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Page

(continued on inside front cover)

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FALL NITROGEN ON TALL FESCUE

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

Beginning in 1998, we started on-farm spring N rate studies on several grass species (tall fescue, perennial ryegrass, fine fescue and annual ryegrass) with a goal of defining the optimum N level for seed crop yield and economic returns. In addition, we were able to assess the impact of using higher than recommended N rates on seed production and potential for leaching of residual NO_3 not taken up by the plant. These data have been reported in the annual Seed Production Research Reports (1998-2001). Specific to tall fescue, we have concluded that the optimum level of spring-applied N for seed production was 90-135 lb N/a.

In all of our spring N trials, fall-applied N was held constant at each grower site, as were other macronutrients (phosphorous and potassium) normally applied in the management for cool-season seed crops. However, additional questions arose in regard to the effects of making adjustments to fall-applied N and how this impacts spring N requirements.

The current OSU recommendation is for 30 to 40 lb N/a to be applied in the fall. However, there is no research available identifying the impact of fall N in combination or alone with spring N needs in tall fescue. Thus, our research proposed to measure wider ranges of fall applied N alone and in combination with spring N to determine how seed yield is impacted by fall and spring N combinations.

This trial is a continuation of research begun in 2002. Three on-farm large plot experiments were established in tall fescue fields during the fall of 2001. The two fields that were newer stands were continued for a second crop year. The third field (an 8 year old stand) was taken out of production and was replaced for 2003 with a new stand in its first year of seed production. Both fall and spring combinations of N fertilizer management were used in order to determine the balance needed. We also continued research for a second year at OSU's Hyslop Research Farm using a small plot trial looking at a wider range of fall and spring N treatments.

All grower sites received three fall N levels (0, 40, and 80 lb N/a) applied the last week of October and two spring N levels (grower rate and grower + 40 lb N/a). The extra 40 lb N/a treatment was applied the last week of March following the normal grower applications to determine if grower spring N rates were adequate with different fall N rates. At the Hyslop Research Farm a factorial arrangement of treatments was used, which included all combinations of four fall N levels (0, 40, 80, and 120 lb N/a) and five spring N levels (0, 40, 80, 120, and 160 lb N/a) for a total of 20 (four fall x five spring) different treatment combinations. Seed yield and components of yield have been measured in each of these trials.

Results

Spring tillering: Plots were sampled at grower sites and at Hyslop prior to spring N applications to determine the effect of fall N treatments on fall tiller development. This factor is can be important as seed yield is directly related to the number of fertile tillers in the stand. Vegetative tillers in a tall fescue seed crop generally need vernalization prior to spring growth in order to produce seed heads. Therefore the development of mature tillers during this period is important in managing the crop for optimum seed production. Spring tiller populations were significantly increased at Hyslop Farm (Table 1) but not at any of the three on-farm locations. Treatments at Hyslop farm increased tiller densities up to 94% over the zero fall N treatment.

Table 1. Spring tiller density response to fall nitrogen prior to spring N applications in tall fescue, 2003.

	Hyslop Farm		Kuehne Farms	Roselawn Farms	Smith Bros. Farm
Fall N (lb N/a)	(tillers / sq. ft.)				
0	128	c	---	316	247
40	186	b	326	324	225
80	248	a	331	334	244
120	241	a	---	---	---
LSD 0.05	21		NS	NS	NS

[1] Means in columns followed by the same letter are not significantly different at FPLSD = 0.05

Other effects from the fall N on spring tillers at Hyslop Farm are detailed in Tables 2, 3 and 4. Use of fall N at Hyslop Farm resulted in larger more robust tillers as shown by the dry weights of the tillers in Table 2. The mean dry weight per tiller increased from 46 mg to 56 mg. Not only were the tillers bigger but there were significant increases in all size classes of tillers (Table 3). The spring tiller density distribution was not affected by fall N rates (Table 4), which was in contrast to 2002 where there were increases in the proportion of largest sized tillers. Weather may have influenced the regrowth as the fall rains didn't arrive until mid-November 2002 as compared to a month earlier in 2001.

Table 2. Spring tiller dry weight responses to fall nitrogen prior to spring N applications in Velocity tall fescue, 2003.

	Dry wt. per tiller by size class (basal diameter)			Mean tiller	Total bio-
	1mm	2mm	3+mm	dry wgt.	mass
Fall N (lb N/a)	---------- (mg/tiller)	----------	----------	----------	(tn/a)
0	12 c[1]	34 b	88 b	46 b	0.28 c
40	13 bc	37 b	94 b	49 b	0.44 b
80	15 ab	43 a	109 a	52 ab	0.61 a
120	16 a	43 a	113 a	56 a	0.64 a
LSD 0.05	2	4	12	6	0.05

[1] Means in columns followed by the same letter are not significantly different at FPLSD = 0.05

Table 3. Spring tiller density responses to fall nitrogen prior to spring N applications in Velocity tall fescue, 2003.

	Tiller density by size class (basal diameter)			Total	Pct. of
	1mm	2mm	3+mm	tillers	0 Fall N
Fall N (lb N/a)	---------- (tillers/sq. ft.)	----------	----------	----------	(%)
0	29 b[1]	82 c	17 c	128 c	100
40	35 b	120 b	30 b	186 b	145
80	64 a	152 a	32 ab	248 a	194
120	54 a	148 a	39 a	241 a	188
LSD 0.05	13	15	7	21	---

[1] Means in columns followed by the same letter are not significantly different at FPLSD = 0.05

Table 4. Spring tiller density distribution response to fall nitrogen prior to spring N applications in Velocity tall fescue, 2003.

Main Factors	Percent in size class		
	1 mm	2 mm	3+mm
Fall N (lb N/a)	----------	(%)	----------
0	22 ab[1]	64	14
40	19 b	65	17
80	25 a	62	13
120	22 ab	61	17
LSD 0.05	4	NS	NS

[1] Means in columns followed by the same letter are not significantly different at FPLSD = 0.05 (0.10)

Seed Yield: Seed yield response to fall N is shown in Tables 5 - 8. At Kuehne's, the trial did not include a 0 N rate in 2003 but at the 40 and 80 lb N/a rates there was no significant seed yield difference due to season (fall or spring) of N application or rate as was the case in 2002. This site is in a high organic matter soil and had rotated out of pasture and other cropping systems the enriched the soil with high levels of organic matter. Results at Roselawn Farms were similar to Kuehne's Farm with no responses to either fall or spring treatments. At Smith Bros. Farm, there was a significant fall x spring interaction which is shown in Table 6. At this site there was a positive response to fall N when the spring applied N was at the normal grower rate. By not using fall fertilizer, yields were significantly less. However, when an additional 40 lb N/a was spring-applied to the grower's normal rate (180 lb N/a total), there was no significant advantage from fall-applied N and even a modest decrease in seed yield. This suggests that (at this site in this year) additional spring N was needed to compensate for not applying N in the fall. This is similar to the response that was observed at the Roselawn site in 2002.

Table 5. Clean seed yields for Fall N x Spring N factorial at three on-farm grower sites, 2003

Location Variety	Kuehne Farms (Yamhill Co) Rebel Exeda (2nd yr)	Roselawn Farms (Marion Co) Tomahawk IIE (3rd yr)	Smith Bros. Farms (Linn Co.) Houndog (1st yr)	Three site average
Fall N (lb/a)				
0	----	1795	2172	----
40	2354	1921	2180	2152
80	2387	1988	2224	2200
LSD 0.05	NS	NS	*[2]	----
Spring N				
Grower N rate[1]	2489 a[3]	1847	2152	2163
Grower + 40 lb N/a	2251 b	1955	2233	2146
LSD 0.05	161	NS	*[2]	----

[1] Roselawn = 110 lb N/a, Kuehne and Smith Bros. = 140 lb N/a.
[2] = Significant interaction at P<0.05.
[3] Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values.

Table 6. Fall x Spring N seed yield interactions at Smith Bros. Farms, 2003.

Main Factors	----------Spring N (lb N/a) --------	
	Grower N (140 lb)	Grower N + 40 (180 lb)
Fall N (lb N/a)	--------------(lb/a)-----------------	
0	2021 b[1]	2322 a
40	2135 ab	2226 a
80	2298 a	2149 a
LSD 0.05	------------- 244 --------------	

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

Data from the trial at Hyslop Farm (4th crop year) also found a mild but important interaction (P value = 0.10) between fall and spring applied N. Because of the highly significant main effects (P value <0.001) both main factor and interaction seed yields are shown in Tables 7 and 8 respectively. Table 7 shows significant increases in seed yield with both fall and spring N treatments with yields increasing up to the higher rates applied. Within the interaction, the highest yielding spring N rate was dependent on the level of fall N applied. As the fall N rate increased, the spring N rate needed for optimum yield decreased. This is similar to the responses in 2002 though the yields were much lower. The 0 fall N responded positively to increased spring N rates up to the highest spring N rate (160 lb N/a) but was less than the seed yield at higher fall N rates at the same spring N rate. For this trial the best seed yields were obtained by combinations (spring + fall) totaling approximately 200 lb N/a and were effective with several combinations: 40 fall + 160 spring, 80 fall + 120 spring, 120 fall + 80 spring. As in 2002, highest yields at Hyslop were at a higher total N (200 lb) than at the grower sites. This can be seen by the data which shows a maximum yield attained at the 150 - 160 lb total N (fall + spring) for the on farm sites.

Table 7. Seed yield response to main factors (fall and spring applied N) in *Velocity* tall fescue, 2003.

Main Factors	------**Main factor seed yields** ---- Fall N	Spring N
N rate (lb /a)	--------------(lb/a)-----------------	
0	462 c[1]	401 d
40	575 b	532 c
80	751 a	689 b
120	794 a	724 b
160	----	881 a
LSD 0.05	51	57

[1] Means in columns followed by the same letter are not significantly different at FPLSD = 0.05

Table 8. Fall x Spring N seed yield interactions in Velocity tall fescue, 2003.

Main Factors	0	Spring N rate (lb /a) 40	80	120	160
Fall N rate (lb /a)					
0	226 c	307 c	491 b	561 b	725 b
40	336 b	418 b	567 b	644 b	911 a
80	489 a	684 a	837 a	814 a	931 a
120	556 a	720 a	860 a	879 a	956 a
LSD 0.10	--------------------		95	--------------------	

[1] Means in columns followed by the same letter are not significantly different at FPLSD = 0.10

Yield components: Figures 1 and 2 show graphically a representation of how fall or spring fertilizer affected the major yield components related to seed yield at Hyslop Farm. In Figure 1 each fall N rate variable is the averaged value across all spring N rates, and in Figure 2 each spring N rate variable is the averaged value across all fall N rates, thus 0 lb fall N value for fertile tillers is the average of all five spring N rates that received 0 lb fall N, and the 0 lb spring N value for fertile tillers is the average of all four fall N rates that received 0 lb spring N. Results are very similar to 2002 in almost all categories. Fall N substantially increased fertile tiller numbers and some increases in spikelet numbers. There were some small negative effects on floret number and 1000 seed weight. Spring N had a lesser but still positive effect on fertile tiller densities and a larger effect on the number of florets per spikelet and thousand seed weight. Potential seed number was significantly increased by both fall and spring N but, as indicated, by differing yield components. Both fall and spring N increased actual seed number, but the level of increase depended on the fall and spring combination as was previously discussed with the seed yield. Harvest efficiency, as measured by the FSU (floret site utilization), is the ratio of the actual seed number harvested compared to the potential seed number calculated. The decrease in FSU indicates that the crop was not able to convert all the improvements in yield components into harvested seed. As the level of N reached an optimum level (160-200 lb N/a) the seed yield reached a maximum plateau and did not increase as dramatically indicating that N was no longer the main limiting factor to yield but other factors may be affecting the crop yield response (genetics, weather, etc.,) The ability to use fall and spring N applications equally may give growers more flexibility on timing of N applications. These results are encouraging in that they are consistent with the current OSU recommendations.

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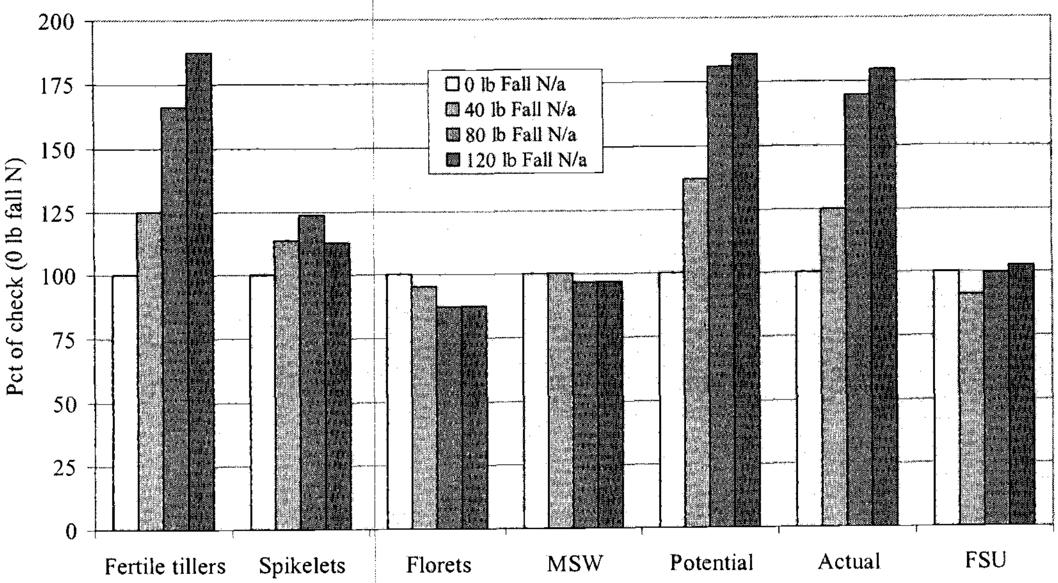

Figure 1. Seed yield components as influenced by rate of fall-applied N in Velocity tall fescue, 2003

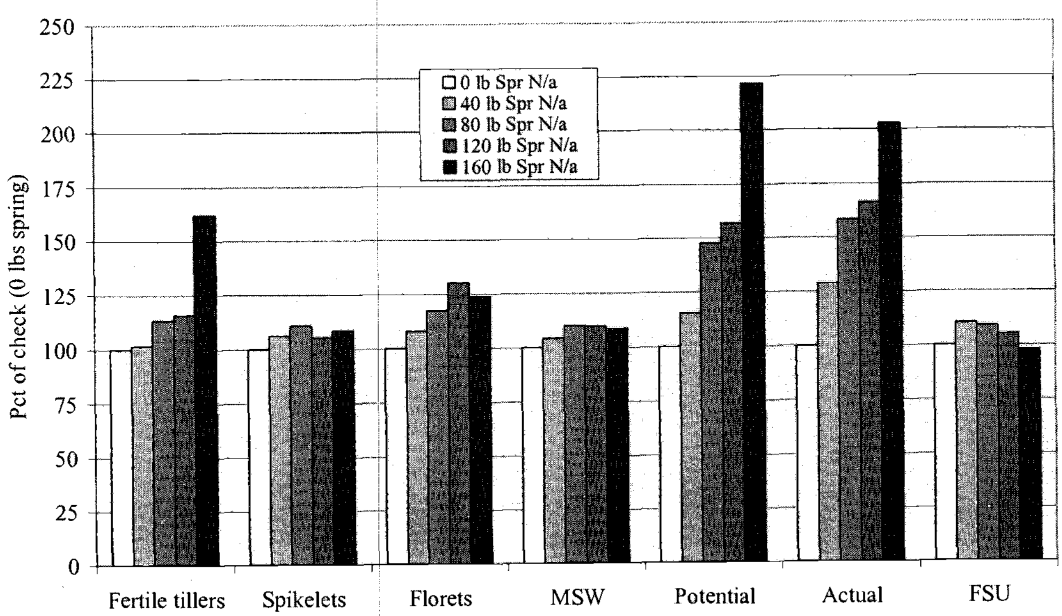

Figure 2. Seed yield components as influenced by rate of spring-applied N in Velocity tall fescue, 2003

USE OF THE NMIN SOIL TEST TO PREDICT N FERTILIZER NEEDS FOR DIRECT-SEED WINTER WHEAT FOLLOWING GRASS SEED CROPS IN THE WILLAMETTE VALLEY

N.W. Christensen, M.L. Fery, M.E. Mellbye and T.B. Silberstein

Winter wheat acreage in the Willamette Valley tripled between 1999 and 2003 in response to weak prices for other commodities and new tools for improving the efficiency of winter wheat production. Increased knowledge about how to manage N fertilizers was among the factors that allowed growers to reduce production costs while improving yields (Sullivan, et al., 1999; Christensen, 2002, and Rost, 2003). Specifically, a nitrogen mineralization soil test (Nmin soil test) developed by OSU scientists can be used to avoid both under- and over-fertilization (Christensen, et al. 1999, 2001). Growers found that use of the Nmin soil test led to lower N rates, less lodging, and higher wheat yields in 2001 and 2002.

In 2002 several farmers in the southern Willamette Valley planted winter wheat directly into untilled grass sod using no-till or direct-seed grain drills. Their goal was to reduce erosion and protect water quality by reducing surface runoff. In January 2003 questions about the applicability of the Nmin soil test under direct-seed conditions led to the establishment of on-farm N rate trials in five no-till (NT) and four conventional-till (CT) fields. Winter wheat response to N fertilizer was measured using large-scale field plots managed by growers.

Objectives

- Determine if the Nmin soil test accurately predicts N fertilizer needs for direct-seed winter wheat.
- Measure the impact of previous crops and crop residue management on the capacity of soils to provide N to a winter wheat crop.
- Identify practices that could improve the accuracy of the Nmin soil test and/or facilitate direct seeding of winter wheat.

Materials and Methods

Composite soil samples were collected from a number of winter wheat fields and analyzed for mineralizable soil N (Nmin) and extractable NH_4-N and NO_3-N in January 2003. In February, nine sites were selected for large-scale, on-farm N fertilizer rate experiments. At five no-till sites winter wheat had been direct-seeded in Oct.-Nov. 2002 following peas, clover, or grass seed (tall fescue, annual ryegrass) where straw had been chopped and returned to the soil surface. Winter wheat had been conventionally seeded in Oct.-Nov. at four other sites following orchard grass, tall fescue with straw baled, grain, or plantain. Conventionally seeded sites were similar to those used to originally calibrate the Nmin soil test (Christensen, et al., 1999, 2001).

In each field, an 80 ft. X 500 ft. area was left unfertilized when N fertilizer was applied in late February at rates recommended (80 to 160 lb N/a) based on soil tests for mineralizable and inorganic N. In the last week of February and the first week of March, a Gandy orbit air spreader was used to topdress 50 lb N/a in 40 ft. wide strips on both the unfertilized area and an adjacent area that had received the recommended rate of N. This created four 40 ft. X 500 ft. plots, each receiving a different rate of Spring-applied N. The two lowest N rates (0 and 50 lb N/acre) were the same at all locations but the two highest N rates varied from site to site depending upon soil tests for mineralizable and inorganic soil N. The third rate of N (80 to 160 lb N/acre) was that applied by growers based on soil tests. The fourth treatment was the grower's N rate plus an additional 50 lb N/acre (130 to 210 lb N/acre).

Whole plant samples were collected from 3 ft. of row at three places within each N rate plot on July 18-23, 2003. Sample weights were recorded before removing wheat heads and weighing samples a second time. Weights were used to calculate the harvest index (HI) for each plot. Sub-samples of straw plus leaves were ground in a Wiley mill and analyzed for total carbon and nitrogen using a Leco CNS analyzer in the CSS Central Analytical Laboratory (CAL). Plots were harvested with growers' combines on July 25 through August 4, 2003. One combine pass (15 to 30 ft. wide X 500 ft. long) was made down the center of each N rate plot. Grain from each plot was transferred to a weigh wagon and grain weights were recorded. Samples representing grain from each plot were collected for measurement of test weight, 1000 kernel weight, NIR grain protein, and NIR grain moisture content. Grain was ground and analyzed for total carbon, nitrogen and sulfur using a Leco CNS analyzer in the CAL.

Grain yield data were used with HI data to calculate straw yields. Measured concentrations of N in grain and straw were combined with yield data to calculate total N recovery in grain and straw. Three "efficiency" indices were calculated to assess the effectiveness of N fertilizer applications. These indices were N uptake efficiency (apparent % recovery of fertilizer N by the crop), Agronomic efficiency (bu grain per lb N applied), and Economic efficiency ($ returned for $ invested in N).

Data were subjected to Randomized Complete Block (RCB) analyses of variance using the nine experimental sites as Blocks and the four N fertilizer rates as treatments. Statistical analyses provide valid comparisons of the means of four treatments: (1) 0 lb N/a, (2) 50 lb N/a, (3) recommended N (R), and (4) R + 50 lb N/a.

Table 1. Winter wheat agronomic response to N fertilizer at nine Willamette Valley sites.

N rate	Grain yield	Test weight	Kernel weight	Grain protein	Grain moisture	Harvest Index
(lb N/a)	(bu/a)	(lb/bu)	(mg)	(%)	(%)	(grain/straw)
0	73.9 c	60.9 d	45.1 a	8.1 d	10.0	1.16
50	86.3 b	61.2 c	43.6 b	8.5 c	10.1	1.09
R[1]	106.3 a	61.6 a	43.0 c	9.1 b	9.9	1.10
R + 50	102.9 a	61.4 b	42.0 d	9.4 a	10.0	1.13
LSD 0.05	4.2	0.2	0.6	0.2	NS	NS

[1]Recommended rates of N fertilizer based on soil tests ranged from 80 to 160 lb N/a.

