lb ai/acre to Tr. 1, but the rate was increased to 0.25 lb ai/acre for Trs. 2 and 3 because of inadequate kill of the barley.

Table 1. Effect of cereal interplanting on weed biomass in perennial ryegrass, Hyslop Farm, 1994.

Treatment	Annual bluegrass	Broadleaf weeds[1]	Perennial ryegrass biomass
	-----(g/0.4m²)-----		(t/acre)
1. Micah barley + fenoxaprop (11/19/93)	26 bcde[2]	193 a	1.5 ab
2. Micah barley + fenoxaprop (1/19/94)	15 de	132 abc	0.8 cd
3. Micah barley + fenoxaprop (3/1/94)	31 bcde	129 abc	0.7 d
4. Steptoe barley Sublethal fenoxaprop (1/19/94 Glyphosate (3/10/94)	8 e	43 c	0.6 d
5. Steptoe barley Glyphosate wick wipe (2/2/94)	37 bcde	109 abc	1.4 abc
6. Steptoe barley + fenoxaprop (1/19/94)	16 de	61 bc	0.7 d
7. No cereal + fenoxaprop (11/19/93)	71 abcd	211 a	1.8 ab
8. No cereal + fenoxaprop (1/19/94)	85 abc	217 a	1.5 ab
9. No cereal + fenoxaprop (3/1/94)	108 a	143 ab	1.8 ab
10. No cereal Sublethal fenoxaprop (1/19/94) Glyphosate (3/10/94)	36 bcde	144 ab	1.9 ab
11. No weed control measures	85 ab	118 abc	1.9 a
12. Carbon planted (No cereal) Diuron (10/10/93) Norton (12/3/93 and 1/19/940	0 e	71 abc	1.8 ab

[1]Significant species monitored at this location included speedwell (*Veronica spp.)*, shepherdspurse (*Capsella bursa-pastoris)*, Common chickweed (*Stellaria media)*, Western bittercress (*Cardamine oligosperma)*, Cutleaf geranium *(Geranium dissectum)*, Mayweed chamomile *(Anthemis cotula)*, and Red dead nettle (*Lamium purpureum)*.

[2]Means followed by the same letter are not statistically different (p=.05).

Fenoxaprop was applied at 0.15 lb ai/acre to Tr. 4 to suppress the barley but allow continued soil coverage through the winter. The barley was later killed with a glyphosate wick wipe on March 10. The cereal in Tr. 5 was killed with glyphosate applied February 2 by a 10 foot wide wick applicator set to contact the barley but not the ryegrass. The plan specified that this application be made at the same time as Tr. 2, but because of weather that kept the plants very wet, glyphosate was applied on February 2.

Each of the treatments listed above was complimented by a control treatment of the exact schedule except that barley was not interplanted with the ryegrass. Other controls treatments included Tr. 11 with no weed control measures, and Tr. 12 with diuron/activated charcoal applied at planting plus ethofumesate applied December 12 and January 19.

Urea (40 lb N/acre) was applied to the entire experiment on March 9; on March 19, half of each plot was treated with Buctril and MCPA.

Weed biomass was cut from a 4 ft. sq. area that encompassed two rows, and weeds were separated by species and weighed. Visual estimation of percent reduction in ryegrass was made along with the effect of the cereal on annual ryegrass. Perennial ryegrass was cut from 4 ft sq on July 8 and weighed to assess impact on ryegrass growth.

Weed biomass data were log transformed to improve homogeneity of variance among treatments. Means were separated using Fishers protected LSD with an alpha value of 0.05.

Results and discussion

Rain immediately after planting gave the barley a good start and it reached 6 inches in height by November 19, the first application date for fenoxaprop. By mid January, winter conditions were causing mortality of the *Micah* barley but *Steptoe* barley was not impacted.

The first application of fenoxaprop appeared to act very slowly because of the cool conditions and the low rate applied. Subsequent applications were increased to O.25 lbs/acre, but even at this rate barley kill was marginal, particularly as the barley grew taller than 12 inches. Fenoxaprop applied on January 19 proved best at killing the barley although *Micah* barley was easier to kill than *Steptoe* barley.

Total weed biomass was significantly reduced by interplanting barley (Table 1). Weed biomass in plots with barley suppressed with fenoxaprop and later killed with glyphosate (Tr. 4) was equal to weed biomass in the diuron/ethofumesate plots (Tr. 12). This same treatment reduced weed biomass by 78 percent compared to the unweeded control (Tr. 11). However, some of the reduction in Tr. 4 may have been due to actual glyphosate contact with the weeds. Interplanted *Micah* barley with fenoxaprop for selective kill (Trs. 1, 2, and 3) tended to reduce total weed biomass compared to the unweeded control but the differences were statistically insignificant. In contrast, *Steptoe* barley killed with fenoxaprop in January reduced total weed biomass to a level comparable to the diuron/ethofumesate control (Tr. 12). In similar treatments, *Steptoe* barley was more effective at reducing total weed biomass than *Micah* barley, probably because *Steptoe* has a more prostate growth habit in early growth stages and did not show signs of winter kill early in December and early January.