Results

Statistical analyses showed that grain yield and protein content were significantly influenced by N fertilizer rate (Table 1). Mean grain yield was highest (106.3 bu/a) where the recommended rate of N (R) had been applied. Response to N was consistent across locations with R ranging from 80 to 160 lb N/a. Unlike grain yield, grain protein content increased significantly with each added increment of N fertilizer. Soft white winter wheat protein concentrations ranged from 8.1 to 10.1% with a mean of 9.1% where recommended rates of N fertilizer had been applied. Grain protein concentrations were similar to concentrations (8.0 to 10.5%) associated with maximum economic grain yields in earlier studies (Christensen, et al., 2001).

Mean test weight was highest (61.6 lb/bu) at recommended rates of N and lowest (60.9 lb/bu) when no N was applied (Table 1). Kernel weights declined with increasing rates of N fertilizer. Harvest Index and grain moisture content were unaffected by N fertilization.

Nitrogen concentrations in grain and straw increased with added N and reached their highest levels at recommended rates of N fertilizer (Table 2). Mean N uptake in grain and straw increased from 74 lb N/a where no N had been applied to 129 lb N/a where recommended rates of N were used. Applying more fertilizer N than recommended increased neither crop N uptake nor grain yield.

Table 2. Tissue N and S concentrations and N uptake as influenced by N fertilizer rates.

N rate	Grain N conc.	Grain S conc.	Grain N:S	Straw N conc.	Grain N uptake	Straw N uptake	Total N uptake	N Harvest Index
lb N/a	(%)	(%)		(%)	-----------------(lb N/a)		-----------------	(grain/straw)
0	1.48 c	0.11	13.3	0.18 c	67 c	7 c	74 c	0.90 a
50	1.56 b	0.12	13.6	0.23 b	81 b	12 b	93 b	0.88 b
R[1]	1.69 a	0.12	14.0	0.31 a	110 a	19 a	129 a	0.86 c
R + 50	1.73 a	0.12	14.1	0.31 a	109 a	18 a	128 a	0.86 c
$LSD_{0.05}$	0.05	N.S.	N.S.	0.03	5	2	6	0.01

[1] Recommended rates of N fertilizer based on soil tests ranged from 80 to 160 lb N/a.

While wheat at all locations responded positively to N fertilization, the relative increase in grain yield depended on the capacity of the soil to supply N (Figure 1). For example, the lowest relative yield (38%; highly responsive) was measured at a site where Nmin plus inorganic soil N was 23 ppm. In contrast, the highest relative yield (90%; slightly responsive) was measured at a site where Nmin plus inorganic soil N was 80 ppm after 10+ years of chopping back annual ryegrass straw. Data confirm that soil tests conducted in January are useful in predicting relative response to Spring-applied N fertilizer.

Data in Table 3 show that the "efficiency" of N fertilizer use dropped dramatically when N was applied beyond the recommended rate. For example, N uptake efficiency dropped from 66 to -3%; agronomic efficiency from 0.35 to -0.07 bu/lb; and economic efficiency from $4.44 to -$0.89 for the last 50 lb N/a added.

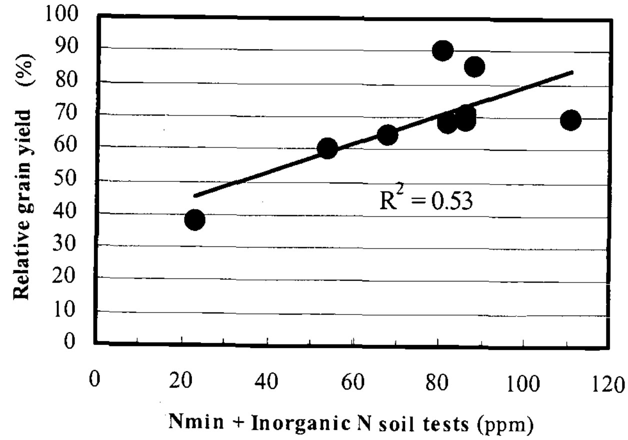

Figure 1. Relative grain yield of the unfertilized control as related to soil N measured in January.

Table 3. Winter wheat N uptake and N fertilizer efficiencies as influenced by N fertilizer rates and conventional or no-till seeding.

Seeding	N rate	Total N uptake	N Uptake[2] efficiency	Agronomic[3] efficiency	Economic[4] efficiency
	(lb N/a)	(lb N/a)	(%)	(bu/ lb N_{fert})	($\$_{grain}/\$_{fert}$)
No-till means	0	89			
n = 5	50	105	33.3	0.15	$1.93
	R	154	93.0	0.47	$6.00
	R + 50	153	-2.7	-0.06	-$0.77
Conventional means	0	55			
n = 4	50	77	44.5	0.36	$4.61
	R	97	33.2	0.20	$2.50
	R + 50	96	-1.5	-0.08	-$1.04
Overall means	0	74 c			
	50	93 b	38.3 b	0.24 b	$3.12 a
	R[1]	129 a	66.4 a	0.35 a	$4.44 a
	R + 50	128 a	-2.8 c	-0.07 c	-$0.89 b
	LSD 0.05	6	12.9	0.11	$1.36

[1] Recommended rates of N fertilizer based on soil tests ranged from 80 to 160 lb N/a.
[2] Change in N uptake by plant (lb N/a) divided by incremental change in N fertilizer rate (lb N/a)
[3] Change in grain yield (bu/a) divided by incremental change in N fertilizer rate (lb N/a)
[4] Change in grain value ($3.80/bu) divided by incremental change in N fertilizer cost ($0.30/lb N)

Nitrogen uptake efficiency (NUE) is a useful index for evaluating the impact of fertilizer management practices (timing, placement, source and rate) and cropping systems on the percentage of applied N taken up by crop. This parameter is especially useful for comparing management practices that may affect N availability to plants and/or soil N losses or additions. The mean NUE for the recommended rate of N (66.4%) was on the high end of the range of NUE (45 to 65%) commonly measured for winter wheat in the Willamette Valley (Table 3). NUEs of 45% or lower generally reflect limited plant growth associated with plant diseases, poor soil drainage, or some other limiting factor.

At one no-till site the NUE for the recommended rate of N was 119%; application of 55 lb fertilizer N/a increased plant uptake by 65 lb N/a. How can this be? Soil Scientists have a name for this phenomenon – it is called the "Added Nitrogen Interaction" or ANI. The ANI is commonly observed where soils contain significant quantities of N in forms that can be mineralized or otherwise become available to crops. Addition of a relatively small amount of fertilizer N stimulates plant growth, allowing the crop to take advantage of the increased supply of soil N. In earlier literature the ANI was sometimes called the "priming effect".

Closer inspection of the data revealed that the sites with the highest NUEs were no-till sites Average efficiency indices for the five no-till and four conventional sites are given in Table 3. One important trend in the data is worthy of note, even though the experimental design does not allow for statistical comparison of no-till and conventional means. At conventionally planted sites, mean NUE decreased from 44.5 to 33.2% as the N rate was increased from 0 to 50 lb N/a, and then from 50 lb N/a to the recommended rate of N (R). In stark contrast, the mean NUE for no-till sites increased from 33.3 to 93.0% as the N rate was increased from 0 to 50 lb N/a, and then from 50 lb N/a to R. Because of the "law of diminishing returns", one would expect the NUE to decline with increasing rates of N as observed for the conventionally seeded sites. The fact that the NUE increased dramatically on the no-till sites indicates that N availability to plants was enhanced by an ANI at these sites. As calculated, the NUE is "apparent" N uptake efficiency. The high NUEs and Total N uptake by the unfertilized control (89 lb N/a) reflect the capacity of soils at no-till sites to supply significant quantities of N to winter wheat (Table 3). Return of previous crop residue to the soils without incorporation probably accounts for the enhanced capacity of soils at direct-seed sites to supply N to plants.

Conclusions

Results show that the Nmin soil test can be used along with other soil test information to accurately predict N fertilizer needs for both no-till and conventionally seeded winter wheat grown in the Willamette Valley. Data suggest that direct-seeded sites may have a greater capacity to supply soil N because residue of previous crops has been returned to the soil without tillage. There is no indication of need to modify the Nmin soil test or calculations of crop N requirements. Results suggest that use of the Nmin soil test combined with direct seeding of winter wheat could lower the cost of production in the southern Willamette Valley.

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

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

Potassium application to grass grown for seed has traditionally been made in the fall. In the last few years, some growers have begun applying potassium in the spring and reporting yield increases from the practice. The spring potassium application has generated questions from growers. They typically ask if spring applied K is better than fall applied K. Conversations with several growers revealed they are asking at least two questions: 1) when should K be applied to grass for seed production and 2) does the chloride (Cl) from a spring application of potassium chloride increase seed yield.

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

The initial research was conducted on small plots at a single location. Although significant, seed yield increases were small, about 100 lb/a. Measurements of yield response to spring Cl application were desired in commercial grass seed fields over a range of soil and environmental conditions.

In addition, the rate of Cl needed to obtain a seed or test weight increase was uncertain. Recommendations from South Dakota and Montana are for 30 to 60 lb/a available Cl in the top 2 feet of soil (PPI). The lowest rate used at Hyslop Farm in the mid-1980's was 75 lb/a. The OSU guide for Combating Take-All for Winter Wheat in Western Oregon recommends a Cl rate of 100 lb/a (Christensen and Hart, 1993). To consistently demonstrate the need for spring application of Cl, a multi-year effort of large plots at several locations and for several species was initiated to investigate the effect of spring application of potassium and chloride on grass grown for seed.

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

In 2003, a randomized complete block design with three replications was established in commercial fields of annual ryegrass, perennial ryegrass, and tall fescue with treatments as shown in Table 1. Treatments were 20 feet wide, allowing a single swath through the middle of each plot to be made for harvest. Fertilizer was applied with a Gandy Orbit-air spreader pulled by a "four wheeler" on dates provided in Table 2.

Table 1. Potassium and chloride application rates from fertilizer sources used in 2003.

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

The plot length was 250 to 400 feet long allowing plots to be harvested with grower combines. Seed from each plot was transferred from the combine to a Brent Yield cart for weighing. A sub-sample of seed from each plot was cleaned and the weight from the combine adjusted with these data to report clean seed yield. Weight of 1000 seeds was determined from the clean seed sub-sample.

Table 2. Management information treatment application and flag leaf sampling dates for 2003.

Grass	Variety	Stand age	Straw management	Treatment application	Flag leaf sample
		(years)		---------------- (date)	------------
Annual Ryegrass	Gulf	Continuous Gulf/Annual	Disked	4/22	5/21
Perennial Ryegrass	Blackhawk	3	Chopped	4/8	6/3
Tall Fescue	Rebel	3	Baled	4/8	5/16

Site and chloride soil test information is provided in Tables 2 and 3. Flag leaf samples were obtained by walking the length of the plots and randomly selecting 60 to 75 fully open flag leaves. Soil samples were taken on February 20, 2003 and submitted to the OSU Central Analytical Laboratory for analyses that are reported in Table 4. Analysis of variance, mean separation, and t-tests were performed using the "Statistix" program.

In 2003, application of chloride increased Cl concentration in flag leaf samples of all species with each increment of added chloride (Table 4). In contrast to chloride application, added potassium only increased flag leaf potassium concentration in annual ryegrass (Table 4). Weight of 1000 seeds increased with chloride application for annual ryegrass and tall fescue, but not perennial ryegrass when treatments receiving no chloride were compared to treatments receiving chloride (Table 5). Seed weight increased from chloride application at two of three sites in 2003, a figure similar to the seed weight increase for three of the five situations from applied chloride in OSU research in the 1980's.

Table 3. Site and soil test information for 2003.

Site location	Soil type	Grass species	SOIL TEST: Chloride, Sampling depth (inches) 0 to 6 (lb/a)	Chloride 6 to 12 (lb/a)	Potassium 0 to 6 (ppm)	Potassium 6 to 12 (ppm)
Tangent	Amity/ Woodburn silt loam	Perennial ryegrass	40	40	165	104
Coburg	Newberg loam/ sandy loam	Tall fescue	35	30	348	188
Junction City	Bashaw clay	Annual ryegrass	50	38	138	93

Table 4. Flag leaf tissue chloride and tissue potassium after spring application of potassium fertilizers.

Treatment		Annual ryegrass		Perennial ryegrass		Tall fescue	
K_2O	Cl	Tissue Cl	Tissue K	Tissue Cl	Tissue K	Tissue Cl	Tissue K
----- (lb/a) ------		(ppm)	(%)	(ppm)	(%)	(ppm)	(%)
0	0	3535a	0.76a	2785a	1.73	2256a	1.48
88	0	3675a	1.24b	3078a	1.89	2058a	1.47
44	35	5934b	1.37bc	8977b	1.95	3378b	1.53
88	70	7206b	1.56cd	14497c	1.76	5059c	1.56
176	140	11567c	1.77e	19195d	2.13	8188d	1.52
					NS		NS

Table 5. Seed weight and yield after spring application of potassium fertilizers.

Treatment		Annual Ryegrass		Perennial Ryegrass		Tall Fescue	
K_2O	Cl	Seed wt.	Seed yield	Seed wt.	Seed yield	Seed wt.	Seed yield
----- (lb/a) ------		(g/1000)	(lb/a)	(g/1000)	(lb/a)	(g/1000)	(lb/a)
0	0	2.55	1499	1.91b	1396	2.30a	1869
88	0	2.58	1461	1.84a	1298	2.32a	1750
44	35	2.65	1535	1.86a	1275	2.37ab	1847
88	70	2.68	1525	1.87ab	1242	2.36a	1795
176	140	2.63	1515	2.04c	1188	2.48c	1838
		NS	NS		NS		NS

Seed yield was not increased by application of potassium and was not expected to do so as soil test potassium was adequate at all sites. When compared to no chloride application, treatments receiving chloride produced an increased seed yield of annual ryegrass, made no change in tall fescue and decreased the yield of perennial ryegrass. The results in 2003 are similar to Turner's where he measured a seed yield increase two of the five times chloride was applied to perennial ryegrass.

Soil test chloride was similar for all sites and did not provide a means to predict if a site would produce increased seed yield from an application of chloride. A similar situation exists for flag leaf chloride concentration. Flag leaf chloride concentration with no chloride application was between 2,000 and 3,500 ppm. Annual ryegrass was the only species producing a yield increase from the application of chloride and the flag leaf tissue chloride concentration from plots with no chloride applied was the highest of the three species.

Summary

Application of chloride increased Cl concentration in flag leaf samples of all species with each increment of added Chloride. The increase in accumulation of chloride by the plant did not produce a similar increase in seed weight or seed yield. Weight of 1000 seeds increased with chloride application for annual ryegrass and tall fescue, but not perennial ryegrass when treatments receiving no chloride applied were compared to treatments receiving chloride. When the same grouping of treatments was compared for seed yield, chloride produced an increased seed yield for annual ryegrass, made no change for tall fescue and decreased the yield of perennial ryegrass.

In contrast to chloride application, added potassium only increased flag leaf potassium concentration in annual ryegrass and had no effect on seed yield or seed weight.

Neither soil test chloride or flag leaf chloride concentration provided a means to predict if a site would produce increased seed yield or seed weight from an application of chloride.

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

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

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

Research in other crops indicates that the plant component in active development at the point of stress will be most adversely affected. Winter and spring rains provide ample moisture for early grass growth and development. However, summer drought conditions impose water stress in the field beginning during critical periods of the grasses' reproductive life cycle, specifically from anthesis through seed fill. Therefore, it would be plausible to assume a reduction in seed number and potentially seed weight as a result of the stress.

The results of this study are intended to contribute to the knowledge base of tall fescue development and assist in establishing irrigation management strategies for producers in the region. Our objectives include: (1) measure the impact spring irrigation has on seed yield components of tall fescue seed crops; (2) develop spring irrigation management practices for Willamette Valley seed producers; and (3) determine if response to irrigation treatments is cultivar dependant.

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

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

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

Seed yield components, including floret, spikelet and fertile tiller number, panicle length, total biomass and reproductive biomass were determined on tiller samples collected prior to anthesis. Potential yield (Y) was calculated using the equation below and is expressed as potential seed number per m^2.

$$Y = \text{Fertile tillers per } m^2 \times \text{Spikelets per panicle} \times \text{Florets per spikelet}$$

Plots were harvested with a small plot swather and combine. Representative yield samples were conditioned and percent clean out was used to report marketable yield. Thousand seed weights were measured on clean seed. Fall regrowth samples (biomass and tiller number) and stand counts were collected to measure the residual effects of spring irrigation on tall fescue seed crops.

Progress
Cool, wet weather during early spring led to above normal precipitation (April rainfall was 216 % of normal). A shift to hot, dry weather beginning near the end of May corresponded with anthesis of tall fescue and shortened the flowering period (May and June rainfall was 54 and 21 % of normal rainfall, respectively). Based on planned irrigation regimes, the weather conditions led to both irrigation treatments being identical, each receiving 85 mm of water between 4 June and 9 June. These treatments were pooled for data analysis.

The tiller samples were collected prior to irrigation application and represent the inherent differences between cultivars (Table 1). Cultivars displayed differences in spikelets per panicle and panicle length (data not shown) but not biomass. Effectively, the cultivars had different potential seed yield.

Table 1. Influence of cultivar on seed yield components in tall fescue. Data is presented as the average of all treatments (samples collected prior to irrigation application).

Cultivar	Fertile tiller number	Spikelets per panicle	Florets per spikelet	Potential seed number
	(per m^2)	--------- (no.)	-----------	(per m^2 x 10^3)
Arid 3	702	75 cd[1]	7.3	3.84 a[2]
Barrington	747	81 bc	7.1	4.25 a
Bingo	690	78 c	7.8	4.17 a
Fawn	525	71 d	7.1	2.64 b
SR8600	700	87 a	7.1	4.18 a
Velocity	678	85 ab	7.2	4.32 a

[1] LSD 0.05 = 6.25
[2] LSD 0.05 = 1.17

The additional moisture available to irrigated plants reduced moisture stress from anthesis through seed fill and resulted in greater yield. Supplemental irrigation increased yield by an average of 26 percent across all varieties. The range of yield increase was from 13 percent ('Velocity') to 38 percent ('Bingo') (Table 2). Across cultivars, seed yields averaged 1694 lb/a under irrigation while nonirrigated yields averaged 1325 lb/a. Yield was increased 107 lb/a per additional inch of applied water. No interactions were found between irrigation and cultivar.

Table 2. Thousand seed weight and seed yield for tall fescue cultivars under irrigated and non-irrigated conditions.

Cultivar	non-irrigated	irrigated	mean
	---------------- 1000 Seed weight (g)	-------------	
Arid 3	2.46	2.57	2.52 b[1]
Barrington	2.35	2.49	2.42 c
Bingo	2.32	2.41	2.37 d
Fawn	3.12	3.29	3.21 a
SR8600	2.37	2.45	2.41 cd
Velocity	2.52	2.58	2.55 b
Mean	2.52 a[2]	2.63 b	2.58
	------------------- Seed yield (lb/a)	----------------	
Arid 3	1318	1650	1484 bc[3]
Barrington	1325	1805	1565 b
Bingo	1527	2113	1820 a
Fawn	775	1002	889 d
SR8600	1613	2019	1816 a
Velocity	1393	1576	1484 c
Mean	1325 a[4]	1694 b	1510

[1] LSD 0.05 = 0.05 for means in column
[2] LSD 0.05 = 0.04 for means in row
[3] LSD 0.05 = 126 for means in column
[4] LSD 0.05 = 125 for means in row

Yield increase can be attributed in part to increased seed weight. However, this does not account for the entire yield increase; therefore, irrigation must have also increased harvestable seed number. Percentage increase of yield due to seed weight was different among cultivars. Some cultivars may provide more assimilates to the fewer seeds produced, thereby increasing seed weight more than in cultivars that spread the available assimilates among a greater number of seeds.

Cultivar differences were not observed in water use patterns. Soil moisture data indicated that the plant utilized all of the additional moisture provided in the range of this experiment. Though irrigated plots received an additional 85 mm of water during the growing season, at swathing irrigated plots contained only 7 mm more water than the non-irrigated plots (Figure 1).

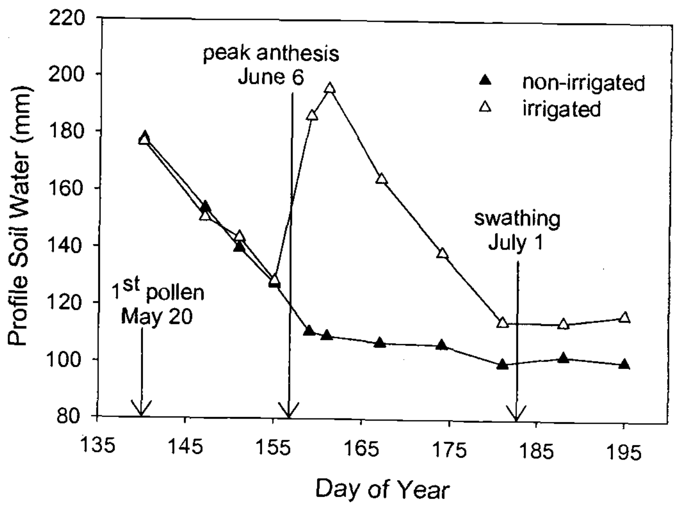

Figure 1. Profile soil water (mm) of irrigated and non-irrigated tall fescue seed crops. No differences were found among cultivars, data presented is averaged across cultivars. Irrigation was applied from June 4 (doy 155) through June 9 (doy 160) totally 85 mm of water.

Field observations showed that lodging and rust incidence were not exacerbated as a result of irrigation. Irrigation caused increases in moisture content of seed at the time of swathing that ranged from 3 to 7%, dependant on cultivar.

Findings to date indicate that irrigation increases tall fescue seed yield. However, spring irrigation does not impact fall growth and development (data not shown). These trials will be continued for another seed harvest to confirm our findings.

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

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

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

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

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

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

Procedure:
Six cultivars of perennial ryegrass were selected for this experiment (Caddieshack, Cutter, Derby Supreme, CIS-PR85, Pirouette, and SR4500). All cultivars were planted May 2002 at Hyslop research farm.

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

Spring tiller and spike samples were taken to observe differences in fertile tiller and seed yield components between varieties and treatments. Grass was swathed at 35% moisture content, and combined at 12%. Seed was cleaned prior to dry weight yield analysis, and sub-samples were hand cleaned to analyze 1000 seed weight. Fall stand count and tiller dry weight was analyzed to determine effect of irrigation on fall regrowth.

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

Fertile tiller number and total dry weight were reduced by irrigation (Table 2). However, sampling of these components occurred shortly after irrigation ended so results may be due to other factors. Spikelet number and length were unaffected by irrigation treatments. Mean florets per spikelet were also not affected by irrigation. Irrigation did not have a significant effect on reproductive efficiency ($P > 0.74$).

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

Treatment	Cultivar	Seed yield	1000 seed wt.	Seed number
		(lb/a)	(g)	(no./sq. ft.)
Control	Cutter	1523	1.85	8545
	Pirouette	1803	1.52	12290
	Derby Supreme	1260	1.81	7219
	SR 4500	1493	1.63	9496
	Caddieshack	1618	1.68	9987
	CIS PR-85	1396	1.47	9877
	Mean	**1515** b[1]	**1.66** b[2]	**9569** b[3]
Profile Filled	Cutter	1895	1.94	10149
	Pirouette	2035	1.62	13039
	Derby Supreme	1526	1.90	8364
	SR 4500	1867	1.80	10777
	Caddieshack	1956	1.75	11609
	CIS PR-85	1655	1.51	11340
	Mean	**1822** a	**1.75** a	**10880** a
Maintained	Cutter	1965	2.00	10179
	Pirouette	2208	1.64	13966
	Derby Supreme	1554	1.93	8340
	SR 4500	1921	1.75	11426
	Caddieshack	2093	1.81	12009
	CIS PR-85	1832	1.61	11843
	Mean	**1929** a	**1.79** a	**11294** a

[1]LSD 0.05 = 200 for bold mean values in column
[2]LSD 0.05 = 0.056 for bold mean values in column
[3]LSD 0.05 = 1012 for bold mean values in column

Tiller samples and dry weight measurements were taken twice in fall 2003 to assess spring irrigation effect on fall regrowth. Neither measurements provided any evidence that spring irrigation has an effect on fall tiller regrowth, and subsequently, dry weight.

Seed yield response in 2003 can be summarized primarily as a response to increased weight per seed, and total seed number. Water use efficiency (WUE) was highest for the control, 0.79 (g seed/mm water). Irrigation treatments had similar WUE, (0.63 and 0.64). Therefore, yield increases observed in irrigated treatments were not the results of improved water use efficiency.

Table 2. Effect of spring irrigation and cultivar on seed yield, seed weight, and seed number of perennial ryegrass.

Treatment	Cultivar	Fertile tiller number	Tiller dry weight
		(no./sq. ft.)	(g/sq. ft.)
Control	Cutter	248	164
	Pirouette	280	164
	Derby Supreme	247	185
	SR 4500	266	165
	Caddieshack	273	163
	CIS PR-85	283	150
	Mean	**265** b[1]	**165** b[2]
Profile Filled	Cutter	239	166
	Pirouette	242	149
	Derby Supreme	246	185
	SR 4500	238	148
	Caddieshack	252	139
	CIS PR-85	269	141
	Mean	**247** a	**154** a
Maintained	Cutter	228	168
	Pirouette	254	148
	Derby Supreme	200	156
	SR 4500	242	165
	Caddieshack	254	161
	CIS PR-85	305	168
	Mean	**247** a	**160** b

[1]LSD 0.05 = 14.0 for bold mean values in column
[2]LSD 0.05 = 15.6 for bold mean values in column

Table 3. Difference in yield, seed number, and seed weight expressed as a percent increase over non-irrigated and moisture maintained treatments in perennial ryegrass.

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

From 2003 results, spring irrigation significantly increased seed yield in perennial ryegrass. Increased seed weight and number were the seed yield components responsible for the observed increases in seed yield. The relative contribution of these two components to yield increases for the six cultivars are expressed as a percentage of the non-irrigated control (Table 3). In addition to natural rainfall and temperature conditions experienced in spring 2003, irrigation was effective in substantially increasing seed yield of perennial ryegrass of these six cultivars. This work will be continued and results reported in a future article.

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

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

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Historic post-harvest residue management practices for fine fescue seed production have mainly consisted of open-field burning of full straw load. This practice has been used to dispose of straw, control disease, recycle nutrients, control volunteer seedlings, and maintain crown size. Open-field burning has been documented as beneficial to subsequent seed yield in three commercially produced fine fescue subspecies [Chewings Fescue (Festuca. *rubra* ssp. *commutata* Gaud.), creeping red fescue (F. *rubra* L. ssp. *rubra*), and slender red fescue (F. *rubra* L. ssp. *littoralis* (Meyer) Auquier)]. Chewings-type fescues have a bunch forming growth habit, and some seed yields have been reported to be acceptable under nonthermal residue management practices. However, both creeping red fescue and slender red fescue have a rhizomatous growth habit and previous studies have indicated that seed yields following nonthermal residue management practices are reduced. A growing body of evidence indicates that increased rhizome production occurs under nonthermal methods, and that increased rhizome numbers are directly associated with low seed yields and unacceptable economic returns. An increased understanding of the cause for decline in yield in fine fescue seed crops is needed to develop new nonthermal management alternatives. The nature and variability in seed yield responses of fine fescue cultivars to nonthermal management need to be characterized.

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

Procedure

Field trials were established at Hyslop Research Farm, Corvallis, Oregon in fall 2000. Trials were arranged in a strip-plot design with four replications of plots that measure 10x50 ft. Ten cultivars of fine fescue seed crops were selected for this research: four cultivars of Chewings fescue ('SR5100', 'Southport', 'Brittany', and 'Barnica'); four cultivars of creeping red fescue ('Shademaster', 'Cindy', 'Silverlawn', and 'Shademark'); and two cultivars of slender red fescue ('Seabreeze' and 'Marker'). Residue management strategies examined in these trials include: (i) removal of straw by open burning (Open burn); (ii) removal of straw by baling, flail chopping low (Flail Low); and (iii) removal of straw by baling, flail chopping high (Flail High). Residue management research has been conducted in 2002 and in 2003, after the first and second seed harvests in each trial, respectively. It is important to note that the initial first seed harvest (2001) was too low to conduct a study, so plots were mowed to prepare for the subsequent seed harvest.

Seed yield components measured include tiller weight, fertile tiller number, spikelets per panicle, florets per spikelet, and panicle length in each cultivar and treatment on samples taken in May of 2002 and 2003. Plots were harvested with a plot swather and plot combine. Bulk seed sacks on the combine were used to determine bulk seed dirt weight harvested from each plot. Clean seed yield and percent cleanout were determined for each cultivar. In 2003, subsamples were cleaned to determine 1000 seed weight.

Results

In 2003, 1000 seed weight, panicle length, and florets per spikelet remained relatively constant across all treatments and cultivars (data not shown). Cultivars displayed differences among treatments in spikelets per panicle and fertile tiller number (Table 1). This provides evidence of different potential seed yield among the cultivars tested.

Table 1. Means for seed yield components of fine fescue subspecies, Willamette Valley.

Subspecies	Cultivar	Fertile tillers	Spikelets per panicle
		(no./ft^2)	(no.)
Chewings	SR 5100	188 c	39.4 a
	Southport	184 cd	36.8 ab
	Brittany	196 bc	37.6 ab
	Barnica	256 a	24.2 c
Strong Creeper	Shademaster	166 d	34.8 ab
	Cindy	127 e	32.0 b
	Silverlawn	178 cd	40.9 a
	Shademark	184 cd	35.9 ab
Slender Creeper	Seabreeze	177 cd	24.3 c
	Marker	216 b	31.3 b

Results of this study show that open-burning plays a significant role in increased seed yield in most subspecies and cultivars (Table 2). However, (flail low) non-thermal methods show acceptable yields in two of the Chewings fescue cultivars and in one cultivar of slender red fescue (Table 2). In contrast, Chewings fescue seed yields did not benefit by the thermal treatment in 'Barnica' and 'Brittany'. However, seed yield of 'Southport' and 'SR 5100' were increased under thermal conditions (Figure 1). Strong creeping red fescue had low, and economically unacceptable yields across all nonthermal methods. Furthermore, the flail high methods produced low seed yields across all cultivars, except one cultivar of slender red fescue, 'Marker'. This may be a result of increased carbohydrate storage due to increased production of rhizomes in strong creeping and slender red fescue.

Moreover, in Chewings fescue, increased etiolation among fall tillers may result in fewer fertile tillers in the spring.

Table 2. Influence of residue management on seed yield of Chewing's fescue, strong creeping, and slender red fescue in the Willamette Valley.

Subspecies	Cultivar	Flail High	Flail Low	Open burn
		(lb/acre)		
Chewings	SR5100	1078 a[1]	1118 b	1165 b
	Southport	770 b	843 ef	850 d
	Brittany	1087 a	1243 a	1230 ab
	Barnica	788 b	806 ef	776 e
Strong Creeper	Shademaster	576 c	666 gh	919 cd
	Cindy	579 c	722 fg	832 d
	Silverlawn	848 b	888 de	994 c
	Shademark	866 b	1084 bc	1346 a
Slender Creeper	Seabreeze	460 c	550 h	631 f
	Marker	1069 a	989 cd	821 de
Residue treatment means		816 b[2]	891 a	956 a

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

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

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

Open-burning and flail low treatments had similar seed yield responses in all Chewing's fescue cultivars and in one slender red fescue cultivar. Creeping red fescue showed the greatest seed yield reduction in response to nonthermal methods. This result supports conclusions from previous studies at OSU.

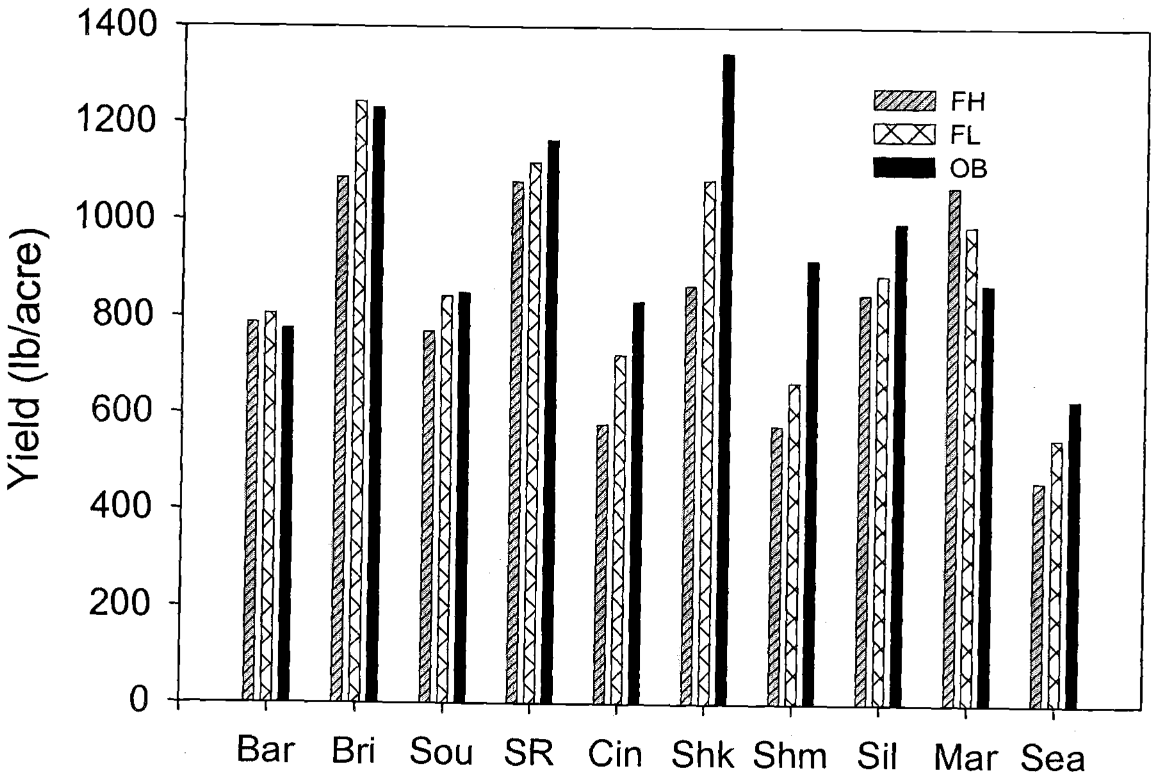

Figure 1. Second year (2003) seed yield responses of fine fescue cultivars to residue treatments (FH: Flail High; FL: Flail Low; OB: Open Burn). Cultivars are: Shm: Shademaster; Bar: Barnica; Sou: Southport; Cin: Cindy; SR: SR 5100; Sea: Seabreeze; Sil: Silverlawn; Bri: Brittany; Shk: Shademark; Mar: Marker.

From 2003 results, open-burning is beneficial to seed yields in most fine fescue subspecies the following crop year. However, substantial evidence indicates that nonthermal (flail low) methods can produce acceptable yields in Chewings fescue by reducing crown biomass and vegetative tiller regrowth. This reveals that some Chewings fescue cultivars can be profitably produced under nonthermal if flailed low. In contrast, the nonthermal flail high treatment did not reduce crown biomass or vegetative tiller production, which resulted in inferior seed yield across most subspecies in this experiment to date. This was correlated to increased rhizome production resulting from increased carbohydrate storage, increased crown size, and increased etiolation among fall tillers, leading directly to immature spring tillers and poor seed yield (data not shown). Overall, results of this study clearly show that open-burning plays a role in maintaining seed yield in Chewings, strong creeping, and slender red fescue. These trials will be conducted for two more seed harvests to confirm our findings. This should provide evidence needed to establish relationships between residue management and yield.

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

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Introduction

Open-field burning has been successfully used as a management tool to remove post-harvest residue in seed production fields of creeping red fescue, and other cool-season grasses, in order to maintain seed yield and seed quality. However, public concern over air pollution caused by open-field burning resulted in significant, legislatively mandated reductions in the acreage burned per year in the Willamette Valley. Since field burning has considerable positive impacts on creeping red fescue seed yield, new practices have to be tested for maintaining those yields as field burning becomes less available as a management tool.

Creeping red fescue grown for seed is prone to lodging, which generally results in lower yields. Use of Palisade, a plant growth regulator (PGR), in fall applications might enhance seed yield as the stand ages by reducing fall plant height and rhizome production. Spring applications are known to control plant height and therefore reduce lodging problems. In addition, they may increase panicle production contributing to higher yields. The use of Palisade could be an alternative practice to lessen the need for open-field burning in creeping red fescue, and still get high yields and seed quality that characterize Willamette Valley grass seed production.

Procedure

A stand of Shademaster creeping red fescue was established on May 5, 1999 at Hyslop Farm, and field trials were conducted to determine the effect of Palisade application and residue management on seed yield and its components. Six Palisade treatments were investigated and compared in burned vs. non-burned (straw removal flail chop stubble) stands. Two rates of Palisade (1.4 pt/acre and 2.9 pt/acre) and two dates of application (early and late) have been tested in fall, and one rate (2.9 pt/acre) and two application dates (early and late) in the spring. One control with no Palisade application was included for each residue management. Dates of Palisade applications for each year are shown in Table 1.

Table 1. Calendar dates for PGR application.

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

Fall tiller number and aboveground biomass were evaluated on 1-ft^2 samples. Tiller basal diameter was assessed by selecting a subsample of 200 tillers from each sample and fitting the broad dimension of each tiller base in a gauge delineated in 1mm increments. Tiller height was measured on ten tillers randomly drawn from each basal diameter size class

Fertile tiller number and height were measured on 1-ft^2 samples taken prior to peak anthesis. Total biomass as well as fertile tiller biomass were recorded. The seed yield components spikelets per panicle, and florets per spikelet, have been ascertained from panicles samples taken before peak anthesis.

The crop was cut with a small plot swather, and dried in windrows to approximately 12% seed water content. Dried windrows were threshed with a small plot combine and the seed was cleaned with a laboratory size air-screen cleaner to determine clean yield.

Results

Overall, there is a tendency to decrease seed yields as the stand ages following the pattern normally seen in seed production fields in the Valley. Nevertheless, there has been a response of the crop to residue management as well as to the Palisade application. Those responses have been different for the three years. In the first year (2001), relatively small differences between seed yield of burned and flailed plots were found (Figure 1). By the second year (2002), yield from burned plots was greater than that of the flailed ones. Differences in seed yield between burned and non-burned were even greater in the third year. The increased magnitude in seed yield differences in burned plots as the stands aged was, in part, due to greater numbers of spikelets per panicle in 2002 and 2003, and a greater number of panicles in 2003 (Table 2). These differences were evident regardless of Palisade application. In addition, in 2003 there has been an increase in the number and weight of fertile tillers for the burned plots. This change in the number of fertile tillers, when multiplied by the increased number of spikelets per panicle, resulted in a higher number of florets and therefore higher yields for the burned plots. Another manifestation of increased number of spikelets per panicle in burned plots was the increased length of panicles to accommodate the greater number of spikelets.

Seed yields revealed a clear interaction between residue management and Palisade application in each year (Figure 1). In 2002 and 2003, both spring applications on burned plots outyielded the flailed and treated, while in the first year yields from burn and flail with spring application of Palisade yielded the same. Spring application increased yield by 40% on both burned and flailed treatments in 2001, and nearly by 50% in 2002. Early spring application resulted in similar yields to late spring application in the two first years. In 2003, there has been a differential response to the spring application between burned and flailed plots. Palisade application increased yield by 44% on the burned plots and there was nearly no difference between the spring treated and the untreated on the flailed plots. In 2001, increases in yield in the early spring application were attributable to a combination of increased flowering (floret number) and estimated seed set (Table 3). In 2002, late spring application did not improve flowering, but markedly increased the estimated seed set in comparison with the early spring application in 2001. Seed set was very high for both spring applications in 2002. In 2003, there was an increase in floret number on the spring treated plots, and a trend of higher seed set on both fall and spring treated plots.

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

So far, we can say that spring applications of Palisade on unburned plots consistently increased seed yield over the untreated burned control in the two first years. Nevertheless, in the third year this increase was no longer evident. In addition, the burned plots out yielded the flail ones in all cases except for the spring applications in the first year where no difference in seed yield was found between burned and flailed. We will continue the trial one more year in order to ascertain the use of Palisade as a management tool in burned and non-burned creeping red fescue in the Willamette Valley.

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

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

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

Table 3. Palisade treatment and date of application effects on florets/spikelet and seed set in Shademaster creeping red fescue.