Broadleaves. The trend for total broadleaf weeds was nearly the same as for total weed biomass. However, of the weeds found and collected at this location, treatment differences in biomass within species were statistically significant only for western bittercress because of the distribution variability among broadleaf weeds at this site. And for Western bittercress, interplanting barley actually tended to increase bittercress biomass (data not shown), a possible response to decreased ryegrass competition. This trend was reversed with *Steptoe* barley, however. Overall, broadleaf weed biomass in the interplanted treatments was similar to that in both the unweeded and diuron control. The glyphosate wick wipe (Tr. 4) and *Steptoe* with fenoxaprop in January slightly reduced weed broadleaf biomass compared to both control treatments, although statistically the difference was insignificant.

Grasses. The trend for Annual bluegrass was much different than broadleaf weeds. On average Annual bluegrass biomass was reduced by 77 percent when comparing the *Micah* barley treatments with all treatments without barley interplanting (*Single degree of freedom contrast of Micah barley treatments (1,2,3) vs all treatments without cereals (7,8,9,11)).* The greatest biomass reduction was noted in Tr. 4 (*Steptoe* barley suppressed by fenoxaprop and later killed with Roundup). Annual bluegrass was suppressed by 90 percent compared to the unweeded control, but some of this reduction may have been due to actual contact with glyphosate. Similar to this level of reduction was the two treatments with *Micah* and *Steptoe* barley interplanted and killed with fenoxaprop in January. These treatments suppressed annual bluegrass by 82 percent. Annual bluegrass biomass in Tr. 8 indicates that this suppression was due to direct interference of the interplanted barley rather than fenoxaprop effects.

Treatment differences were not significant for volunteer perennial ryegrass emerging between rows. However, trends in percent reduction were similar to those with annual bluegrass. Annual ryegrass control was best in the glyphosate wick-wipe treatment, and biomass reduction also was noted in the interplanted barley plots.

Perennial ryegrass performance. In general, perennial ryegrass biomass was reduced by the interplanted cereals. In the wick-wipe treatments damage may have been due to the glyphosate itself. Treatment 1 had the least impact on perennial ryegrass growth. Fenoxaprop may have injured perennial ryegrass when applied in January, accounting for some of the poor performance in Tr. 2 with the cereal interplant and Tr. 8 without. On average, cereal interplanting reduced perennial ryegrass growth by 44 percent.

Summary

Annual bluegrass was suppressed an average of 77 percent. Suppression of Annual ryegrass was less than for annual bluegrass, and was likely due to the fenoxaprop application. Suppression of volunteer perennial ryegrass between rows indicates the potential effect of barley on perennial ryegrass when in direct competition with barley. Barley was difficult to kill with fenoxaprop after it grew taller than 12 inches. But killing the barley in November actually increased broadleaf growth compared to the control treatment, even though there was still a significant reduction in annual bluegrass biomass. Barley control was also difficult in this situation because some barley seed had not yet germinated. Barley was killed best when fenoxaprop was applied in January. Perennial ryegrass growth also was reduced, although much less than annual bluegrass. Some of the injury to the perennial ryegrass may have been due to fenoxaprop as indicated by the trend toward lower biomass accumulation in Tr 8. However, the January 19 treatment with fenoxaprop and *Steptoe* or *Micah* barley interplanting was one the best treatments when considering removal of the barley, the affect on ryegrass, and suppression of annual bluegrass biomass accumulation. Though annual bluegrass and total weed biomass suppression was significant with some of the interplanted barley treatments, the impact on perennial ryegrass was unacceptable. Techniques which reduce competition with the perennial ryegrass must be explored such as fertilizer banding beneath the ryegrass row and drilling cereals between ryegrass rows rather than broadcasting.

BIOLOGICAL CONTROL OF WEEDS USING DELETERIOUS RHIZOBACTERIA

W.R. Horwath, L.F. Elliott and G.W. Mueller-Warrant

We have identified non-specific inhibitors of *Poa annua* and perennial ryegrass in order to obtain a broad spectrum biological control potential. Investigations with perennial ryegrass are intended to address the problem of volunteers in certified grass seed production fields. The bacterial isolates were tested against a diverse genetic source of *Poa annua* and 'Derby' perennial ryegrass provided by a local seed company and USDA Seed Laboratory.

Laboratory Studies

Efforts have focused on isolating a significant number of bacteria capable of inhibiting *Poa annua* and perennial ryegrass seedlings. A wide spectrum of sites have been sampled from within several different crop and non-crop fields as well as both conventional and organic farming systems. Successful isolates exhibit 70-75% root inhibition and are bioassayed twice to confirm efficacy. Sample sites yielding particularly high numbers of isolates are currently being evaluated for similarities. These isolates and 9 previously isolated organisms are currently being prepared for growth chamber studies to evaluate their potential as *Poa nnua* biocontrol agents for field work.

Field Studies

A field trial was established in December 1993 at the Hyslop field station to evaluate the inhibition potential of 3 bacterial isolates. Plots measuring 6.4 m^2 were arranged in a randomized complete block design with four replications. The trial site has been maintained without herbicides for two years. Initial treatments were applied December 10, 1993, with additional treatments applied January 20 and March 7, 1994. The applications include spraying over previous inoculations as well as untreated areas to examine the effect of inoculum potential and temporal aspects of isolate efficacy.

Plots were monitored for *Poa annua* growth through the spring of 1994. Isolates A17 and A21 reduced *Poa annua* growth significantly by 20 to 25 percent following the first two applications (Table 1). These results were obtained under conditions of no plant competition. It is expected that with the additional pressure of plant competition as found in commercial grass seed fields, root growth of *Poa annua* would be further inhibited. Future field trials will include grass seed species to accurately assess the biological control of *Poa annua* and will give a more realistic evaluation of the efficacy of these biocontrol agents.

Table 1. Biological Control of *Poa annua* at Hyslop field station trial in 1993-94.

Bacterial isolate	Organism application date: 1/20/94	12/10/93 and 1/20/94	3/7/94
	--------(Number plants/6.4m²)------		
Control	382	386	391
A21	334	306 *	418
A17	297 *	308 *	471
B15	368	349	316
LSD (0.05)	82	73	133

* Significant at (p=0.05) compared to the control.

Future Activities

We are continuing to isolate bacteria that inhibit the growth of *Poa annua* and perennial ryegrass and to assess their inhibition potential in growth chamber and greenhouse trials. Isolates exhibiting consistent inhibition will be tested in the field in certified grass seed stands. The success of the isolates will depend on their ability to compete against other organisms in the rhizoplane of *Poa annua* roots. We plan to use greenhouse and molecular techniques to study the microbial ecology of the deleterious organisms. This information will provide an insight into the competitive ability of the isolates and processes that need to be considered for effective field biocontrol practices. Additionally, the mode of action will be examined to determine how to enhance the deleterious characteristics of the biocontrol mechanisms.

PROGRESS IN UNDERSTANDING BOTANICAL AND ZOOLOGICAL IMPLICATIONS OF ENDOPHYTES

A.M. Craig and R.E. Welty

The Grass Seed Industry

In recent years, as pressure developed to end field burning as a method of straw disposal within the grass seed industry in Oregon, producers sought to develop alternative markets for their supplies. Both grass seed and livestock producers have benefited from the fact that the grass and seeds can be utilized as a nutritious food resource (6-7% protein) for livestock either by grazing animals on the fields or by feeding harvested straw. However, there is a problem with some turf grass varieties.

The high levels of endophytes that protect turf grasses from the effects of drought and insect predation produce alkaloids that are detrimental to the health of herbivores. The question then to be resolved became *"How can we continue to safeguard the grasses without causing disease and killing livestock?"* Research toward answering that question has been conducted along several lines from both the botanical and zoological worlds.

Endophytes and Alkaloids

We have developed new assays for establishing toxin levels for both ergovaline (in tall fescue) and lolitrem B (in perennial ryegrass). These tests are available at the OSU Veterinary Diagnostic Laboratory (503-737-3261).

There are a total of 10 alkaloids in endophyte-infected (E+) tall fescue and 10 in perennial ryegrass. Although the level of fungus in any particular variety of grass remains virtually the same, the amount of toxins produced can vary by as much as 55% from year to year depending on environmental conditions of temperature, water availability, amount of sunlight, etc. (R.E. Welty, unpublished).

Based on a survey done in 1992 and 1993 in commercial seed production fields of four cultivars each of tall fescue and perennial ryegrass, ergovaline concentrations in seed and straw increased as the percent endophyte infection in seeds increased. Seeds and seed screenings from E+ cultivars should not be fed to livestock without a toxin assay. Since ergovaline production varies from year to year, straw residues from E+ cultivars should also be assayed before being used for feed.

Species and Cultivar	Endophyte Infection	Ergovaline	
		Seed	Straw
	(%)	--------- (ppb) --------	
Tall fescue			
Fawn (9)[a]	1	6	3
Trident (7)	13	295	15
Tribute (8)	57	1392	110
Titan (6)	72	2637	331
Perennial ryegrass			
Gator (8)	3	49	4
Charger (9)	26	911	69
Citation II (2)	56	1622	99
SR4200 (10)	84	2144	150

[a]Number of fields sampled in 1992 and 1993 used for means.

Livestock Disease

Our research projects established the correlation between toxin levels in both tall fescue and perennial ryegrass and the appearance of clinical disease (fescue foot, staggers, reproductive problems, etc.) in cattle, horses, and sheep. Although ruminants are somewhat protected from the toxins by rumen microbes, the stress of winter environmental conditions exacerbates the toxic effects of the alkaloids.

	Tall Fescue Ergovaline	P. Ryegrass Lolitrem B
Horses	300-500 ppb	Not determined
Cattle	500-825 ppb	1800-2000 ppb
Sheep	800-1200+ ppb	1800-2000 ppb

Annually for the past three years, veterinarians, Extension agents, and agricultural producers have submitted to the OSU College of Veterinary Medicine more than 225 grass, straw, and seed samples for analysis. At the Veterinary Teaching Hospital 12 major outbreaks of disease and death have been dealt with (over 600 animals were affected). This is only a portion of the toxicity problem as practitioners have reported other cases and livestock producers are undoubtedly seeing even more.