Palisade Treatment	Florets/spikelet			Estimated seed set (%)		
	2001	2002	2003	2001	2002	2003
Untreated	4.8 b*	4.4	6.7 ab	16.4	22.1	11.8
Early Fall	4.9 b	4.7	6.5 b	18.9	23.9	13.5
Late Fall	4.5 b	4.5	6.3 b	18.0	24.3	13.1
Early Spring	5.4 a	4.9	7.0 a	19.6	32.8	12.9
Late Spring	4.9 ab	4.8	6.9 a	23.4	31.9	16.2

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

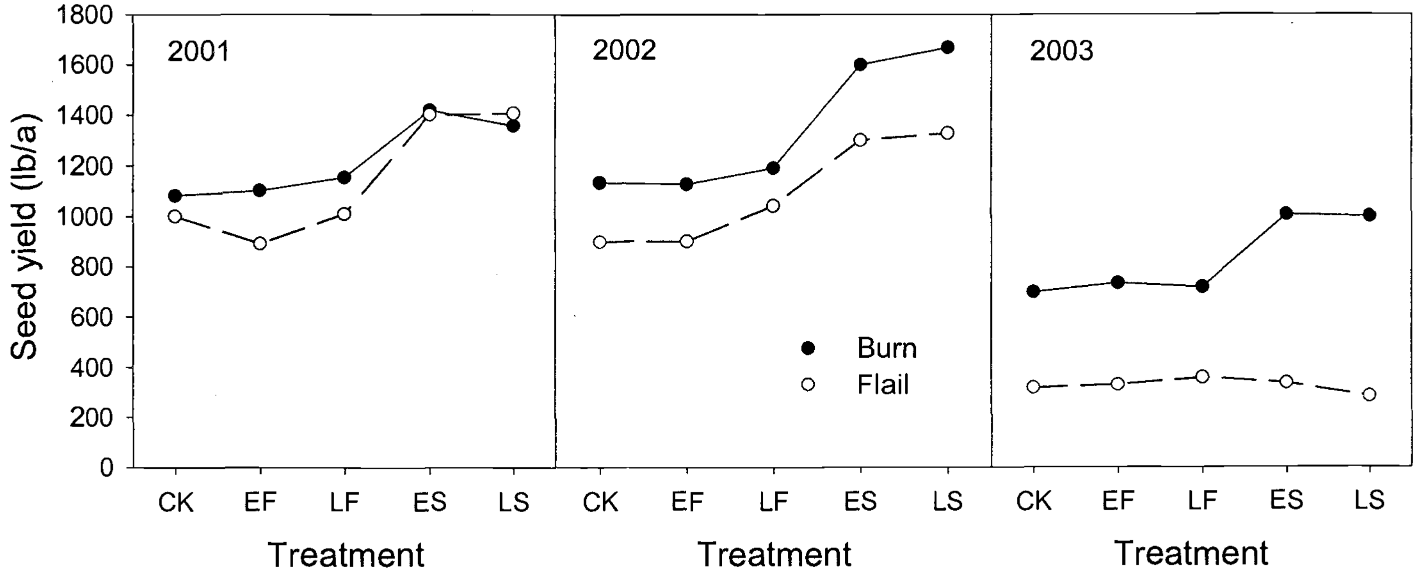

Figure 1. Effect and interaction of Palisade treatment and residue management on seed yield of creeping red fescue on first year (2001), second year (2002), and third year (2003). Treatment legend: CK=control; EF=early fall; LF=late fall; ES=early spring; LS=late spring application.

DECREASING SHATTERING LOSSES BY APPLICATION OF AVG IN PERENNIAL RYEGRASS

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Introduction

Loss of seed due to shattering, which is caused by abscission before harvest, is one of the major problems in grass seed production. Shattering of grass seed before harvest causes reduced seed yields and is promoted by a naturally-occurring hormone in the plant, ethylene. Delay of detachment from the mother plant gives an opportunity for the seed to properly fill. Several compounds have been developed to block ethylene synthesis in the plant but only aminoethoxyvinylglycine (AVG) is available for use in commercial agriculture. AVG inhibits ACC oxidase, which converts SAM (S-adenosylmethionine) to ACC (1-aminocyclopropane-1-carboxylic acid), a precursor of ethylene. The objective of this study was to test the use of AVG to decrease seed shattering in perennial ryegrass.

Procedure

Green house trial.

Greenhouse trials were conducted examine a non-vernalizing clone of 'Cutter' perennial ryegrass. Flag leaf chlorophyll content was measured to determine AVG effects on crop maturity at the time of treatment and again every week until harvest with the Minolta chlorophyll meter (SPAD-502). We want to know how AVG might affect crop yield components (spike number, spikelets per spike, florets per spike) of perennial ryegrass. The Zadoks stage of development of tillers was determined at the time of treatment and recorded. AVG was applied at 50 ppm (0.0033 g a.i/pot) and 100 ppm (0.0066 g a.i/pot), and replicated 9 times at stem elongation, boot, inflorescence, and anthesis stages. In addition, a 0 ppm (water control) treatment was applied at each growth stage.

Field trial

Trials were conducted in a field of 'Cutter' perennial ryegrass at Hyslop Farm planted in spring 1999. This trial was designed to determine applications of AVG on shattering-induced seed losses and crop yield in perennial ryegrass. AVG was applied in when the inflorescence was emerged at 100 ppm (180 g a.i./ha), 200 ppm (360 g a.i./ha), 300 ppm (540 g a.i./ha), and was replicated 4 times. AVG treatments were applied at walking speed using a 10-foot wide bicycle-type boom sprayer with nozzles at 18 inch spacing.

Results

There are two different abscission layers, which are the points of disarticulation. The first type of shattering occurs at the rachilla and results in the loss of the floret. The second type involves loss of the entire spikelet and occurs at the pedicel. In the greenhouse study, we counted shattered florets and spikelets separately. Examination of shattered seeds showed that AVG application reduced shattering as both florets and spikelets compared with the untreated control (data not shown). The lower seed shattering resulted from the higher AVG rate (100 ppm) at the inflorescence stage application (Figure 1). Furthermore, the higher AVG rate had more chlorophyll than the control at inflorescence stage application (Figure 2). Examination of the greenhouse trial data reveals that the inflorescence stage is the optimum application timing.

Seed yield was significantly increased only at 300 ppm, whereas 100 ppm and 200 ppm produced lower yields than the control. The lowest yield resulted from a 100 ppm application (Figure 3). Seed size (1000 seed weight) was increased by low AVG rate at 100 ppm and 200 ppm and decreased by higher AVG rate at 300 ppm application (Figure 4).

AVG had no significant effect on the level of seed abortion; however, application of AVG reduced shattering prior to swathing (Table 1). Seed shattering losses after swathing (during the drying period) were slightly greater with AVG treatment than the control, but not significantly so. It is possible that swathing caused wound-induced production of ethylene resulting in additional seed shattering, especially in AVG treated plots. Overall, the total seed losses attributable to shattering were not effected by AVG and the effect on seed yield was nominal (Figure 3). The only statistically significant difference in seed yield was that the 300 ppm AVG rate out yielded the 100 ppm rate. A possible explanation for this lack of yield improvement with reduced shattering might involve the effect of AVG on seed weight (Figure 4). Seed weight responses to AVG rate were inversely proportional to those responses observed for seed yield. As more seed was retained in AVG-treated plots, especially at higher rates (Table 1), seed weight was reduced at these high rates. Since work on wheat indicates that AVG increases seed weight, it is likely that the greater retention of seed caused the photosynthates to be allocated among a greater number of seeds.

Table 1. Effect of AVG treatment on seed shattering of Cutter perennial ryegrass.

AVG treatment	Abortion	Shattering (No. of seeds/spike) Before swathing	Windrow	Total
Check	43	85	16	101
100ppm	47	60	31	92
200ppm	46	61	27	88
300ppm	53	49	32	80
LSD 0.05	NS	21	NS	NS

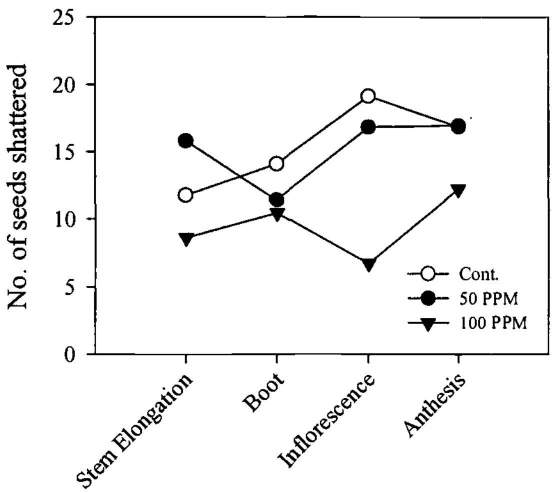

Figure 1. AVG treatment effect on seed shattering of Cutter perennial ryegrass.

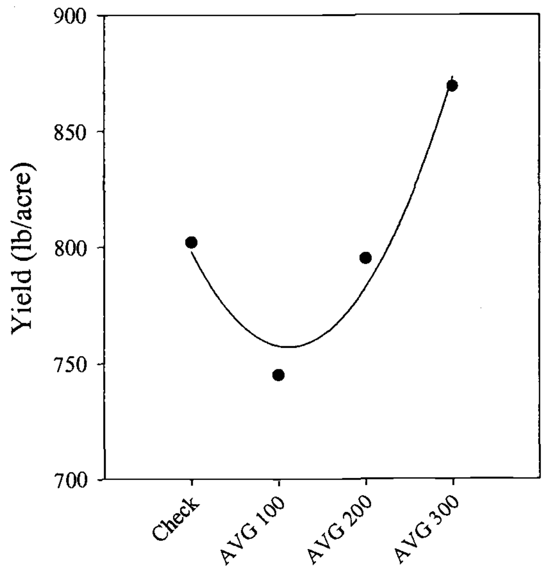

Figure 3. AVG treatment rate effects on clean seed yield of Cutter perennial ryegrass at Hyslop, 2003.

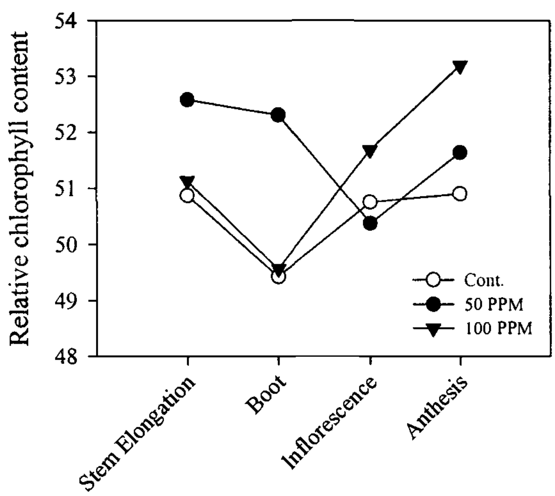

Figure 2. AVG treatment effect on chlorophyll contents of Cutter perennial ryegrass.

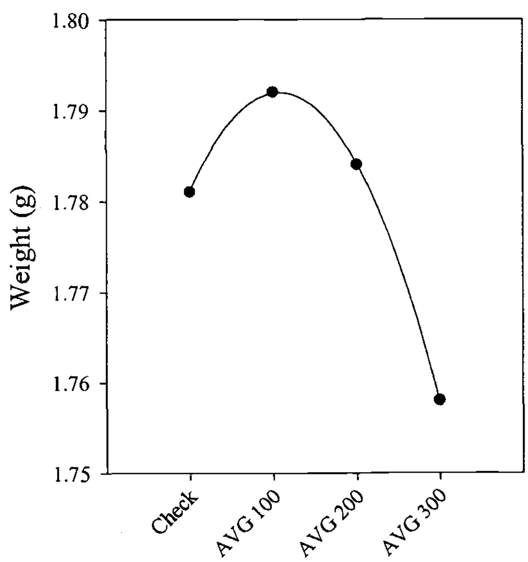

Figure 4. Average 1000 seed weight of Cutter perennial rye-grass following varied rates of AVG, 2003.

ANNUAL BLUEGRASS CONTROL IN CARBON-SEEDED PERENNIAL RYEGRASS

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

Introduction

The application of activated charcoal (carbon) over the seed row to safen a perennial ryegrass crop to preemergence herbicides has been a common practice in grass seed production in Oregon for over three decades. During that time annual bluegrass (*Poa annua*) developed resistance to diuron (Karmex, Direx) in some fields. Stand establishment in these fields would benefit from an alternative to diuron.

Four trials were conducted to assess the merits of applying norflurazon (Solicam), pronamide (Kerb), and flumioxazin (Valor), as preemergence broadcast treatments over activated carbon.

Methods

The experimental design for each trial was a randomized complete block with four replications. Individual plots were 8 ft by 35 ft. Soil at the OSU Hyslop Research Farm was a Woodburn silt loam with an organic matter content of 2.4% and a pH of 5.6; soil at the Tangent site was a Dayton silt loam with an organic matter content of 6.2% and a pH of 5.0; and soil at the Shedd site was an Amity silt loam with an organic matter content of 6.2% and a pH of 6.7. The Hyslop site was infested with non-resistant annual bluegrass. Both sites in growers' fields were infested with suspected diuron-resistant annual bluegrass. 'Affinity' perennial ryegrass was seeded September 22, 2002 in the Hyslop trial. 'Prelude' perennial ryegrass was seeded on October 2, 2002, at the Tangent site, and October 8, 2002, at the Shedd trial. Activated carbon was applied over the seed row in a 1-inch band at 300 lb/a during the planting process at all sites. Herbicide timing was September 23, 2002 for the Hyslop trial, October 4, 2002 for the Tangent site, and October 8, 2002 for the Shedd site. Herbicides were applied in water at 20 gallons per acre at 20 psi. Visual evaluations were conducted periodically to assess annual bluegrass and volunteer perennial ryegrass control and perennial ryegrass injury.

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

Results

Annual bluegrass control was less effective in growers' fields than at the Hyslop site (Table 1). Flumioxazin, when added to diuron, was not effective in providing annual bluegrass control. The pronamide and norflurazon treatments were most consistent in controlling annual bluegrass. Annual bluegrass control within the seed row was most consistent where norflurazon was applied.

Crop protection with activated carbon was adequate in all herbicide treatments and at all locations. The norflurazon and pronamide treatments at both off-station sites caused considerable chlorosis through February, but did not impact grass seed yield (Table 2).

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

Pronamide is legal for use at a lower rate than that tested. Norflurazon and flumioxazin are not labeled for any application in grass seed production.

Table 1. Annual bluegrass control in carbon-seeded perennial ryegrass for three locations approximately 3 months after treatment.

Treatment	Rate	Annual bluegrass control		
		Hyslop	Tangent	Shedd
	(lb a.i./a)	----------(%)----------		
Check	0	0	0	0
Diuron + norflurazon	1.6 + 0.98	78	79	79
Diuron + norflurazon	1.6 + 1.96	75	90	90
Diuron + pronamide	1.6 + 0.375	80	91	91
Diuron + pronamide	1.6 + 0.5	85	81	81
Diuron + flumioxazin	1.6 + 0.1	69	44	44
Diuron + flumioxazin	1.6 + 0.2	50	48	48
Diuron	2.4	50	50	38
Pronamide + norflurazon	0.375 + 0.98	88	85	83
Pronamide + flumioxazin	0.375 + 0.1	76	88	83
Norflurazon + flumioxazin	0.98+ 0.1	NA	64	56
LSD 0.05		6.6	9.9	12.1
CV		7.02	10.44	13.32

Table 2. Perennial ryegrass injury in three trial locations.

Treatment	Rate	Perennial ryegrass injury					
		Hyslop		Tangent		Shedd	
		10/7/02	2/5/03	11/4/02	2/7/03	11/4/02	2/7/03
	(lb a.i./a)	(%)					
Check	0	0	0	0	0	0	0
Diuron + norflurazon	1.6 + 0.98	11	3	10	0	10	0
Diuron + norflurazon	1.6 + 1.96	20	3	14	21	18	14
Diuron + pronamide	1.6 + 0.375	3	0	10	38	11	15
Diuron + pronamide	1.6 + 0.5	0	0	14	38	11	18
Diuron + flumioxazin	1.6 + 0.1	0	0	3	3	10	5
Diuron + flumioxazin	1.6 + 0.2	3	0	0	13	11	5
Diuron	2.4	0	0	4	3	9	3
Pronamide + norflurazon	0.375 + 0.98	0	0	0	3	13	3
Pronamide + flumioxazin	0.375 + 0.1	10	0	18	31	21	31
Norflurazon + flumioxazin	0.98 + 0.1	NA	NA	8	31	21	25
LSD 0.05		7.7	NS	6.3	14.0	6.3	10.2
CV		115.23	7.02	60.67	59.5	35.42	7.1

TOLERANCE OF FALL-PLANTED SEEDLING GRASSES TO CARFENTRAZONE TANK-MIXES

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Introduction

Moderate injury to spring-planted seedling grasses with carfentrazone (Aim) tank-mixed with various broadleaf herbicides was observed in our previous studies. Similar experiments were conducted in 2002-2003 to evaluate carfentrazone on fall-planted seedling perennial ryegrass, tall fescue, orchardgrass, fine fescue, bentgrass, and annual ryegrass. The same treatments were applied to all six grasses, however, ethofumesate (Nortron) is not registered for fine fescue, orchardgrass, or seedling bentgrass.

Methods

Six trials were conducted at the OSU Hyslop Research Farm near Corvallis with one trial for each of the following grasses: 'Affinity' perennial ryegrass, 'Cochise II' tall fescue, 'Potomac' orchardgrass, 'Shademaster' fine (creeping red) fescue, 'King' colonial bentgrass, and blended annual ryegrass. Perennial ryegrass, tall fescue, and orchardgrass were carbon-seeded in 12 inch row spacing on September 20, 2002, with 25 lb/a of carbon and treated with 2.6 lb a.i./a of diuron on September 23. The fine fescue, colonial bentgrass, and annual ryegrass were seeded without carbon on October 8. Experiments were arranged as randomized complete blocks with four replications of 8 ft by 10 ft plots of perennial ryegrass, tall fescue, and orchardgrass; and 8 ft by 15 ft plots of fine fescue, colonial bentgrass, and annual ryegrass. The soil was a Woodburn silt loam with an organic matter content of 2.4% and a pH of 5.6. Treatments were applied early postemergence to grass seedlings with 2 leaves and late postemergence to grasses with at least 3 tillers. Herbicides tank-mixed with carfentrazone were 2,4-D amine, MCPA amine, dicamba (Banvel, Clarity), tribenuron (Express), clopyralid+MCPA (Curtail M), bromoxynil+MCPA (Bronate), or ethofumesate.

Results

Crop safety with fall-planted grasses was much greater than in previous research with spring-planted grasses. The reduction in crop injury is presumably from cooler temperatures and shorter photoperiods in late-fall and winter resulting in slower metabolism compared to environmental conditions in late-spring and early-summer. Most of the injury from the 2-leaf timing was no longer visible by January, but injury was observed again in March when grasses resumed more active growth (Tables 1 and 2). Carfentrazone alone caused minimal crop injury.

For perennial ryegrass and tall fescue, the 2-leaf timing was more injurious than the 3-tiller timing (Tables 1 and 3). Herbicides tank-mixed with carfentrazone tended to increase injury at the 2-leaf timing, but not excessively. The addition of tribenuron to carfentrazone was the most injurious of all the treatments for both grasses at either timing (Table 4).

Orchardgrass was the most sensitive grass tested, as in previous research. Bromoxynil + MCPA with carfentrazone at the 2-leaf timing severely injured orchardgrass and resulted in reduced stand density (Table 1). Clopyralid + MCPA and ethofumesate also slightly reduced the orchardgrass population. Herbicides applied at the 3-tiller timing improved crop safety on orchardgrass for all treatments.

For fine fescue and colonial bentgrass, initial crop injury was greater at the 3-tiller timing than the 2-leaf timing (Tables 2 and 3). At the final evaluation there was minimal injury from any treatment except ethofumesate, which is not registered. Biomass yield for fine fescue may not represent treatment effects because of stand variability (Table 5). There was no observable injury from 2,4-D and carfentrazone on colonial bentgrass, but this treatment reduced biomass more than any other, with the exception of ethofumesate.

Annual ryegrass injury was minimal and biomass yield did not differ among treatments.

Table 1. Herbicide injury on fall-planted seedling grasses with 2 leaves at time of application on Hyslop Farm, Corvallis, Oregon, 2002-2003.

Treatment	Rate	Perennial ryegrass			Tall fescue			Orchardgrass		
		3 d 10/14/02	12 wk 1/8/03	24 wk 3/31/03	3 d 10/19/02	12 wk 1/8/03	24 wk 3/31/03	3 d 10/19/02	12 wk 1/8/03	24 wk 3/31/03
	(lb a.i./a)	(% injury)								
carfentrazone	0.016	6	0	0	4	0	0	15	0	0
carfentrazone / 2,4-D	0.016/ 0.25	8	0	0	9	0	0	19	3	0
carfentrazone / MCPA	0.016/ 0.375	10	0	0	8	0	0	23	11	10
carfentrazone / dicamba	0.016/ 0.25	4	0	5	10	0	0	11	8	0
carfentrazone / tribenuron	0.016/ 0.0156	10	0	25	5	0	0	19	4	0
carfentrazone / clopyralid + MCPA	0.016/ 0.3	20	0	8	14	0	0	23	8	13
carfentrazone / bromoxynil + MCPA	0.016/ 1.0	25	0	28	19	0	0	48	25	23
carfentrazone / ethofumesate	0.016/ 1.5	14	0	18	11	0	0	30	13	5
check	0	0	0	0	0	0	0	0	0	0
LSD 0.05	---	6	NS	12	7	NS	NS	10	17	16

Table 2. Herbicide injury on fall-planted seedling grasses with 2 leaves at time of application on Hyslop Farm, Corvallis, Oregon, 2002-2003.

		Fine fescue			Colonial bentgrass			Annual ryegrass		
		6 d	8 wk	18 wk	6 d	7 wk	17 wk	10 d	9 wk	21 wk
Treatment	Rate	12/2/02	1/22/03	3/31/03	12/9/02	1/22/03	3/31/03	11/15/02	1/8/03	3/31/03
	(lb a.i./a)	(% injury)								
carfentrazone	0.016	8	0	0	13	0	0	10	0	0
carfentrazone / 2,4-D	0.016/ 0.25	9	0	0	16	0	0	18	0	0
carfentrazone / MCPA	0.016/ 0.375	13	0	0	15	0	3	14	13	0
carfentrazone / dicamba	0.016/ 0.25	13	0	0	15	0	10	15	0	0
carfentrazone / tribenuron	0.016/ 0.0156	9	0	0	14	0	10	14	9	0
carfentrazone / clopyralid + MCPA	0.016/ 0.3	14	0	5	25	0	10	20	16	0
carfentrazone / bromoxynil + MCPA	0.016/ 1.0	18	0	0	25	0	5	21	20	0
carfentrazone / ethofumesate	0.016/ 1.5	11	75	100	19	26	63	14	0	0
check	0	0	0	0	0	0	0	0	0	0
LSD 0.05	--	5	0	10	7	1	20	7	10	NS

Table 3. Herbicide injury on fall-planted seedling grasses with at least 3 tillers at time of application on Hyslop Farm, Corvallis, Oregon, 2003.

Treatment	Rate	Perennial ryegrass 13 d 1/22	Perennial ryegrass 12 wk 3/31	Tall fescue 13 d 1/22	Tall fescue 12 wk 3/31	Orchard-grass 13 d 1/22	Orchard-grass 12 wk 3/31	Fine fescue 6 d 3/4	Fine fescue 5 wk 3/31	Colonial bentgrass 6 d 3/4	Colonial bentgrass 5 wk 3/31	Annual ryegrass 13 d 1/22	Annual ryegrass 12 wk 3/31
	(lb a.i./a)	---(% injury)---											
carfentrazone	0.016	4	0	8	0	6	3	9	5	13	5	5	0
carfentrazone / 2,4-D	0.016/ 0.25	3	0	5	0	5	5	16	5	20	18	3	0
carfentrazone / MCPA	0.016/ 0.375	3	0	3	0	3	13	18	0	20	13	3	0
carfentrazone / dicamba	0.016/ 0.25	3	0	6	0	4	0	18	0	18	3	4	0
carfentrazone / tribenuron	0.016/ 0.0156	1	13	3	0	6	0	13	8	13	8	1	0
carfentrazone / clopyralid + MCPA	0.016/ 0.3	6	0	6	0	4	10	23	11	33	10	11	0
carfentrazone / bromoxynil + MCPA	0.016/ 1.0	5	0	11	0	15	10	21	13	36	20	19	0
carfentrazone / ethofumesate	0.016/ 1.5	4	10	6	0	3	0	9	94	21	93	5	0
check	0	0	0	0	0	0	0	0	0	0	0	0	0
LSD 0.05	---	5	12	4	0	4	16	8	10	11	20	5	0

Table 4. Fresh biomass of grasses harvested before heading, following herbicide applications on grasses with 2 leaves or at least 3 tillers at Hyslop Farm, Corvallis, Oregon, 2003.

Treatment	Rate	Growth stage at application	Perennial ryegrass biomass 5/27/03	Tall fescue biomass 5/19/03	Orchardgrass biomass 5/5/03
	(lb a.i./a)		-------------------------------(tons/a)	-------------------------------	
carfentrazone	0.016	2-leaf	7.1	12.1	7.5
carfentrazone / 2,4-D	0.016/ 0.25	2-leaf	6.0	11.4	5.4
carfentrazone / MCPA	0.016/ 0.375	2-leaf	6.3	13.4	4.3
carfentrazone / dicamba	0.016/ 0.25	2-leaf	5.0	12.4	5.2
carfentrazone / tribenuron	0.016/ 0.0156	2-leaf	4.3	9.5	5.9
carfentrazone / clopyralid + MCPA	0.016/ 0.3	2-leaf	5.7	10.2	5.4
carfentrazone / bromoxynil + MCPA	0.016/ 1.0	2-leaf	4.4	10.3	3.3
carfentrazone / ethofumesate	0.016/ 1.5	2-leaf	4.4	10.6	4.9
carfentrazone	0.016	3-tiller	4.9	12.0	7.5
carfentrazone / 2,4-D	0.016/ 0.25	3-tiller	6.2	12.8	5.1
carfentrazone / MCPA	0.016/ 0.375	3-tiller	4.3	13.9	7.8
carfentrazone / dicamba	0.016/ 0.25	3-tiller	5.4	10.9	7.5
carfentrazone / tribenuron	0.016/ 0.0156	3-tiller	4.3	10.5	7.7
carfentrazone / clopyralid + MCPA	0.016/ 0.3	3-tiller	6.4	11.6	7.4
carfentrazone / bromoxynil + MCPA	0.016/ 1.0	3-tiller	6.0	13.5	5.7
carfentrazone / ethofumesate	0.016/ 1.5	3-tiller	5.4	12.6	5.3
check	0	---	6.6	13.9	7.3
LSD 0.05	---	---	2.1	2.7	3.1

Table 5. Fresh biomass of grasses harvested before heading, following herbicide applications on grasses with 2 leaves or at least 3 tillers at Hyslop Farm, Corvallis, Oregon, 2003.

Treatment	Rate	Growth stage at application	Fine fescue biomass 6/2/03	Colonial bentgrass biomass 6/2/03	Annual ryegrass biomass 4/1/03
	(lb a.i./a)		(tons/a)		
carfentrazone	0.016	2-leaf	1.6	6.6	10.7
carfentrazone / 2,4-D	0.016/ 0.25	2-leaf	1.8	4.6	10.6
carfentrazone / MCPA	0.016/ 0.375	2-leaf	1.0	7.0	9.4
carfentrazone / dicamba	0.016/ 0.25	2-leaf	2.2	5.6	10.0
carfentrazone / tribenuron	0.016/ 0.0156	2-leaf	2.5	5.2	9.4
carfentrazone / clopyralid + MCPA	0.016/ 0.3	2-leaf	2.4	5.1	9.6
carfentrazone / bromoxynil + MCPA	0.016/ 1.0	2-leaf	2.3	6.4	9.6
carfentrazone / ethofumesate	0.016/ 1.5	2-leaf	0.0	4.3	9.3
carfentrazone	0.016	3-tiller	1.4	4.8	9.5
carfentrazone / 2,4-D	0.016/ 0.25	3-tiller	1.8	3.9	10.0
carfentrazone / MCPA	0.016/ 0.375	3-tiller	2.1	5.3	9.9
carfentrazone / dicamba	0.016/ 0.25	3-tiller	1.5	5.8	10.3
carfentrazone / tribenuron	0.016/ 0.0156	3-tiller	1.5	5.3	10.4
carfentrazone / clopyralid + MCPA	0.016/ 0.3	3-tiller	1.6	5.3	10.2
carfentrazone / bromoxynil + MCPA	0.016/ 1.0	3-tiller	1.4	5.1	10.1
carfentrazone / ethofumesate	0.016/ 1.5	3-tiller	0.0	0.8	9.0
check	0	---	2.5	6.0	10.1
LSD 0.05	---	---	1.4	1.9	NS

EFFECT OF HERBICIDE RATE AND APPLICATION TIMING ON ANNUAL RYEGRASS COVERCROP REMOVAL WITH GLYPHOSATE

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Introduction

Annual ryegrass has been undergoing testing in the Midwestern and Southern regions of the U.S. as a winter cover crop within conventional tillage corn-soybean rotations. Winter cover crops have been proven effective in reducing soil erosion via runoff, consequently mediating nitrate and herbicide losses following snowmelt. Soil organic matter is also improved when the plant material is turned into the soil. However, concerns have been raised that annual ryegrass has the potential to be yet another troublesome weed if it is not *completely* controlled before planting corn or soybeans in the spring. Four trials were established during the fall of 2002 in Corvallis, OR; Simpson, IL; West Lafayette, IN; and Jackson, TN to test the efficacy of glyphosate in removing an annual ryegrass winter cover crop.

Materials and Methods

A custom-mixed blend of several Oregon-grown common annual ryegrass cultivars was sown at a rate of 30 lb/a at each location. Three rates of glyphosate, 0.5, 1.0, and 2.0 lb a.i./a, were applied at each of four annual ryegrass growth stages: late tiller, second node, boot, and early flower. An untreated check was also included for a total of 13 treatments. The experimental design for each trial was a randomized complete block with four replications. Individual plots were 10 ft by 15 ft. Spray volume for all trials was 10 gallons per acre. Annual ryegrass biomass was measured in Oregon, Illinois, and Tennessee by clipping a 10.6 ft^2 swatch from a random location within each plot and differentially weighing the living and dead portions of the sample. Total biomass was measured in Indiana. Ten randomly selected seed heads were collected from each plot to test for seed production and viability. Planting, application, and sampling dates for each trial location are presented in Table 1.

Results and Conclusions

Annual ryegrass control at each location was directly related to glyphosate rate, regardless of growth stage at the time of application. Glyphosate applied at 2.0 lb a.i./a to late tiller annual ryegrass provided the most complete control in Oregon and Illinois. No treatment provided greater than 90 percent annual ryegrass control in Illinois. Glyphosate at 2.0 lb a.i./a provided greater than 95 percent control when applied prior to early flowering in Indiana, but no rate was adequate when applied later. Annual ryegrass was most effectively controlled in Tennessee with the high rate of glyphosate applied at the late tiller and early flower stages of growth (Table 2).

Annual ryegrass biomass was reduced when compared to the untreated check with all glyphosate treatments and at all but the Tennessee location (Table 3). Less biomass was produced in Tennessee than the other locations. Glyphosate applied at the high rate to early- flower annual ryegrass provided total control while returning the greatest relative quantity of biomass to the soil. No effort was made to segment the annual ryegrass biomass in Indiana. More living biomass was measured following 2.0 lb a.i./a glyphosate applied at boot and early-flower stages of growth in Illinois versus Oregon and Tennessee. The increase in biomass at the Illinois site is probably a result of following a legume cover crop in fallow.

The return of viable seed to the soil is of major concern, and was observed frequently in both Illinois and Tennessee (Table 4). No seed was recovered in Oregon or Indiana; however, a more exhaustive sampling technique may produce a different result. No single rate of glyphosate at any timing was effective in both completely killing annual ryegrass and preventing viable seed production. The escapes may be the result of insufficient spray coverage, or the presence of a more tolerant ryegrass cultivar in the seeding blend.

In practice, glyphosate is usually applied aerially at spray volumes around 5 gallons per acre, which is lower than the spray volume used in these studies. This application method is necessary because soil moisture conditions in the spring will not allow a wheeled spray rig in the field prior to seed bed preparation and/or planting operations. A sequential herbicide application program may be required to provide adequate control.

Table 1. Planting, application, and sampling dates for 4 trial locations near Corvallis, OR, Simpson, IL, West Lafayette, IN, and Jackson, TN.

	Location			
	Oregon	Illinois	Indiana	Tennessee
Planting date	September 19, 2001	September 13, 2001	September 20, 2001	October 5, 2001
A. ryegrass stage of growth at each glyphosate application				
Late tiller	February 13, 2002	February 22, 2002	April 12, 2002	February 11, 2002
Second node	April 12, 2002	April 10, 2002	April 23, 2002	March 11, 2002
Boot	April 23, 2002	April 23, 2002	May 10, 2002	April 22, 2002
Early flower	May 1, 2002	May 10, 2002	May 22, 2002	April 29, 2002
Sampling date	May 23, 2002	May 23, 2002	June 14, 2002	May 21, 2002

Table 2. Annual ryegrass control as influenced by glyphosate rate and application timing.

Glyphosate treatment[b]	Rate	Annual ryegrass control[a]			
		Oregon	Illinois	Indiana	Tennessee
Timing	(lb a.i./a)	(%)			
Late tiller	0.5	65	28	94	73
	1.0	92	65	98	89
	2.0	96	83	99	96
Second node	0.5	29	25	92	18
	1.0	40	50	96	31
	2.0	60	71	97	46
Boot	0.5	39	25	40	30
	1.0	65	45	91	50
	2.0	84	78	96	88
Early flower	0.5	67	35	20	41
	1.0	75	73	40	61
	2.0	75	73	33	90

[a]Visual control ratings for Corvallis, Simpson, West Lafayette and Jackson taken on May 13, May 23, May 28 and May 13, 2002, respectively.
[b]Roundup™ ULTRA MAX (5 pounds per U.S. gallon of the active ingredient glyphosate, in the form of its isropylamine salt) applied in 10 gallons per acre spray volume.

Table 3. Effect of glyphosate rate and application timing on annual ryegrass cover crop biomass production.

Glyphosate treatment[b]	Rate	Annual ryegrass biomass[a]											
		Oregon			Illinois			Indiana			Tennessee		
		Alive	Dead	Total	Alive	Dead	Total	Alive	Dead	Total	Alive	Dead	Total
Timing	(lb a.i./a)	(Grams per square meter)											
Late tiller	0.5	91	0	91	490	18	508	NA	NA	68	91	0	91
	1.0	7	0	7	90	0	90	NA	NA	15	38	0	38
	2.0	0.5	0	0.5	39	0	39	NA	NA	1.3	8	0	8
Second node	0.5	604	0	604	564	61	625	NA	NA	159	193	0	193
	1.0	592	3	595	386	48	435	NA	NA	89	184	0	184
	2.0	153	144	297	41	18	59	NA	NA	31	177	0	177
Boot	0.5	577	5	582	669	115	783	NA	NA	608	190	0	190
	1.0	340	188	528	485	169	654	NA	NA	273	245	12	257
	2.0	5	401	405	105	543	648	NA	NA	250	0	251	251
Early flower	0.5	287	280	568	693	238	931	NA	NA	437	205	0	205
	1.0	47	558	605	716	256	972	NA	NA	394	124	115	239
	2.0	4	596	600	571	339	910	NA	NA	396	0	290	290
Untreated	0	1060	0	1060	1075	0	1075	NA	NA	951	204	0	204
LSD 0.05		145	154	165	184	119	122	NA	NA	158	72	67	53

[a]Annual ryegrass biomass samples collected for Corvallis, Simpson, West Lafayette and Jackson on May 23, June 25, June 14, and May 21, 2002, respectively.
[b]Roundup™ ULTRA MAX (5 pounds per U.S. gallon of the active ingredient glyphosate, in the form of its isopropylamine salt) applied in 10 gallons per acre spray volume.

Table 4. Effect of glyphosate rate and application timing on annual ryegrass seed viability near Simpson, IL, and Jackson, TN[a].

Glyphosate treatment	Rate	Annual ryegrass seed viability[b] Illinois	Tennessee
Timing	(lb a.i./a)	---------(Yes/No)	------------
Late tiller	0.5	Yes	Yes
	1.0	Yes	Yes
	2.0	Yes	Yes
Second node	0.5	No	Yes
	1.0	Yes	Yes
	2.0	No	Yes
Boot	0.5	Yes	Yes
	1.0	Yes	No
	2.0	Yes	Yes
Early flower	0.5	Yes	Yes
	1.0	Yes	No
	2.0	No	Yes
Untreated	0	Yes	Yes

[a]Seeds were not recovered in Corvallis, OR and West Lafayette, IN.
[b]Seeds were collected from 10 inflorescences selected randomly in each plot and tested for viability by planting them in potting soil in the greenhouse.

FALL PLANTING DATE AFFECTS SPRING STEM RUST LEVEL IN FIRST-YEAR PERENNIAL RYEGRASS

W.F. Pfender

Introduction

Choice of planting date within the season is a cultural practice that can affect plant disease development. For many diseases of fall-planted crops, early planting can increase exposure to autumn inoculum, and thus infection. Although late autumn planting might reduce disease in spring, a late-planted crop may produce lower yields than an early-planted crop in the absence of disease. Also, if later planting results in later maturity, the crop may be exposed to a more prolonged rust epidemic during summer before harvest. The purpose of the experiments reported here was to determine whether date of fall planting has an influence on severity of stem rust in the spring for first-year perennial ryegrass seed crops, and whether seed yield potential is affected by planting date. Rust severity and yield in the first-year stands were compared also with those in established (second-year) stands.

Methods

Experiments were conducted at Hyslop Experiment Farm. Seed was planted in autumn, using a carbon band (containing 7-7-0-6 fertilizer) and Direx herbicide. Additional N fertilizer (granular urea) was applied in mid-March and mid-April each year, at a rate of 60 lb/a of N for each application. Second-year stands received 38 lb/a each of N, P (as P_2O_5), and K in October, i.e., approximately one year after planting.

Severity of stem rust was determined in June of each year. For each measurement, a square frame with a 6 X 6 inch opening was tossed arbitrarily into a plot, and pressed down against the grass. The number of erumpent pustules of stem rust visible on the plant tissue within the frame opening (0.25 ft^2) was counted. For severities > 100 pustules per sample, severity was estimated as % rusted leaf area, then converted to number of pustules for analysis.

Two types of experiment were conducted. One was designed to measure effects of stand age (first or second seed-crop year), and planting date (early or late autumn) within first-year stands, on stem rust severity and yield potential in one cultivar. In the second type of experiment, planting date (early or late) was assessed for its effect on stem rust severity in first-year stands of several different cultivars.

Stand age and planting date effects on yield potential and rust severity. 'Morningstar' perennial ryegrass was planted in plots (14 X 30 ft), with 45-ft alleys kept free of grasses and other weeds with herbicides. For each planting date treatment, there were two treatments with respect to management of stem rust: treated with fungicide (for yield potential measurement), or non-treated (to permit rust development). The six treatments were arranged on the field as a completely randomized experimental design, with four replications. The experiment was conducted in 1998-2000, and repeated in 1999-2001.

In the experiment conducted for harvest in 2000, the planting dates for early-planted and late-planted first-year plots were 16 September 1999 and 3 November 1999. Second-year plots had been planted 20 September, 1998. Rust severity was determined on 6 June, 2000. Effect of planting date on yield potential (yield in the absence of disease) was determined by harvesting seed from the fungicide-treated plots. Stem rust severity was controlled to <10 pustules per 0.25 ft^2 throughout the season in the fungicide-treated plots by applying Tilt (6 oz/a) on 19 April, 23 May, 5 June, and 19 June, 2000, and Quadris (9 oz/a, with surfactant added) on 12 May, 2000. Plots for each planting-date treatment were swathed when the moisture content of the ripening seed had fallen to 35%. In 2000, early-planted first-year plots were swathed on 5 July, second-year plots on 6 July, and late-planted first-year plots on 7 July. After swathing, the cut plants were put into burlap bags where they were allowed to dry outdoors for 12 days, then oven-dried overnight and threshed in a belt thresher. Seed was cleaned to industry standards and weighed.

In the experiment conducted for harvest in 2001, planting dates were 16 September 1999 for the second-year treatment, and 21 September and 6 November 2000 for early- and late-planted first-year treatments. In addition, there was an intermediate planting date treatment ("mid-planted") for first-year plots, planted on 16 October 2000. Stem rust severity was determined on 19 June 2001. Fungicides were applied as follows: Tilt on 10 May and 3 June, and Quadris on 20 June. Fungicide-protected second-year plots were swathed on 2 July, 2001. Early- and mid-planted first-year plots of protected ryegrass were swathed on 3 July, and late-planted first-year plots on 6 July. Seed was threshed and cleaned.

Comparison of cultivars. The effects of autumn planting date on spring stem rust severity in first-year stands of several different cultivars were compared in an experiment conducted in 2000-2001, and repeated (new plantings) in 2001-2002. The cultivars in the study were: Jet, Morning Star, Manhattan 4, Elka, Kingston and Marathon. The last two cultivars are New Zealand forage cultivars.

Each year, the experiment was established as a completely randomized design with 6 replications for each of the 6 cultivars. Each replicate plot was 10 ft long and 3 rows wide, with 3 ft distance of bare ground between adjacent plots. In the first experiment, early and late plantings were done on 5 October and 7 November, 2000, respectively. Emergence dates were 20 October and 29 December, 2000. Stem rust severity in these plantings was assessed on 6 June, 2001, based on 3 measurements per replicate plot. When the experiment was repeated, early and late plantings were done on 4 October (emergence 16 October) and 6 November (emergence 27 December), 2001, respectively. Stem rust severity was determined on 3 June, 2002.

Results

Severity of stem rust in perennial ryegrass cultivar "Morningstar" on 6 June, 2000 was significantly greater in plots planted on 16 September, 1999 than in those planted on 3 November, 1999. When the experiment was repeated for the 2001 harvest year, the early-planted plots again had more disease than the late-planted plots on 3 June. Disease levels in the second-year stands were intermediate between the early- and late-planted first-year stands (Table 1). Disease severity in the additional, mid-fall planting date (16 October) in the 2000-2001 experiment did not differ from that in the late-planted treatment.

Seed yield potential of first-year perennial ryegrass was affected by fall planting date (Table 1). In stands kept free of stem rust by fungicide applications, seed yield was significantly less in November-planted plots than in September-planted plots. The additional, mid-fall planting date (16 October 2000) that was done in the 2000-2001 experiment produced the same yield as the early-planted treatment, significantly more than the late-planted crop. Analysis of the combined data for 2 years showed no significant difference in yield between second-year and early-planted first-year plots.

The significant difference in stem rust severity of first-year stands due to fall planting date was observed also for 5 of 6 perennial ryegrass cultivars in the two cropping years (Table 2). For cultivar Jet, which had the greatest rust severity, late planting resulted in a 32-fold decrease in disease severity compared to early planting. For cultivars with sequentially decreasing rust severities at the June observation date (Morning Star, Manhattan 4, Kingston, and Marathon), disease severities in late plantings were 17, 8, 4, and 4 times lower than in early plantings of the respective cultivars. For cultivar Elka, which had the lowest level of rust, there was no significant difference in severity of stem rust in June due to fall planting date.