Some Possible Answers

As more new assays are being developed, plant geneticists will be able to develop the "ideal" seed, one that contains enough endophyte to be hardy for turf applications and yet is safe for animal consumption when grown as pasture or when utilized as straw feed.

In a related study involving tansy ragwort toxicosis, we successfully transferred protective microbial populations from sheep to the more susceptible cattle species. The cattle were then able to consume food contaminated with tansy without developing liver cirrhosis or other symptoms of toxicosis.

We are now attempting to identify microbial species that will degrade endophyte toxins to provide similar protection from tall fescue toxicosis and ryegrass staggers. While more research will be required, we look forward to development of a commercial product to afford life-saving protection to livestock species.

COMPOST UTILIZATION RESEARCH

D.B. Churchill, W.R. Horwath, L.F. Elliott and D.M. Bilsland

Removal of grass seed straw residue has historically been troublesome and cost prohibitive. More recently, public concern for the environmental consequences of open-field burning has led to legislation that severely restricts this practice. In August 1991, the Oregon Legislature signed into law a measure sharply reducing the total area of open-field burning allowed in grass seed production. The number of acres permitted burned is being steadily reduced within the next few years. Without another means of straw removal, increased potential exists for disease, insect and weed seed problems in grass seed lots. Other forms of disposal in the field, such as shredding and chopping, have been investigated but may not be entirely satisfactory.

Composting of grass seed straw into an easily spread soil amendment has been shown to be possible without the addition of a high-nitrogen component such as inorganic nitrogen or manure. Reapplication of the soil-like product may benefit the crop by producing short term increases in yield and or long-term improvement in soil quality. As a result, the objectives of this study were to determine the response of perennial ryegrass to the addition of known rates of nitrogen in composted grass seed straw and to assess its value as a plant nutrient source and determine whether some or all of the inorganic nitrogen normally applied by grass seed growers could be replaced with composted grass straw.

Field Studies:
Two sites were established for conducting experiments on the reapplication of composted grass seed straw residue to determine whether short term benefits in seed yield result from applying compost. Site 1 tests were conducted in an older, established perennial ryegrass field in its fifth year of production. An application of herbicide to control grass seedlings in the fall of 1993 weakened the crop and its overall strength was relatively low. Site 2 tests were conducted in a perennial ryegrass field in its second year of production.

In preparation for composting, perennial ryegrass straw was collected using two common methods available to the region's growers. The first method was to rake only long straw from the field to form compost windrows. This left finer material behind on the field for other forms of disposal. A ground-driven wheel rake and farm-built buck rake were used to collect long straw. The second method of straw collection was to rake, bale and remove long straw first, then form compost windrows with only the short straw that was flailed and vacuumed from the field. Compost material for site 1 was prepared by turning six times throughout the year with a commercial, straddle-type compost turner, and site 2 was prepared by turning two times throughout the year using the same compost turner. No addition of nitrogen or water, other than rainfall of about 35 inches, was made at either site.

Table 1. Chemical analysis of long and short straw compost.

	Moisture	pH	Total N	Nutrient ---- content ---	
	(%wb)		(%)	(ppm)	(lb/t)
Long Straw compost	49.0	7.6	1.14	--	--
P	--	--	--	184	0.4
K	--	--	--	6045	13.3
Ca	--	--	--	4320	9.5
Mg	--	--	--	936	2.1
Na	--	--	--	336	0.7
B	--	--	--	3.05	--
Short Straw compost	47.8	7.3	1.33	--	--
P	--	--	--	213	2.2
K	--	--	--	4485	9.8
Ca	--	--	--	5280	11.6
Mg	--	--	--	1140	2.5
Na	--	--	--	274	0.6
B	--	--	--	1.7	--

Site 1:
During July and August 1993, finished compost of both types of straw was collected and analyzed for moisture and nitrogen content and other plant nutrient levels (Table 1). For this field an average of 180 lb/acre of inorganic nitrogen is normally applied annually. Rates of application of compost were then calculated based on equivalent nitrogen application of 0, 20, 45, 90, and 180 lb/acre. Quantities of compost were weighed and bagged based on moisture content, nitrogen content and application rate in preparation for later application to field plots. Two blocks of thirty 10 ft x 10 ft plots were established on an existing perennial ryegrass field. One block of plots was established for ap-

plication of both the normal rate of inorganic fertilizer and varying amounts of compost. This block of plots received approximately normal to 200% of normal maximum rates of nitrogen application. The other block of plots was established for application of a small initial amount of inorganic nitrogen in the fall (25 lb/acre) with the remaining nitrogen coming from compost. This block of plots received 14% to 114% of normal maximum nitrogen. Compost was broadcast over individual plots at prescribed rates during October, 1993. Three replications of each condition were made resulting in a total of thirty randomized plots in each of the two blocks. Both blocks of plots received normal pesticide applications including fungicide, insecticide, molluscicide and herbicide. Plots were periodically checked for visible differences in color and plant growth throughout the fall, winter and early spring and differences noted. During July 1993, shortly before normal swathing of the field, a swath from the center of each plot was harvested at ground level using a sickle bar mower. Straw with seed still attached was bagged, labeled and dried for later weighing, threshing and seed conditioning.

Yields from compost addition in replacement of inorganic nitrogen were 38% to 76% of normal (Figure 1). Determining long-term benefits of addition of compost to the soil structure and its capacity to hold moisture and plant nutrients will require several years of study as will the results of depletion of previously applied inorganic nitrogen fixed in the soil. Physical and chemical properties of the compost that may influence its effect on plant growth are in need of investigation.

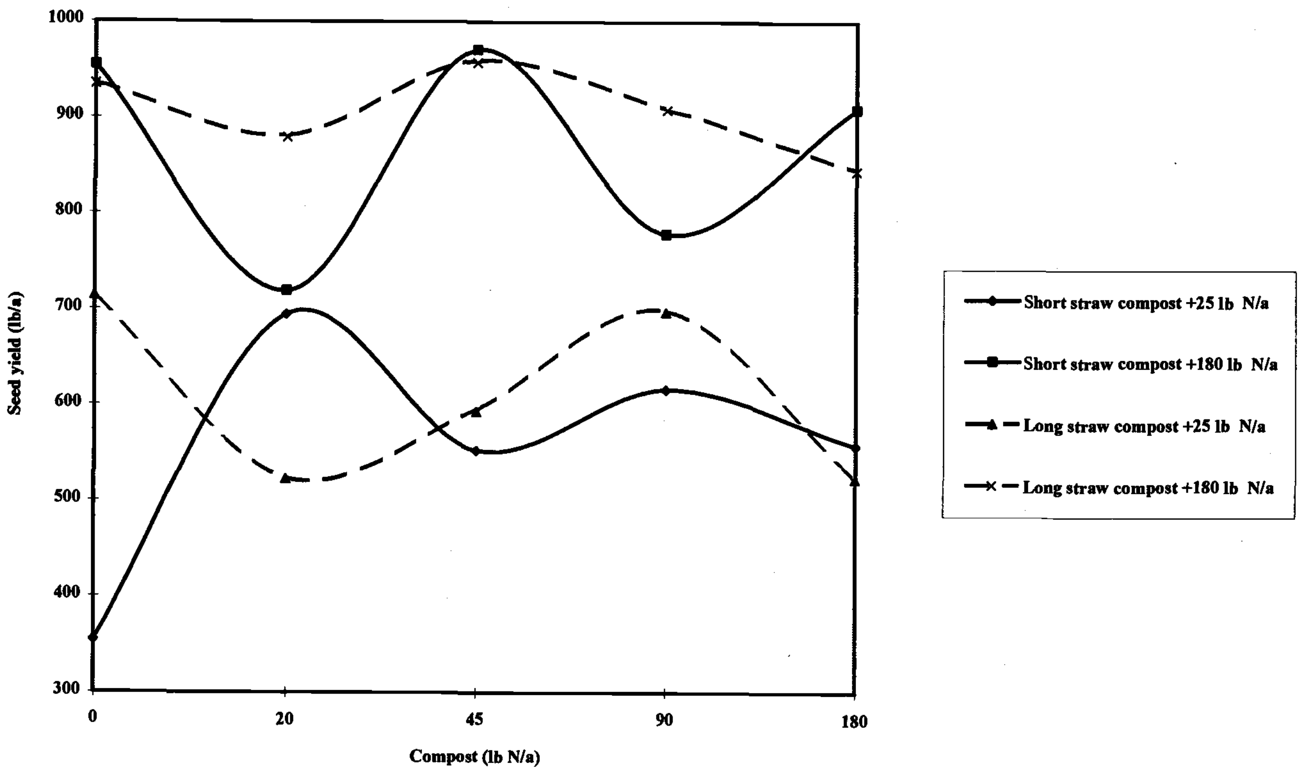

Figure 1. Site 1 seed yield from plots with different amounts of compost N from fall-applied long and short straw plus two rates of inorganic fertilizer, 25 lb N/a (fall) and 180 lb N/a (fall + spring).

Site 2:

Only short straw, characterized by straw particles less than 100 mm in length and including considerable dust and shattered seed, was collected after the long straw was removed. For this field an average of 140 lb/acre of inorganic nitrogen is normally applied annually. Application rates of 0, 70 and 140 lb/acre of nitrogen from compost were selected to represent 0, 50 and 100% of the normal inorganic nitrogen applied to this field. Quantities of compost were weighed and bagged in preparation for application in October 1993 to plots where the previous season's crop residue either remained or had been removed. No additional inorganic nitrogen was applied to these plots. Four replications of each condition of residue and compost rate were made resulting in a total of 24 plots. Additionally, for comparison, four separate plots were established for application of the normal amount of inorganic nitrogen and no compost. During July 1994, shortly before normal swathing of the field, a swath from the center of each plot was harvested at ground level using a sickle bar mower. Straw with seed still attached was bagged, labeled and dried for later weighing, threshing and seed conditioning.