Summary

Date of autumn planting had a consistent and statistically significant effect on severity of stem rust in first-year stands of perennial ryegrass. Stands planted in early November had only 2% to 4% as many rust pustules in June as did stands planted in the latter half of September. There was a productivity cost to late planting, however, as late-planted stands produced a seed yield 23% less than the early-planted stands, in plots where rust was essentially eliminated by the use of fungicides. In the repeat of the study, an intermediate autumn planting date (mid-October) produced a stand with yield potential equivalent to the early-planted stand, but with the favorable rust reduction seen in the late-planted stand. Therefore, it appears possible that appropriate choice of planting date could reduce the hazard of subsequent stem rust development without sacrificing yield potential. Additional research is required to determine the factors involved (and their predictability) in balancing yield potential against disease hazard in choice of planting date.

The results suggest that autumn planting date affects spring stem rust epidemics for most cultivars of perennial ryegrass. Cultivars representing turf and forage types, of intermediate and early maturity, showed the effect. The most highly susceptible cultivars showed the greatest benefits to late planting. Among the cultivars tested, an exception to rust reduction by late planting was seen in cultivar Elka, which is a very late-maturing variety. Other observations we have made (unpublished) show that Elka becomes severely rusted later in the season, and it is possible that an effect of planting date on disease severity would have been observed later in June.

The explanation for the association of early fall planting with increased spring rust severity in spring is likely the longer duration of exposure of plants to inoculum and thus potential infections in the fall, although this hypothesis was not directly tested. Overwinter weather conditions could then influence survival of rust. Fall infections would provide the starting population, and a larger population would have a greater probability of surviving, through reproduction, than a smaller population. A detailed study is in progress to quantify and model the factors involved in overwinter survival of stem rust on ryegrass plants.

If prolonged availability of host tissue for infection in the fall is the primary explanation for the association of early planting with increased spring rust severity, it is interesting that the second-year stands are less severely diseased in the spring than are the early-planted first-year stands. Second-year plants present a greater leaf area, with overall longer duration, in the autumn than do early-planted new crops. The older plants may be less susceptible to infection, and/or their dynamics of plant growth and leaf senescence in winter may be different from that of first-year plants and less favorable to survival of the rust population.

Acknowledgments:

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

Table 1. Effect of stand age and fall planting date on spring stem rust severity and yield potential of 'Morningstar' perennial ryegrass grown for seed.

Harvest year	Stand age	Planting date	Rust severity[x]	Yield potential (lb/A)[y]
2000	1st-year	16-Sep-1999	536.0 a	1649
	1st-year	3-Nov-1999	9.5 b	1342
	2nd-year	20-Sep-1998	124.9 a	1405
			P <0.001	P = 0.126 (n.s.)
2001	1st-year	21-Sep-2000	86.1 a	1564 a
	1st-year	16-Oct-2000	0.3 b	1528 a
	1st-year	6-Nov-2000	3.1 b	1117 b
	2nd-year	16-Sep-1999	26.5 a	1780 a
			P = 0.001	P = 0.008
Combined[z] 2000 and 2001	1st-year	September	217.8 a	1605 a
	1st-year	November	5.6 c	1231 b
	2nd-year	September (prior year)	57.9 b	1592 a
			P <0.001	P = 0.002

[x] Number of stem rust pustules per 0.25 ft^2 plant canopy in plots receiving no fungicide treatments. Severity measured on June 6, 2000 for harvest year 2000 and June 19, 2001 for harvest year 2001.

[y] Seed yield from other plots of the same planting date, but with stem rust development prevented by fungicide applications. Plots harvested July 5-7, 2000 (2000 harvest year) and July 2-6, 2001 (2001 harvest year).

Within each column and harvest year, values followed by the same letter do not differ at the 0.05 level, as determined by the Student-Newman-Keuls procedure. The P value for treatment effects from the analysis of variance is shown for each data set. 'n.s.' = no signficant difference due to treatment.

[z] Effect of planting date from 2-way analysis of variance using harvest year and planting date as factors.

Table 2. Stem rust disease severity in June for six perennial ryegrass cultivars planted early or late the previous fall.

	Jet	Morningstar	Manhattan 4	Kingston	Marathon	Elka
Early-planted[w]	244.5[v]	74.9	23.5	20.9	10.0	1.8
Late-planted[x]	6.8	3.5	2.0	4.6	2.0	1.2
P value[y]	0.001	0.001	0.001	0.02	0.02	NS

[v] Number of rust pustules per 0.25 ft^2 of grass canopy in first-year stands of ryegrass. Values are averages of 2 separate experiments conducted in sequential years, 6 replicates per cultivar per year.

Severity determined on 6 June 2001 for the 2000 plantings, and 3 June 2002 for the 2001 plantings.

[w] Seed planted in October of the year prior to disease assessment: 5 October 2000 or 4 October 2001.

[x] Seed planted in November of the year prior to disease assessment: 4 November 2000 or 6 November 2001.

[y] P value for difference between early- and late-planted treatments within each cultivar, from 2-way analysis of variance with experiment (year) number and planting date as factors.

NS = no significant effect of planting date.

RAPID RUST INCREASE AFTER FLOWERING IS DUE TO SPREAD WITHIN A PLANT, NOT CHANGE IN SUSCEPTIBILITY

W.F. Pfender

Introduction

Host growth stage is an important factor affecting development in many plant diseases. It is a common observation among growers of perennial ryegrass seed crops that stem rust becomes particularly severe around the time of anthesis, after flower stems have fully extended. This observation has led to a commonly-held assumption that the plants are especially susceptible to infection at and immediately after the time of flower stem extension.

The objectives of the study were to determine whether there are differences in susceptibility of perennial ryegrass plants to infection by the stem rust fungus that are correlated with tissue age and/or growth stage from tillering to flowering. In addition, I report here the very important influence of growth stage on the ability of the pathogen to spread from a single primary infection, producing many stem infections within an infected plant.

Procedures

Perennial ryegrass (cultivar Morningstar) was grown outdoors in 1-gallon pots, 3 plants per pot, starting in September. For the experiments on growth stage and susceptibility, four different stages were induced by bringing plants from the outdoors into the warm, long-day greenhouse on four different dates. At the time of inoculation, the stages were: penultimate leaf (leaf below the flag leaf) visible, boot stage, head emerging, and anthesis beginning.

One tiller on each plant was selected for inoculation, and a standard amount of inoculum (rust spores) was applied to each tiller. Plants were placed overnight (15 h) in a chamber with conditions favorable for rust infection. The plants then were moved onto the greenhouse bench, and maintained until observed for results.

The number of pustules per plant organ (each leaf blade, leaf sheath, flower head and stem) on each inoculated tiller was determined 14 days, or approximately 1½ latent periods, after inoculation. Pustule number per inoculated plant area was calculated separately for each plant organ, based on the area present on the day of inoculation.

To test growth stage as a factor in average susceptibility of plants, a one-way analysis of variance (ANOVA) on whole-plant averages of infection severity (total number of pustules divided by total inoculated area for each pot) was used. For the evaluation of organ position as a factor in susceptibility, a one-way ANOVA was used within each developmental stage to test organ type and position as a factor affecting number of pustules per inoculated area.

Another experiment, to test the idea that the stem rust pathogen can spread to the elongating tiller stem from a single leaf sheath lesion, is described in the results section.

Results

Growth stage and susceptibility. When perennial ryegrass plants were inoculated with urediniospores of the stem rust fungus, the average full-tiller susceptibility to infection (number of pustules divided by plant area inoculated) was not significantly different among the growth stages tested. That is, a given level of inoculum produced about the same number of infections per inoculated area of the tiller whether plants were in the stem extension stage, boot stage, head emergence, or fully-emerged head stage. Within each growth stage, however, there were statistically significant differences in disease severity (pustules per plant area) among plant organs of different positions on the tiller. For the youngest growth stage tested, the leaf blades were equally susceptible, whereas some of the lower (older) leaf sheaths were less susceptible. For the other growth stages, the most recently exposed plant organs were usually the ones with the most disease, although in some cases older organs also were as severely diseased as young organs. For tillers in the boot stage, the flag leaf sheath was particularly receptive to infection. When the head was emerging from the boot, the flag leaf sheath and the newly-exposed inflorescence were especially susceptible. After the inflorescence had emerged completely, and its subtending stem was newly exposed above the sheath of the flag leaf, this stem was significantly more receptive to infection than most other parts of the plant.

Within-plant spread of disease. Approximately 3 weeks after the inoculatIon date (1 week after the previously-described results were observed), elongated rust lesions appeared on the flower head and/or the flower stem on many of the tillers that had been inoculated at the boot or head-emerging stages. These elongated lesions appeared much later than most of the pustules, which had appeared about 9 days after inoculation. Furthermore, the late-appearing pustules appeared on flower heads and stems that had not yet been exposed at the time the initial inoculum was applied.

These observations suggested that the elongated diseased areas were the result of secondary spread within the plant, arising from primary infections on leaf sheaths enclosing the emerging flower heads. It appeared that primary infections on the flag leaf sheath penetrate its inner surface, where they provide inoculum for multiple, adjoining infections of the enclosed flower head as it moves upward past the inner surface of the primary infection site on the sheath.

To test the hypothesis of secondary spread on elongating tillers, individual tillers were each inoculated at a single site on the flag leaf sheath. About 2½ weeks later, elongated lesions occurred on flower heads or stems of most of the tillers that had a pustule on the sheath. There was no rust disease produced on the flower heads or stems of any tillers that lacked a lesion on the flag leaf sheath. Therefore, there was a clear association between lesions on the sheath and elongated lesions on the emerging flower. Additional measurements confirmed that the stem lesions arose from the sheath lesions.

The final length of rusted area on the flower stem results directly from the amount of stem elongation that occurs after the start of spread of infection from the overlying sheath. Under the conditions of these experiments, final lengths of secondary stem infections arising from each single sheath pustule ranged from 1½ to 6 inches.

Microscopic examination of the stem and enclosing sheath confirmed that the rust fungus penetrates the full thickness of the sheath, and produces sporulating pustules on both the outer and inner surfaces at about the same time. Within a day, rust spores released from the pustule on the inner sheath surface germinate on the surface of the enclosed stem and start new infections there.

Summary

The youngest leaves or stems of perennial ryegrass plants were generally more susceptible to rust infection than the older parts. However, in comparing average susceptibility over the whole plant (number of infections per inoculated plant area), there was no significant difference among growth stages from late tillering (prior to flag leaf emergence) to full extension of the inflorescence. Therefore, the increased level of rust commonly appearing near flowering is not due to a greater susceptibility of plants at this stage.

Whereas the effect of plant and tissue age on susceptibility has only limited bearing on stem rust epidemic development, the impact of growth stage on the process of within-plant spread is far more important. This within-plant spread permits a single primary infection on a leaf sheath to be multiplied manyfold through secondary infections on the enclosed, elongating flower head and stem. In addition, the newly expanded sheath and enclosed inflorescence are both young tissue and therefore particularly susceptible to infection. The result is a rapid surge in disease severity (and consequently additional inoculum for the rust epidemic) starting about one latent period (8-12 days) after head emergence, if infections have occurred on the flag leaf sheath. This increase is independent of airborne inoculum and, perhaps to some degree, weather conditions.

Although this study was performed on the flag leaf sheath and enclosed inflorescence, it is likely that the same process occurs on lower sheaths and the structures enclosed there as well. Given the great potential for secondary lesion elongation, within-plant spread may be the predominant mode of stem rust epidemic increase during tiller extension and early flowering in perennial ryegrass.

The existence of extensive, elongated areas of rust disease on the flower and stem of perennial ryegrass is a common observation, but the process by which they develop was previously unknown and generally assumed to be the result of numerous individual stem infections arising from airborne spores. We can now see that this phenomenon results from the ability of the pathogen to penetrate and sporulate on the inner surfaces of sheaths, thereby applying inoculum to an extensive length of particularly susceptible tissue as it elongates past the inoculation point.

The process of within-plant spread has important implications for disease management. The ability of fungicides to affect spore production at the inner face of the sheath, or to affect spore germination or penetration at the stem surface under the sheath, would be critical to their effectiveness. A study on this question is in progress. Also, it may be possible to select for host genetic resistance based on a plant's ability to restrict sporulation of the rust fungus on the inner surface of the sheath.

Acknowledgments:
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THE EFFECT OF STROBILURIN FUNGICIDES ON PERENNIAL RYEGRASS SEED YIELDS IN A YEAR OF LOW RUST PRESSURE

M.E. Mellbye and G.A. Gingrich

Introduction

Stem rust is the major disease problem in perennial ryegrass seed production in the Willamette Valley. Depending on the age of the stand, the variety, and seasonal weather patterns, fields receive from 1 to 4 fungicide applications per year. Although a significant production expense, excellent rust control is obtained with available fungicides. The new class of strobilurin fungicides (Quadris/Abound and Headline) has been reported to provide a seed yield boost beyond that from disease control. Positive effects on yield in other crops have been attributed to physiological effects on plants resulting in better nitrogen utilization and increased stress tolerance. In addition to strobilurin fungicides, claims are made that other products such as foliar fertilizers applied during late bloom or early seed fill in combination with fungicide applications increase grass seed yields. Another example is AuxiGro, a non-fertilizer product reported to enhance yields and/or quality in horticultural crops. These yield-enhancing effects have not been documented in grass seed production in Oregon.

This study was conducted primarily to determine if strobilurin fungicides increase the seed yield of perennial ryegrass under conditions of low disease pressure, or when comparable disease control has been achieved with a different class of fungicides. Foliar fertilizer and AuxiGro treatments were included as part of this trial.

Methods.

Large scale, on-farm seed yield trials were conducted on turf type perennial ryegrass at two farm locations, one in Marion County and one in Linn County. Fungicide products used were:

Propiconazole (Tilt 428 GS)
Chlorothalonil (Bravo Weather Stik 6 SC)
Pyraclostrobin (Headline - or BAS 500 in previous trial work)
Azoxystrobin (Quadris/Abound)

Additional products included for evaluation were: a foliar fertilizer blend (Envy 20-20-20 plus micronutrients), boron (Solubor 17.5% B), and gamma aminobutryic acid or GABA (AuxiGro WP 0.6% a.i.). Treatment dates, product rates, and crop growth stage are listed in Table 1. Applications were made using an ATV mounted sprayer with a 20 ft boom equipped with TeeJet 11002 VS nozzles at 30 psi calibrated to apply 14 gpa. All fungicide treatments included crop oil concentrate (COC) at 0.50%. Plots were arranged in a randomized complete block design with three replications. Individual plot size was 24 feet wide x 250 to 400 feet in length to allow swathing and harvest with grower equipment. A weigh wagon was used to measure combine yields from each plot. Sub-samples of the harvested seed were collected to determine 1000 seed weight, percent cleanout and calculate total clean seed weight.

Results

Weather conditions in 2003 resulted in low rust pressure throughout the Willamette Valley. Only two fungicide applications were needed in these field trials (three were originally planned), and all treatments provided excellent stem rust control. Check plots were mostly rust free throughout the season. Field plots treated with strobilurin fungicides or with foliar fertilizers often appear to remain greener longer into summer; however, in 2003 there were no discernable visual differences among the treatments in these trials with respect to color, the presence of other foliar diseases, or in general appearance.

Seed yields obtained were above the 2003 county averages for perennial ryegrass. A significant increase in seed yield was measured at both locations from all fungicide products tested (Table 2). Average seed yields from the fungicide treatments that included two spray applications (without foliar fertilizer or AuxiGro) were 230 lb/a greater than the check plots.

The strobilurin products Headline and Quadris (Abound) in a sequential fungicide program with Tilt + Bravo provided the highest seed yields, but there was no yield difference between the two strobilurin products. Averaged across locations, an additional yield boost from using a strobilurin over the Tilt + Bravo/Tilt program was 128 lb/a on the first year field in Marion County but only 35 lb/a on the second year field in Linn County. When Headline was combined with foliar fertilizer or with foliar fertilizer plus AuxiGro, the average increase in seed yield over the Tilt treatment was 145 lb/a. As with Headline alone, the increase in seed yield over the Tilt program and over the check plots was greater on the first year field than on the second year field. The results from this trial, a year with low disease pressure suggests a yield benefit to fungicide applications on perennial ryegrass beyond the effects of stem rust control alone.

Acknowledgement:

Appreciation is extended to BASF, Syngenta, and Emerald BioAgriculture Corporation for their support of OSU Extension Service fungicide field trials.

Table 1. Treatment table: fungicide, foliar nutrient, and Auxigrow application rates and timings on two Willamette Valley perennial ryegrass seed fields in Linn and Marion Counties, 2003.

	Application dates (Linn / Marion Co.) and rates (product/acre)		
Treatments	May 10 / 13 Late boot stage	Jun 5 / 6 Early Anthesis	June 19 / 20 Early seed fill
1. Tilt + Bravo/Tilt	Tilt 5/6 oz. + Bravo 1 pt	Tilt 6 oz.	--
2. Tilt + Bravo/Quadris	Tilt 5/6 oz. + Bravo 1 pt	Quadris 9 oz.	--
3. Tilt + Bravo/Headline	Tilt 5/6 oz. + Bravo 1 pt	Headline 9 oz.	--
4. Tilt + Bravo/Headline (+ Foliar fertilizer)	Tilt 5/6 oz. + Bravo 1 pt	Headline 9 oz. + 20-20-20F + B (5 lb Envy + 2.85 lb Solubor)	20-20-20F + B (1 lb Envy + 0.6 lb Solubor)
5. Tilt + Bravo/Headline (+ Foliar + AuxiGro)	Tilt 5/6 oz. + Bravo 1 pt	Headline 9 oz. + 20-20-20F + B (5 lb Envy + 2.85 lb Solubor)	Auxigrow 4 oz. + 20-20-20F + B (1 lb Envy + 0.6 lb Solubor)
6. Headline/Tilt	Headline 9 oz	Tilt 6 oz. (Marion Co. only)	--
7. Headline/Headline	Headline 9 oz	Headline 9 oz. (Linn Co. only)	--
8. Check treatments	Tilt 5 oz. + Bravo 1 pt. / no subsequent fungicide (Linn County) No fungicide (Marion County)	--	--

Note: First and second application with 1/2% COC. Third application (foliar and Auxigrow treatments) with 1/4% COC.
Varieties: Vibrant, second seed crop (Linn Co.) and Charger II, first seed crop (Marion Co.)
Envy = 20-20-20 + micronutrient foliar fertilizer blend.
Solubor = 17.5% B formulation

Table 2. Results summary: the effect of fungicides, foliar nutrients, and Auxigrow on the seed yield of perennial ryegrass, Linn and Marion Counties, 2003.

		Results						
		Marion County			Linn County			
Treatments		Seed yield	Cleanout	1000 seed wt.	Seed yield	Cleanout	1000 seed wt.	Two-site average seed yield
		(lb/acre)	(%)	(g)	(lb/acre)	(%)	(g)	(lb/acre)
1.	Tilt + Bravo / Tilt	1770	4.9	1.75	1718	25.8	1.79	1744
2.	Tilt + Bravo / Quadris	1910	5.1	1.84	1780	26.3	1.78	1845
3.	Tilt+ Bravo / Headline	1885	5.2	1.81	1726	25.5	1.79	1806
4.	Tilt + Bravo / Headline (+ Foliar fertilizer)	1985	5.0	1.78	1824	23.9	1.67	1905
5.	Tilt + Bravo / Headline (+ Foliar + AuxiGro)	1885	5.6	1.77	1858	23.1	1.70	1872
6.	Headline / Tilt	1900	5.5	1.78	--	--	--	--
7.	Headline / Headline	--	--	--	1761	23.3	1.62	--
8.	Check treatments[1]	1597	--	--	1535	27.4	1.74	1566
LSD (0.05)		100	NS	0.06	172	NS	0.15	--

[1]At the Marion co. site, the check was harvested as one strip and not included in statistical analysis

YIELD LOSS ESTIMATES ASSOCIATED WITH PANICLE DISEASES OF ORCHARDGRASS

S.C. Alderman and C.M. Ocamb

In 2002, a decay of immature panicles (stem rot) was observed in several orchardgrass fields. Freezing injury of the immature panicle while still in the stem, and subsequent colonization by one or more bacteria, is believed to be the principal cause of the problem. However, research is under way to establish whether or not freezing temperatures contribute to the stem rot and the role that bacteria recovered from symptomatic stems may have in the development of stem rot. During 2003, a survey was conducted in 10 orchardgrass fields, four of which exhibited stem rot in 2002. Fields surveyed were located in Benton or Linn County. One hundred panicles were collected along each of four transects across each field in a W-shaped pattern. In addition to stem rot, presence of choke and Rathay's were also recorded.

Rathay's disease is a bacterial disease of the grass flower, characterized by a sticky, yellow exudate that covers a part or all of the seed head. The nematode *Anguina* is believed to vector the bacterium. Choke is a common and serious fungal disease of orchardgrass. It is characterized by a proliferation of fungal growth in the upper half of the reproductive tiller, which prevents emergence of the panicle. The white, felt-like growth turns orange and resembles a small orange cattail.

Stem rot was observed in 8 of the 10 fields, affecting 0.5 to 1.9% of the panicles (Table 1). Rathay's disease was detected in 7 of the 10 fields, with incidence as high as 5.3%. Choke occurred in 9 of the 10 fields sampled, with incidence as high as 8.6%. Since there is little to no seed produced on panicles infected with these diseases, percentage of panicles infected roughly equates to an equivalent percentage of seed loss.

Table 1. Percentage of panicles with stem rot, Rathay's, or choke each of 10 fields of orchardgrass surveyed in 2003. Percentage is based on 400 panicles from each field.

	Percentage of panicles with		
Field no.	Stem rot	Rathay's	Choke
1	0	0	2.3
2	2.5	1.9	5.9
3	1.6	3.8	8.6
4	0	0	0
5	0.3	0	12
6	0.3	5.3	1.1
7	1.1	1.1	6.3
8	0.3	2.9	1.9
9	2.8	4.6	0.3
10	0.3	0	7.7

Collectively, the panicle diseases reduced seed yield as much as 14%, and choke was responsible for the greatest portion of the loss. The level of choke is consistent with previously published choke surveys. Rathay's disease has occurred in Willamette Valley orchardgrass fields for decades and there is no indication that this disease has increased in recent years. However, the potential increase of stem rot in orchardgrass is not known. Annual surveys for orchardgrass panicle diseases are planned for the next few years.

HOST RANGE OF CEREAL LEAF BEETLE, AN EMERGING PEST IN OREGON

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

Introduction

The cereal leaf beetle (CLB) is a new exotic pest in Oregon. In 1999 it was reported from two counties in Oregon, and within three years, it was detected in 17 out of 36 counties in the state. The adults disperse rapidly and new county records are added each year.

CLB is known as a pest in grains, but it is also reported feeding on native and cultivated grasses such as orchardgrass. At present there is little information on its impacts on other cultivated grasses raised extensively in Oregon. In the past two years, heavy infestation by adult CLB was observed in a new planting of tall fescue in a field near Portland, and in Kentucky bluegrass in LaGrande in eastern Oregon. These are the first reports of CLB infestation and damage in grass seed crops in the Oregon. The present study was conducted to determine the impact of CLB on grasses, and compare responses to cereals.

Procedures

In this study we examined the responses of overwintering and late summer adult CLB to fall and spring planted grasses in the presence of oats and triticale. The study was conducted near LaGrande, OR in Union county. The following were planted in 3.3 x 10 ft plots: fall planted grasses (perennial ryegrass, annual ryegrass, orchardgrass, Kentucky bluegrass, fine fescue, tall fescue), spring planted oats, triticale, plus spring planting of all 6 grasses listed above. The experiment was set up as a randomized block design with 3 replicates. Weekly observations were made on the number of adults, eggs and larvae in 1-ft row samples from the end of April till the first week in July.

Results

The average number of CLB adults, eggs and larvae observed in spring oats through the season are presented in Figure 1. Adults moved from overwintering sites to plots in late April and after mating, egg laying was commenced. Peak egg laying was observed in mid-May. Larvae appeared in mid May and peak numbers of larvae were observed in mid June.

The average numbers of CLB adults, eggs and larvae observed on various grasses and cereals tested is presented in Table 1. An estimation of feeding damage is also summarized in Table 1.

The data indicate that, in the presence of spring planted oats and triticale, spring planted grasses did not attract overwintering CLB adults. However, in summer, adults that emerged were attracted to all grasses though fine fescue had few adults. Damage to grasses ranged from low to high (Table 1). In contrast, fall planted grasses such as perennial ryegrass, annual ryegrass, tall fescue and orchard grass attracted overwintering adults. Feeding and egg laying was observed on these grasses but damage was not significant. Narrow leaved grasses such as Kentucky bluegrass and fine fescue attracted few adults in comparison.

Discussion

This study indicates that spring planted grasses such as annual and perennial ryegrass, orchardgrass and tall fescue are at risk for damage by adults at the end of summer when the cereals are dry and CLB adults need a food source prior to dispersal to overwintering sites. Overall, the impact of CLB on grass seed appears to be dependent on the presence of cereals in neighboring areas. It is critical that CLB adults are monitored in grass seed fields in late summer to determine whether an insecticide application may be necessary. New seedlings need to be watched to see if damage in early stages of development affects plant growth as this can have an impact on subsequent seed yield.

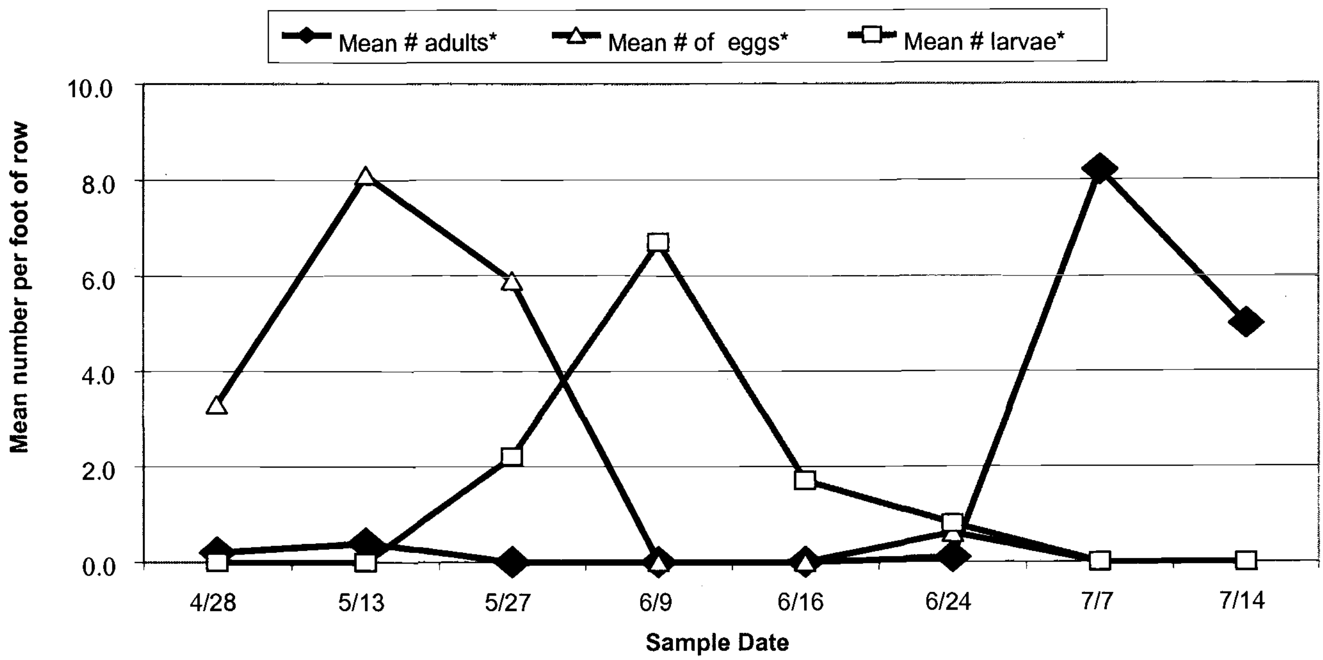

Figure 1. Seasonal abundance of cereal leaf beetle life stages in Otana (spring planted) spring oats in 2003.

Table 1. Mean number of CLB in cereals and grasses per 1-ft row samples in a field plot in Union County, LaGrande.

Host plant	4-28-03 Adults	5-13-03 Eggs	6-9-03 Larvae	6-9-03 Damage	7-14-03 Adults	7-14-03 Damage
Oats	0.2	8.1	6.7	High	5.0	High
Triticale	0.1	4.3	1.0	Medium	24.3	High
Annual ryegrass (SP)[1]	0.0	0.0	0.0	low	17.4	High
Perennial ryegrass (SP)	0.0	0.0	0.0	low	19.7	Medium
Orchardgrass (SP)	0.0	0.0	0.0	low	29.3	Medium
Tall fescue (SP)	0.0	0.0	0.0	low	14.7	Medium
Kentucky bluegrass (SP)	0.0	0.0	0.0	none	14.1	Low
Fine fescue (SP)	0.0	0.0	0.0	none	1.9	None
Annual ryegrass (FP)[2]	0.9	10.9	0.1	low	mowed	--
Perennial ryegrass (FP)	0.2	7.2	0.2	low	mowed	--
Orchard grass (FP)	1.1	6.6	0.0	low	mowed	--
Tall fescue (FP)	0.3	3.4	0.2	low	mowed	--
Kentucky bluegrass (FP)	0.0	1.4	0.0	none	mowed	--

[1]SP = spring planted
[2]FP = fall planted

PROGRESS ON DEVELOPMENT OF A GENETIC TEST TO DISTINGUISH ANNUAL AND PERENNIAL RYEGRASS

R.N. Brown, R.E. Barker, S.E. Warnke, J.E. Dombrowski and J.C. Baldwin

Introduction

Seed purity is a significant challenge in perennial ryegrass seed production. Annual ryegrass is widespread as both a crop and a weed. Seed of the two types are indistinguishable, but annual ryegrass plants in a perennial ryegrass turf are highly undesirable. In the past the seedling root fluorescence (SRF) test has been used to determine contamination of seed lots. The test, however, often over-estimates the degree of contamination, costing growers money (Barker et al. 2000).

Beginning with the 2002 crop year, the SRF test has been augmented by a grow-out test. In this test all of the fluorescent seedlings from a SRF test are transplanted to pots, along with 25 non-fluorescent seedlings from the test and 25 annual ryegrass control seedlings (AOSA Cultivar Purity Testing Handbook). These plants are then grown for six weeks in a controlled environment under conditions optimized to induce heading in annual ryegrass. Seedlings that head or have wide, light colored leaves are counted to determine the contamination level of the seedlot. The addition of the grow-out test results gives a lower estimate of contamination levels, which benefits growers. The grow-out test, however, is expensive, time-consuming to conduct, and the results can be altered by even minor changes in the conditions under which the plants are grown.

Genetics Background

Ryegrass types and cultivars can be differentiated by their physical appearance, or phenotype. Phenotype is determined by the interaction of a plant's genes (genotype) and by the conditions it is exposed to (environment). The genotype is constant for a specific plant, although for ryegrass it varies from plant to plant within a cultivar or population. The environment changes from place to place and over time. Changes in the environment cause changes in the phenotype. Thus even a field planted entirely to cloned plants of a single genotype still will not have a completely uniform phenotype. Both the SRF test and the grow-out test measure phenotype. They are inherently less accurate than tests that can measure genotype directly by examining the DNA sequences for specific genes of individual plants. DNA tests are also faster and less expensive to run. With automation, the 400 samples needed to determine the purity of a single seedlot could be analyzed in less than one day.

Objectives

DNA tests require a great deal of research effort to develop. The most challenging aspect of developing DNA tests is determining which characteristics actually distinguish annual and perennial ryegrass, and identifying the portion of the DNA sequence of the genes that control those characteristics. In nearly every case we need to determine the specific genes involved. Annual and perennial ryegrasses are considered to be separate species, but they are very closely related and can interbreed in the field. Because ryegrass pollen is spread by wind, and ryegrass is propagated from seed, genetic variation among plants is extremely high. In addition, we need to be able to detect both mechanical mixtures, where seeds of an annual cultivar have been mixed in with seeds of a perennial cultivar, and genetic mixtures, where plants of the perennial cultivar were pollinated with pollen from annual ryegrass (hybrids).

Within a cultivar of a self-pollinated crop such as wheat, every plant is genetically identical to every other. The same is true of clonally propagated crops such as fruit trees or Bermuda grass, or Kentucky bluegrass that produces seed via apomixis. This is not the case in ryegrass. One can easily tell by looking whether a field is planted to annual ryegrass or perennial ryegrass. A breeder or experienced grower could distinguish between fields planted to two different varieties of perennial ryegrass. However, if 100 seeds of an annual cultivar were mixed with 100 seeds of a perennial cultivar, and the mixture planted, while most plants could be distinguished by type, it would be very difficult to accurately separate <u>every</u> plant (Figure 1). Note the overlap of flowering time among the three groups of plants. When plants are classified by phenotype in the field, many different characteristics can be considered.

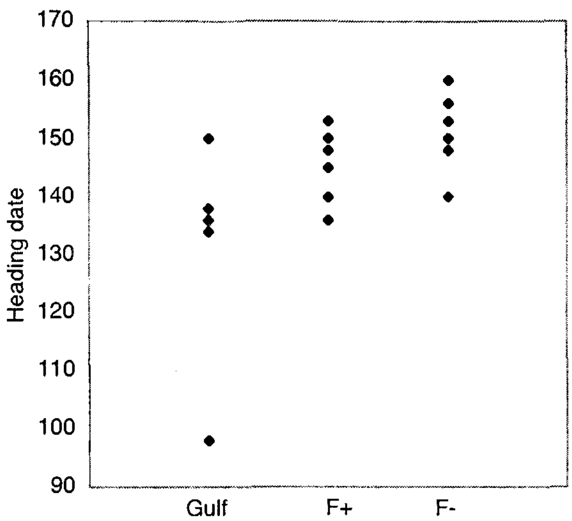

Figure 1: Heading dates for 15 annual ryegrass plants (Gulf), 15 fluorescent seedlings from a perennial ryegrass seedlot, and 15 non-fluorescent seedlings from the same cultivar. Note that there is overlap between the heading date distributions for Gulf and the non-fluorescent perennials. All seedlings were planted in the field in the fall.

If the two cultivars are allowed to interbreed, and the progeny are planted, it becomes impossible to detect annuals and perennials based on any trait other than flowering time along with a number of other phenotypic characteristics (Figure 2).

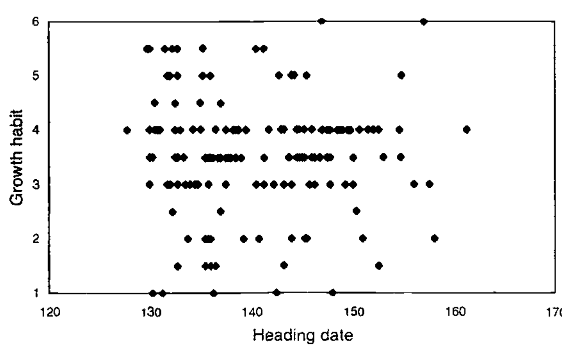

Figure 2: Correlation of growth habit and heading date for the progeny of a cross between an annual ryegrass and a perennial ryegrass. Growth habit was scored on a scale of 1-6, with 1 being fully prostrate and 6 being fully upright. Note that it is not possible to separate the population into two types.

While observing a number of mature plant characteristics improves the accuracy of sorting the two plant types (Figure 3), there still can be considerable overlap of characteristic combinations and this method just is not practical for seed purity testing.

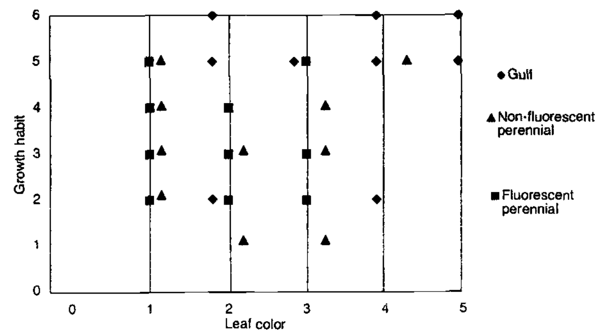

Figure 3: The same plants as in Figure 1, classified by growth habit and leaf color. Growth habit was scored on a scale of 1-6, with 1 being prostrate and 6 upright. Leaf color was scored on a scale of 1-5, with 1 being dark green. The points for each population are slightly offset on the horizontal axis. The separation between the two types is clearer in this graph, but some Gulf plants are still indistinguishable from the perennials.

Some of the more obvious characteristics for which annual and perennial ryegrass cultivars grown in Oregon differ are ability to flower without vernalization, earliness of flowering, leaf width, rate of growth, and leaf color. All of these traits are controlled by multiple genes, and can be greatly affected by environment. In many cases, little or nothing is known about the DNA sequences controlling the traits. We have focused on identifying the genes controlling flowering, as these have been most extensively studied in other plants such as wheat, barley and rice. We know that some of these genes are expressed differently in annual and perennial ryegrass, because the phenotypes are different and the two plant types respond differently to the amount of vernalization they recrive. Our goal is to identify the DNA sequences responsible for the differences in gene expression, and to use these sequences to develop DNA tests that can quickly distinguish the two types.

Progress

Researchers working in wheat have identified two genes that control whether a plant needs exposure to cold temperatures before flowering (vernalization). Because most annuals do not need vernalization and most perennial ryegrass plants do, it seemed logical to try to identify these vernalization genes in the ryegrasses. The sequence of one of the vernalization genes in wheat was determined in 2003 (Yan et al. 2003, Danyluk et al. 2003).

We utilized the wheat DNA sequence as a starting point to determine the sequence of a vernalization gene in ryegrass. We expected to find significant differences in the DNA sequences between annual ryegrass and perennial ryegrass. After isolating the genes, however, we found only simple single base differences between the sequences for 'Gulf' and for 'Manhattan' (Brown and Barker 2004) and these differences might be attributed to random genetic change. We need to conduct several studies to find out.

We now believe that the differences between the two ryegrass types may really lie in the promoter region of the gene, which we have not yet sequenced. The promoter is the portion of the gene that turns the gene on and off in response to signals from the environment. Alternatively, the differences in flowering between annual and perennial ryegrasses may be controlled by the other vernalization gene, or by one of the photoperiod genes. We are currently working to identify genes that are turned on or off when perennial ryegrass is vernalized and other flowering control genes. Using special kinds of DNA procedures, we are also trying to identify DNA sequences that are present in perennial ryegrass, but not in annual ryegrass. Some sequence information is available from the cereals for the second vernalization gene and the photoperiod genes, but not enough that we can utilize that information yet. So, we are working ourselves on sequencing these genes in ryegrass.

We have developed a DNA test for one of the most promising single base differences in the first vernalization gene sequence between 'Gulf' and 'Manhattan'. This test is currently being optimized in our lab to determine if it will be useful in seed purity testing. We are continuing to work on sequencing the promoter region of this gene, in hopes of finding a larger sequence difference. We are also running vernalization trials under carefully controlled conditions to further understand how temperature and daylength influence flowering in both perennial and annual ryegrasses that are grown in Oregon. These trials differ from standard field trials in that we are searching for changes in the expression of genes by examining genes that are active at the time the phenotype actually changes, then determine the DNA sequences of those genes.

Over the years we have been involved in this research, we have identified other chemical and molecular differences between annual and perennial ryegrass that could be the basis for DNA-type tests. Dr. Warnke determined that the enzymes superoxide dismutase (SOD) and phosphoglucose isomerase (PGI) differ in size between annual and perennial ryegrass (Warnke et al. 2002). At present, we feel the tests needed to determine the enzyme sizes in individual plants are too slow and expensive for use in the seed lab. However, we are in the process of determining the DNA sequences for the genes that control these enzymes. If we can identify sequence differences that cause the size differences, we can develop DNA tests to look for the enzyme sizes associated with annual ryegrass in perennial ryegrass seed lots.

Genes that control plant appearance factors such as leaf width, color, and growth rate would make the most accurate DNA-based markers for testing seed lots and preventing off-type plants in turf. However, these traits cannot be tested directly in the lab. At the present time we do not know what genes control these traits in ryegrass, or in related cereals. We have measured many of these traits on our genetic mapping population and are in the process of adding the data to our ryegrass genetic map (Warnke et al. 2004). This is a preliminary step towards identifying and sequencing the genes controlling these traits.

Conclusion

DNA-based tests would enable the seed lab to screen perennial ryegrass seed lots more quickly and with greater accuracy. Developing the tests requires knowledge of the genetic differences between annual and perennial ryegrass. We have been working on the tests for several years, and have discovered that the differences are less clear-cut than originally thought. However, we are making progress on the problem, and have begun trialing possible tests in our lab.

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GRASS SEED FIELDS, SEASONAL WINTER DRAINAGES, AND NATIVE FISH HABITAT IN THE SOUTH WILLAMETTE VALLEY

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We are in the third year of a study determining where and how native aquatic wildlife utilize winter seasonal streams that drain grass seed farms in the southern Willamette Valley. We are also finding out what the nutrient concentrations are in the water moving through these drainages when aquatic animals are present. We need information showing the best ways to adapt conservation practices to grass seed agriculture when needed. This research will improve our understanding of how grass seed field practices and conservation methods may be managed to improve aquatic wildlife habitat.

More than 20 growers in the Benton, Lane, and Linn counties are allowing us to sample on their farms along different sized drainage channels of the Calapooia, Luckiamute, Mary's, Amazon, Muddy, Flat, and Long Tom watersheds. We are looking exclusively at drainages that are dry during the summer. We count fish and other aquatic wildlife numbers using combinations of minnow traps, hoop nets, and electrofishing. We also collect water samples to find out what its quality was when aquatic animals are present, and capture invertebrates that may constitute their food in these seasonal channels and the neighboring land areas. We are also working with growers to find the most appropriate conservation practices that can be used to protect soil in grass fields and reduce erosion by winter runoff from fields and in drainages.

This research is being supported by the Oregon Seed Council, Oregon Department of Agriculture, USDA-CSREES Grass Seed Cropping Systems for Sustainable Agriculture Special Grants Program, Hyslop Endowed Extension Chair, OSU Departments of Fisheries & Wildlife and Forest Engineering new faculty member startup funds, USDA-NRCS Wildlife Habitat Management Institute, and USDA-ARS National Forage Seed Production Research Center.