Seed yields in plots with 0, 70 or 140 lb/acre compost N and residue remaining or removed averaged 59% to 90% of normal when no inorganic N was applied (Figure 2). The higher rate of compost application resulted in significantly higher seed yield than the lower rate or no compost application, however, inorganic N application at the normal rate gave the highest seed yield (data not shown). The presence of residue apparently reduced yield with or without compost. With the very least input (no residue removal and no compost addition) 59% of the usual seed yield was achieved. This 41% reduction in seed yield over the normal average was presumably the result of no addition of fertilizer or compost and the effect of residue remaining. Ninety percent of the normal yield was achieved where residue had been removed and compost had been applied at its highest rate.

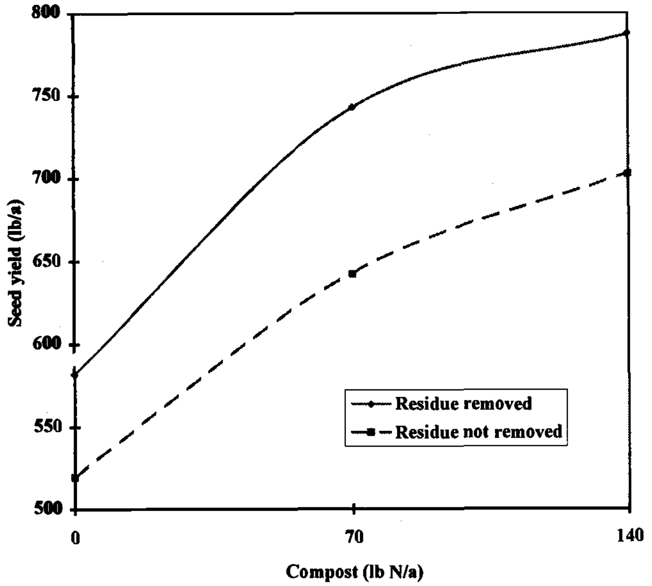

Figure 2. Site 2 seed yield from plots with different amounts of compost N from short straw where crop residue had been removed or not removed.

DECOMPOSITION OF THE LIGNIN FRACTION DURING WINDROW COMPOSTING OF PERENNIAL RYEGRASS STRAW

W.R. Horwath, L.F. Elliott, and D.B. Churchill

Crop residues are key components that maintain soil organic matter and optimum soil physical, chemical, and biological properties. These beneficial soil characteristics are critical for maintaining a sustainable cropping system. However, managing crop residues for the benefit of the current crop can be a challenging problem. The decomposing straw can be toxic to the crop, encourage pathogen invasion, and cause crop growth problems that are poorly understood.

The recycling of crop residues using procedures such as composting can diminish the toxic and pathogenic properties of residues and is an important step in conserving nutrients for the establishment of sustainable cropping systems. Composting, through high temperature decomposition, of crop residues kills pathogens that can cause the problems associated with field managed crop residues. Other benefits from the application of composted residues in cropping systems include fertilizer value, soil conditioning effects, and increases in crop growth not readily attributable to the fertilizer value. However, theory has been that high carbon to nitrogen materials, such as grass straw, cannot be composted without the addition of nitrogen (co-composting), which greatly complicates and increases the cost of composting crop residues. Our studies have shown that grass straw can be effectively composted. These studies were conducted to determine the mechanisms that are critical to processes so that it can be applied to other agricultural wastes and to address the possibility of developing alternative products.

A windrow composed of long straw (straw left after threshing) and one of reclipped straw (clipped standing stubble and grass re-growth) were formed. Straw was placed in nylon mesh bags 12 x 9 in and then sealed. The bags were inserted into the windrows 1 ft and 3 ft deep. The bags were connected to the straw surface with a plastic twine and a tag so they could located and identified.

Turning or mixing of the windrows was done with a front end loader at different times during composting process (Table 1). The long straw treatment (LS) was turned 4 times and the reclip treatment (RT) was turned twice (Table 1). The third treatment was a control and consisted of long straw with no turning or mixing (0T). The decomposition bags were removed during the turning operations (including the control treatment) and then replaced immediately in all treatments. Decomposition bags were removed frequently during the experiment for the analysis of the lignin fraction that provided data on the rate of total residue decomposition.

The results showed that 96 percent of the lignin in the straw had been altered, showing that the straw had been extensively decomposed during the composting process. The mechanism is that lignin decomposition was much more extensive than would have been predicted from previous studies and methods used to measure lignin degradation. The decomposition of the lignin exposes the components of the straw cell wall (cellulose and hemicellulose) for more rapid decomposition of the total residue. Additional laboratory studies have shown that rice and wheat straw should also compost readily using our method of field composting.

Table 1. Date and number of turns in the windrow treatments.

Date turned	Treatment Reclip	Long straw
1/13/94	X	X
3/30/94	X	X
5/3/94		X
6/7/94		X
Total turns	2	4

Upgrading crop residues by composting is an alternative to managing residues in the field and will alleviate problems associated with in-field residue management practices. We are in the process of developing economic information on the in-field composting process to determine its feasibility as a long-term management practice to promote cropping system sustainability.

WHITE CLOVER CULTIVAR RESPONSES TO DIFFERENT PRODUCTION PRACTICES

J.J. Steiner

Background and Objectives

There are numerous cultivars of white clover (*Trifolium repens* L.) utilized for forage in the United States. These cultivars vary by growth form and adaptation to the different forage production regions in which they are utilized. White clover seed can be produced in several regions within the western U.S. However, very little information is available that describes how white clover cultivars respond to different seed production agronomic practices. Such information is critical if best management practice production systems are to be developed for white clover seed production.

Two common agronomic practices used to produce white clover seed are the removal of crop vegetation during early-flowering in late spring and the use of supplemental irrigation. The marginal production costs of hay removal can be negative if the forage is chopped and left in the field. Positive revenue can result if the forage is removed and ensiled or if grazed by sheep. Forage removal can also be an effective post-emergence weed control method. The cost of a single water application by overhead sprinklers at a farm scale is about $50 per acre. A single application of 5.5 inches is usually adequate to fill the active soil profile to field capacity.

The purpose of this report is to demonstrate how white clover cultivars grown for seed in the Willamette Valley can interact with two commonly manipulated production practices: (i) the use of supplemental irrigation; and (ii) early flowering period vegetation removal. General guidance practice recommendations are being presented to consider the ways that different cultivars may respond to irrigation and forage removal so that specific best management practice production systems can be developed for your farming conditions and production practice options.

Materials and Methods

To separate experiments were conducted to investigate the effects of these practices on intermediate and Ladino-type white clover cultivars. The supplemental water application experiment was conducted in 1991 and the hay removal experiment in 1993. Each experimental plot was 2 x 6 m with each cultivar replicated four times. Irrigation and forage removal treatments were applied in split-plot arrangements.

To determine the effects of supplemental water application, ten cultivars and experimental germplasms (New Zealand, California Ladino, Regal, White Dutch, Arcadia, Louisiana S-1, Titan, Osceola, Brown Loam, and SRVR) were either not irrigated or received a single application of water that filled the active soil profile (4 feet) to water holding capacity when the soil water depletion was estimated to be 64%. All plots had been mowed once at early bloom stage and the forage removed.

To study the effects of forage removal in early spring, nine cultivars (New Zealand, California Ladino, Regal, White Dutch, Arcadia, Louisiana S-1, Titan, Osceola, and Canopy) either were not moved or mowed once at early bloom stage and the forage removed. None of the plots were irrigated. The rate and progression of flower development was measured in all treatments in both experiments. The plots were harvested, the plant materials dried, and the seeds threshed, cleaned, and weighed.

Conclusions

Results from these experiments indicate that white clover cultivars should be managed using specific cultural practices that are best suited to achieve maximum seed yields for each cultivar. The eight cultivars could be grouped into four response classes: (i) positive response to both hay removal and irrigation; (ii) positive response to irrigation but a neutral response to hay removal; (iii) negative response to both hay removal and irrigation; and (iv) neutral response to both hay removal and irrigation (Figure 1). None of the cultivars responded positively to hay removal and negatively to irrigation.

The best management practice concept could be adapted to the specific farm production resource availability and cropping systems needs. For example, the cultivars Arcadia, Louisiana S-1, and Titan can be minimally managed for maximum seed yield without supplemental irrigation or early bloom forage removal. These cultivars would be suited to farms or fields that do not have irrigation and that do not have an outlet for spring fresh cut fodder. These cultivars would also be good in crop rotations to reduce weed populations since seed yield is not affected by hay removal. California, Regal, and Osceola all respond positively to supplemental irrigation, so these cultivars are well suited to irrigated production systems. The intermediate leaf size cultivars White Dutch and New Zealand should not be mowed or receive supplemental irrigation to prevent seed yield reductions.

For more information, contact Jeffrey Steiner, National Forage Seed Production Research Center, USDA-ARS, 3450 SW Campus Way, Corvallis, OR 97331, (503) 750-8734.

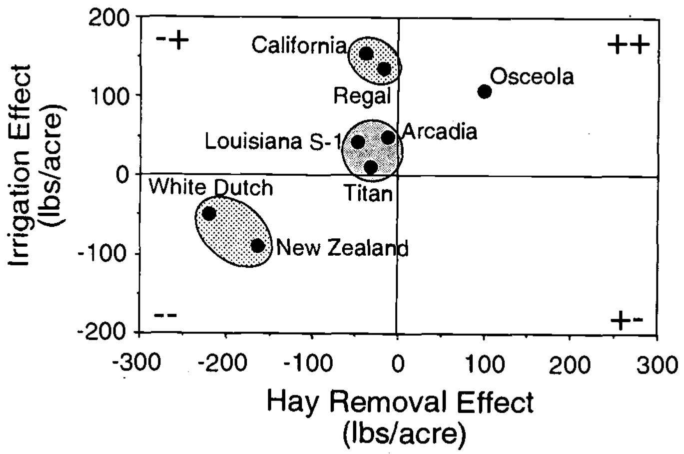

Figure 1. Effect of early-flowering hay removal and supplemental irrigation on white clover cultivar seed yield stability for the purpose of developing guidance practices.

POST-HARVEST RESIDUE MANAGEMENT EFFECTS IN CHEWINGS FINE FESCUE SEED PRODUCTION

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Burning fields after harvest is the most effective and economical method of removing crop residue. It exposes the crown area to light and temperature fluctuations important to tiller growth and development. However, increased regulation of open-field burning and legislation effectively reducing the annual acreage allowed to be burned has encouraged the industry to evaluate alternative methods of residue management.

Results from a long-term post-harvest residue removal trial on a Chewings fine fescue field in Marion county are discussed here. Data are from the fifth seed harvest of the cultivar Center, and were collected in on-farm trials. Residue treatments have been applied each fall following seed harvest. Seed yield and crop development data was collected each year. The trial was established in 1990 and has been continued through four years. The results of previous years data are reported in OSU Seed Production Research reports Ext/CrS 89 (1991), Ext/CrS 93 (1992), and Ext/CrS 98 (1993).

Plots were arranged in a randomized complete block design with four replicates. Plots were 22 x 120 ft., which accommodated standard commercial sized harvest equipment. A full 12 foot swather width was cut down the center of each treatment at maturity. This center swath was combined to determine seed yield and quality. The harvested seed from each plot was collected in garbage cans, weighed and a sub-sample taken to determine clean seed yield, calculate clean out and determine seed quality. A complete description of experimental residue management procedures has previously been reported (Ext/CrS 89).

Following seed harvest in 1993, plots were baled on August 19. Post-harvest residue treatments were subsequently applied as listed: 1) Crew-cut, August 20; 2) Flail chop, August 20; 3) Open burn, August 28; and 4) Propane burn, August 28. Except for these treatments, all other production practices were performed by the growers. However, no fall herbicides were applied to the plot area in 1993; only a spring application of phenoxy herbicides was made for the control of broadleaf weeds. Plots were swathed on July 8 and combine harvested on July 21.

Seed yield in 1994 did not differ significantly across residue management treatments, however, yields were below average due to competition from fall-germinated grass weeds (Table 1). Absence of fall-applied herbicides resulted in a near solid stand of rattail fescue (*Vulpia myuros*) and annual bluegrass (*Poa annua*) between seeded crop rows. Thus, herbicidal control of grass weeds appear to be mandated regardless of residue management system (thermal or nonthermal) used in Chewings fine fescue seed fields.

Fertile tiller number at maturity did not differ significantly, although total dry weight of biomass harvested from thermally-managed plots was greater than in non-burn treatments (Table 1). One thousand seed weight and percent germination of harvested seed did not differ (data not shown). Results from a purity analysis of sub-samples taken at harvest (combine-run) did not differ across residue management treatments, but weed seed content ranged between 15 and 25 percent, evidence of severe competition from weed grasses (data not shown).

Table 1. Effect of residue management on seed yield, fertile tiller number and total dry weight in Center Chewings fescue, 1994.

Residue Treatment	Seed yield	Fertile tillers	Total dry weight
	(lb/a)	(per yd^2)	(ton/a)
Open burn	423	2385	5.9
Propane burn	366	2709	4.9
Crew-cut	406	2205	3.9
Flail chop	455	2358	3.9
LSD 0.05	NS	NS	1.0

As mentioned previously, results from each years' data collection has been reported. Individual year effects and comparisons are important; however, the accumulative results over the life of a stand is the ultimate concern when changing residue management practices. This was the last year for treatments and data collection. Figure 1 shows the cumulative effect on seed production of the various treatments during the past four years.

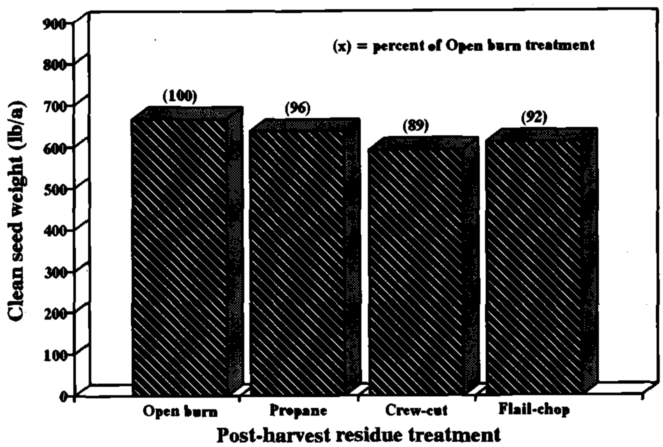

Figure 1. Four-year average (1991-94) seed yield of Chewings fine fescue as influenced by post-harvest residue management.

Seed yield reductions have not been as dramatic in the Chewings fine fescue trial as in previously reported studies with creeping red fescue. However, an average yield reduction of 8 to 11 percent has resulted from the non-burned treatments.

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