What we have found thus far

Our findings are interesting and very encouraging regarding the potential positive contributions grass seed production systems may have on aquatic habitats. Our results are showing that winter drainages not only provide seasonal shelter to various native species of fishes when flows in the river main stems are high, but also that some of these species may even reproduce and find nursery habitat in such drainages. In addition, we are finding that the invertebrates (e.g., insects and fresh water crustaceans) inhabiting these seasonal water bodies constitute an important component of the spring diets of some fish species.

Total numbers and kinds of aquatic wildlife caught. Both native fish and amphibians utilize agricultural drainages as winter habitat for refuge and reproduction. In our second sampling year, a total of 2,356 individuals representing 14 native species and four exotics were trapped. Ninety-eight percent of the fish and amphibians caught were native species. The native fish species found included: redside shiner, reticulate sculpin, riffle sculpin, speckled dace, three-spined stickleback, northern pikeminnow, largescale sucker, cutthroat trout, rainbow trout, and chinook salmon. The native species of amphibians included: roughskin newt, redlegged frog, long-toed salamander, and Pacific treefrog. Only 43 individuals from four exotic species were caught, and they seemed restricted to a few of the watersheds and not generally distributed across all of areas sampled. Although we cannot fully explain at this time the differences in the distributions of native and exotic species, our data suggest that exotic species only enter some of the seasonal channels later in the winter or early spring, and do not travel far from the river main stem.

Quality of the drainage water. Nitrate- and ammonium-nitrogen (N) concentrations were generally below what are referred to as the lowest observed adverse concentrations (LOAC) when aquatic wildlife is present. A LOAC is typically far less than an acute concentration such as the LD_{50} (lethal dose at which 50% of the test sample dies). Previous work has shown that not all nitrogen forms found in drainages come from fertilizer applications. Naturally occurring nitrate-N moves with precipitation run-off from soils to streams and typically spikes in early winter when significant precipitation begins following the dry summer season. In winter 2002-03, the average nitrate-N concentration when aquatic animals were present at the sites was 4.2 ppm (range = 0.05 to 14.5 ppm), with 94% of all samples being less than 10 ppm. The average ammonium-N concentration when aquatics were present was 0.23 ppm (range = 0 to 9.8 ppm), with 85% of all samples being less than 0.5 ppm, and 97% less than 1 ppm. The pH of the water measured in these systems when aquatics were present was 7.2. The average phosphate-phosphorus concentration was 0.05 ppm (range = 0 to 0.4 ppm, with all but one sample less than 0.25 ppm), when aquatics were present. Our research results to date do not provide any alarming trends regarding the concentration of nutrients when aquatic wildlife was found.

What do fish eat? A limited number of redside shiners had their stomach contents examined in 2003, and the stomach contents of more fish species are being determined in 2004. The aquatic invertebrates found in the diet of redside shiners included: cyclopoid copepods, ostracods, oligochaete worms, caddisflies, amphipods, and mayflies. Most of the invertebrates consumed by the fish are fresh water crustaceans, with a smaller component of the diet consisting of aquatic insects such as caddisfly. We have trapped very few soil-borne invertebrates, such as oribatid mites and springtails, which originate from adjacent grass seed field or riparian zones next to the drainages where the fish are found. These terrestrial invertebrates help decompose residue in grass seed fields, but do not appear to be significant contributors to fish diet. Grass seed fields managed with full straw chop-back have greater abundance of soil-borne invertebrates. However, the invertebrates in grass seed fields probably only move from the fields to drainages when overland flow occurs during high precipitation periods in winter. Many of the crustaceans and aquatic insects we found can only reproduce in still water and are not found in abundance in fast-moving streams. Thus, it appears that roadside ditches beside seed fields provide habitat to a variety of aquatic invertebrates that in turn contribute to the food base of the fish and amphibians that are found in those ditches, as well as further down in the drainage network.

What are the best-suited conservation practices for grass seed farms? Information is needed to show the best ways to adapt conservation practices to grass seed agriculture when they are needed. Also, grass seed farmers have generally not had access to USDA Farm Program payments until the conservation title was included in the 1992 Farm Bill. Seven farmers began participating in a pilot project to test different conservation practices that may be compatible with grass seed production and find the best ways to use them. Examples of potential practices include:

- Grass waterways along streams where water overflows the channel during the winter and causes erosion.
- Stabilization of ditch banks that have high water flow amounts.
- Planting forested riparian buffers to meet USDA Wetland Reserve Program (WRP) requirements.
- Livestock exclusion fencing to protect streams and riparian areas.
- Comparison of vegetated and chemical-sterile field borders.
- Determining ways to implement no-till crop rotation.

A meeting was held in November of 2002 with a dozen representative grass seed farmers at the Tangent Service Center to meet with USDA-NRCS and USDA-FSA staff and identify constraints to their participation in USDA Conservation Programs. As a result of this meeting, USDA-NRCS has begun to work with the grass seed industry in the southern Willamette Valley on conservation issues.

All of the activities done in this research will help produce information that farmers can use to determine how to know when they need to protect natural resources and to choose the best options for their farm.

What we still need to know and want to do

We want to continue this work for at least two more years to ensure our results represent the general conditions found in most years across the grass seed industry in western Oregon. We have begun to look at the physical characteristics of the drainages that may predict where aquatic wildlife will most likely be during the winter season. Our thinking is native aquatic wildlife seek and tend to occupy habitats that are physically similar to those found before settlement of the Willamette Valley prairie when seasonal wetlands and side-channels were more abundant than they are today. We want to find out whether conservation practices such as grassed waterways not only stabilize drainage banks, but also enhance aquatic wildlife habitat and increase the numbers of wildlife using them. We will also determine the economic trade-off between income forgone by not farming poorly drained portions of grass seed field, where seed yields are lower than better-drained portions of grass seed fields, and Farm Program payments for establishing conservation practices in those areas. An additional research component for this project is being developed to document how riparian areas neighboring grass seed fields are utilized by game birds, native birds, and other terrestrial vertebrates.

Acknowledgments.

In addition to the south Willamette Valley seed growers who are graciously giving us access to their farms, many other people have contributed to this project. These include Machelle Nelson, Richard Caskey, and Donald Streeter from the USDA-ARS; William Gavin and Douglas Bilsland from the Department of Crop & Soil Science; Randy Colvin and William Gerth from the Department of Fisheries & Wildlife; and William Floyd from the Department of Forest Engineering.

METAM SODIUM FOR WEED CONTROL DURING ESTABLISHMENT PERIOD OF CHEWINGS FINE FESCUE

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

Introduction

Weed control during the establishment period of seedling grasses for seed production is particularly difficult due to a lack of availability of selective herbicides for certain hard to control weed species such as common groundsel, henbit, and common mallow. Metam sodium (Vapam®), which is used for soil borne plant disease control, also has herbicidal properties that might be used to reduce grass and broadleaf weed seed numbers in the soil immediately prior to seeding a grass crop. A study was conducted to evaluate the weed control effects of metam sodium at different product and water rates during the seedling establishment period of chewings fine fescue.

Procedure

The experimental area was located at the Hermiston Agricultural Research and Extension Center, OR during late summer 2002. Metam sodium treatments were applied preplant on August 26, 2002 using a chemigation simulator designed to apply water to small plots with an intensity similar to that achieved with the center pivot irrigation systems commonly used in the Columbia Basin region of northeastern Oregon. Air temperature at time of application was 67 F, soil temperature was 75 F at 0", 72 F at 1", and 70 F at 2" depth. Treatments included three rates of metam sodium (10, 20 and 30 gal/a) in 2 rates of irrigation water carrier (0.15 and 0.30 acre-inches). All treatments were applied through the simulator at 59 psi with flood nozzles. Plots were 8 ft by 35 ft, in an RCB arrangement, with 4 replications. Soil at the site was a sandy loam (71.2% sand, 25.6% silt, 3.2% clay, 1.0% organic matter, 6.6 pH, and CEC of 9.7 meq/100 g). Soil was left undisturbed after treatment until crop seeding. The objective of the chemigation treatment was to use a low amount of irrigation water in an attempt to concentrate metam sodium near the soil surface where weed seeds are most likely to germinate and establish. Chewings fescue (var. Tiffany) was seeded on September 12, 2002 at 5 lb/a on 11 in. row spacing. Crop stand counts were made October 7, 2002 and crop injury and weed control were rated December 10, 2002.

Results

Stand counts were variable but were not significantly different when counted 25 days after crop planting (Table 1). Crop stand variability was not related to metam sodium treatment. Slight crop injury was noted when evaluated on December 10th, but differences were not significant, and not well correlated with metam sodium treatment (data not shown). Control of common mallow, henbit, and common groundsel populations were visibly estimated on Dec. 10, 2002. The high rate of metam sodium with the high rate of water generally gave the best control of the three weed species evaluated. There appeared to be a consistent trend toward improved weed control with the higher amount of irrigation water carrier volume. The 30 gal/a metam sodium rate resulted in slightly better weed control, but not at a significantly greater level than the 10 gal/a rate. These results indicate that metam sodium may facilitate weed control during the establishment period of chewings fescue under conditions similar to those in this study. However, treatment with metam sodium should not be considered as an alternative for selection of fields with a history of slight weed problems.

Table 1. Seedling chewings fescue response to metam sodium chemigation treatment. Exp. #03-720.

Treatment*	Product per acre	Crop stand count
		(plants/m of row)
Control (L)	--	112
Control (H)	--	126
Vapam (L)	10 gal	116
Vapam (H)	10 gal	120
Vapam (L)	20 gal	118
Vapam (H)	20 gal	84
Vapam (L)	30 gal	100
Vapam (H)	30 gal	132
LSD 0.05		NS

* L = 0.15 acre-inch and H = 0.30 acre-inch irrigation water.
NS = not significant at a 5% probability level.

Table 2. Weed control response to metam sodium during establishment of seedling chewings fescue. Exp. #03-720.

Treatment*	Product per acre	Common mallow control	Henbit control	Common groundsel control
		------------------	(%)	---------------
Control (L)	--	0 b	0 b	0 b
Control (H)	--	0 b	0 b	0 b
Vapam (L)	10 gal	46 ab	45 a	33 ab
Vapam (H)	10 gal	84 a	85 a	59 a
Vapam (L)	20 gal	60 ab	80 a	53 a
Vapam (H)	20 gal	45 ab	63 a	40 a
Vapam (L)	30 gal	53 ab	63 a	63 a
Vapam (H)	30 gal	90 a	86 a	73 a
LSD 0.05		43	35	29

* L = 0.15 acre-inch and H = 0.30 acre-inch irrigation water. Visible control ratings followed by the same letter are not significantly different at the 5% probablity level.

WILD OAT CONTROL IN SEEDLING KENTUCKY BLUEGRASS

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

Introduction
Northeastern Oregon grass seed producers may encounter a problem with wild oats when rotating grass seed after wheat. Currently, there are no herbicides registered for control of wild oats in fall seeded, seedling Kentucky bluegrass. This study was established to evaluate potential herbicides for wild oat control and selectivity in seedling Kentucky bluegrass grown under Columbia Basin, irrigated conditions.

Procedure
A study was conducted at the Hermiston Agricultural Research and Experiment Station, OR to evaluate wild oat (*Avena fatua*) control in seedling Kentucky bluegrass grown for seed production. Kentucky bluegrass (var. Baron) was planted August 25, 2002. Early fall postemergence (EPOST) treatments were applied on September 26, 2002 to Kentucky bluegrass at 1 inch height. Late fall postemergence (LPOST) treatments were applied on October 8, 2002 to Kentucky bluegrass at 1.5 inches in height. All treatments were made with a hand-held CO_2 sprayer delivering 16 gpa at 30 psi. Plots were 6 ft by 35 ft in size, in an RCB arrangement, with 4 replications. Conditions at time of both applications are summarized in Table 1. Soil at the site was a sandy loam (74.2% sand, 21.6% silt, 4.2% clay, 1.0% organic matter, 6.9 pH, and CEC of 8.8 meq/100g). Evaluations of crop injury were made on October 31, 2002 and March 25, 2003. Evaluations of wild oat control were made on October 31, 2002. Wild oat control did not change after the October evaluations. Plots were swathed on June 19, 2003 with a plot swather and harvested on July 3, 2003 with a experimental plot combine. Seed samples were cleaned prior to yield determination.

Table 1. Application conditions.

	Sep. 26, 2002	Oct. 8, 2002
Kentucky bluegrass (in)	1	1.5
Timing	EPOST	LPOST
Air temp (F)	57	58
Relative humidity (%)	56	72
Wind velocity (mph)	calm	1-2
Soil temp 0 inch (F)	58	68
Soil temp 1 inch (F)	57	62
Soil temp 2 inch (F)	54	54
Soil temp 4 inch (F)	53	50

Results
Treatments containing MSMA (Bueno 6) resulted in negligible crop injury (Table 2), but gave only marginal wild oat control, while yields were unaffected (Table 3). The registration for MSMA on grass grown for seed has been cancelled, and it is unlikely to be suited to reregistration. Everest treatments provided good crop safety as well as good wild oat control. The EPOST treatment was slightly more effective than the LPOST treatment. Yields with Everest were similar to MSMA. Treatments containing Puma, Discover, Nortron, or Assert + Avenge produced severe crop injury (Table 2) and greatly reduced or eliminated bluegrass seed yields (Table 3). Nortron did not appear to be as injurious as the previously mentioned treatments when visual injury ratings were taken (Table 2), however, seed yield was severely reduced. Further testing will be conducted with Everest on seedling Kentucky bluegrass for seed production. The project has been given approval for investigation through the IR-4 program, so progress toward registration may be forthcoming for this herbicide.

Table 2. Herbicide treatment effects on wild oat control in seedling Kentucky bluegrass (KBG). Exp. # 03-751.

Treatment	Product per acre	Timing	KBG injury 10/31/02	KBG injury 3/25/03
			-----(%)-----	
MSMA	6 pt	EPOST	0	0
MSMA	8 pt	EPOST	1	1
Assert + Avenge	.75pt + 2 pt	EPOST	68	78
Puma	.66 pt	EPOST	76	99
Everest	.61 oz	EPOST	29	6
Discover	3.2 fl oz	EPOST	85	99
Nortron	2 pt	EPOST	50	54
MSMA	6 pt	LPOST	0	0
MSMA	8 pt	LPOST	0	4
Assert + Avenge	.75 pt + 2 pt	LPOST	28	64
Puma	.66 pt	LPOST	45	97
Everest	.61 oz	LPOST	5	8
Discover	3.2 fl oz	LPOST	45	99
Norton	2 pt	LPOST	3	21
Nortron / Nortron	2 pt / 2 pt	EPOST/ LPOST	56	93
Control	--	--	0	0
LSD 0.05			10	9

Non-ionic surfactant at 0.25% v/v was added to MSMA, Assert + Avenge, Everest, and Nortron treatments. Adjuvant DSV was added to the Discover treatment.

Table 3. Herbicide treatment effects on wild oat control and seed yield in seedling Kentucky bluegrass (KBG). Exp. # 03-751.

Treatment	Product per acre	Timing	Oat control 10/31/02	KBG clean seed yield
			(%)	lb/a
MSMA	6 pt	EPOST	13	270
MSMA	8 pt	EPOST	19	320
Assert + Avenge	.75 pt + 2 pt	EPOST	92	30
Puma	.66 pt	EPOST	95	0
Everest	.61 oz	EPOST	97	360
Discover	3.2 fl oz	EPOST	98	4
Nortron	2 pt	EPOST	69	70
MSMA	6 pt	LPOST	35	390
MSMA	8 pt	LPOST	45	450
Assert + Avenge	.75 pt + 2 pt	LPOST	61	80
Puma	.66 pt	LPOST	84	9
Everest	.61 oz	LPOST	76	380
Discover	3.2 fl oz	LPOST	86	17
Norton	2 pt	LPOST	14	0
Nortron / Nortron	2 pt / 2 pt	EPOST/ LPOST	96	0
Control	--	--	0	180
LSD 0.05			12	62

Non-ionic surfactant at 0.25% v/v was added to MSMA, Assert + Avenge, Everest, and Nortron treatments. Additive DSV was added to the Discover treatment.

FIRST YEAR RESPONSE OF KENTUCKY BLUEGRASS RESPONSE TO NITROGEN

D.A. Horneck

Introduction

Kentucky bluegrass is a relatively new crop in the Columbia Basin. Current acreage is approximately 4000 acres. Past research in Union County and the OSU Fertilizer Guide (FG 31, Revised March 1985) would suggest that between 135 and 190 pounds of N per acre annually is required for optimum seed production. October/November applications should be 100-120 of the total N applied. The sandy and low water holding capacity soils of the Columbia Basin makes fall N applications a higher risk to reach ground water or leach below bluegrass's rooting capabilities than might happen on finer textured soils. Grower N fertilization practices in the irrigated Columbia Basin for Kentucky bluegrass varies from 150 lb N/a to 300 lb N/a per year.

Much of the Lower Umatilla Basin is part of a groundwater management area for nitrate, therefore maximizing nitrogen use efficiency (NUE) for Kentucky bluegrass production is of interest. Past in-season soil sampling by the author of fifty fields to a depth of five feet showed nitrate only to be elevated at the five foot depth for fields under bluegrass production. There are several possible ways to improve NUE, first is to optimize N application rates and timing. Second, is to develop a tool for determining in-season N application rates such as tissue tests or use of a chlorophyll meter. Because seed crops are evaluated for turf quality and not agronomics, variety improvement for nitrogen use or seed yield is not currently considered an alternative.

N-rates and timing treatments were determined in consultation with a grower committee. The objectives were to determine optimum N-rate and N-timing for Kentucky bluegrass and to see if a chlorophyll meter can be used to asses N adequacy and predict application needs.

Method

A small plot experiment was established in the fall of 2001 with Midnight Kentucky bluegrass at the Hermiston experiment station. N-rates were from 40 lb N/a to 500 lb N/a as shown in Table 1. Planting or early fall N was applied via a pivot as solution-32. The remaining N was applied using urea with a dry spreader. Irrigation water was applied according to crop need.

Tissue samples were taken in January. Dry matter samples were taken on May 1, May 15, May 31 and June 13 in 2002. Each sample was analyzed for weight and analyzed for N, P, K, Ca, Mg, S, B, Zn, Mn, Cu, Fe and Al. Seven chlorophyll meter readings were taken starting in January and finishing in May using a Minolta SPAD-502. Each chlorophyll meter reading is an average of 10 readings. Readings are tabulated and averaged by the meter. Treatment impact on tiller number was measured on June 13 in 2002 and at several dates in 2003.

Table 1. Nitrogen timing for 2002 and 2003 crop years.

Treat-ment	Planting	Oct. - Nov.	Jan.	Spring	Total
	------	------	(lb N/a)	------	------
1	40	0	0	0	40
2	40	200	0	60	300
3	100	300	0	100	500
4	40	100	0	60	200
5	40	0	0	200	240
6	300	0	0	0	300
7	40	0	200	0	240

Results

Seed yields were less than 300 lb/a for the seven treatments in 2002 and 2003 with significant treatment differences observed (Table 2). Seed yield ranked the same from highest yielding (tr. 7) to lowest (tr. 2) in both 2002 and 2003. Treatment 4 represents the rate recommended by the OSU Fertilizer Guide, which was intermediate in yield. Where nitrogen application was delayed to January (tr. 7) yields were the highest. Fertile tiller number was also impacted by N treatment (Table 2). Fertile tiller number was negatively correlated with seed yield in 2002 (R^2=0.61) and positively correlated to seed yield in 2003 (R^2=0.20).

Dry matter production was impacted by N-rate (Table 3). Mildew had a large impact on dry matter 2002. Early in the growing season treatment 1 (40 lb N/a) had the highest dry matter yields (Table 3). The higher N-rates were more impacted with powdery mildew even after three fungicide applications. Mildew impact was measured in June, however this was too late to asses its damage. The grass was not able to recover in dry matter production at the higher N-rates until later in the season. This effect can be observed in treatment 5 which ranked fifth on the May 1st sampling and first on the June 13th.

Table 2. Seed yield and fertile tiller number in 2002 and 2003.

Treatment	2002 Harvest Seed yield	2002 Harvest Fertile tillers	2003 Harvest Seed yield	2003 Harvest Fertile tillers
	(lb/a)	(per ft row)	(lb/a)	(per ft row)
1	145 bc[1]	58.9 a	111 bc	60.5 b
2	116 c	63.2 a	89.3 c	84.0 ab
3	160 b	36 bc	123 b	98.3 a
4	150 b	62.9 a	115 b	106 a
5	140 bc	49.8 abc	107 bc	81.5 ab
6	158 b	54.2 ab	122 b	101.3 a
7	193 a	32.8 c	148 a	100.5 a

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

Table 3. Dry matter yields for four harvest dates in 2002.

Treatment	2002 Harvest date 1-May	15-May	31-May	13-Jun
	--------------------------(lb/a)	--------------------------		
1	2343 ab[1]	4139 a	4399 bc	4299 a
2	1496 c	2802 c	3666 cd	4032 a
3	2344 ab	3713 ab	5453 a	6130 b
4	2066 abc	3689 ab	4721 ab	4922 a
5	1682 bc	3302 abc	4975 ab	6261 b
6	1581 c	2487 c	3418 d	3900 a
7	2406 a	2987 bc	4512 abc	4425 a

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

Chlorophyll meter readings were impacted by treatment (Table 4). Treatment 1 shows a decrease in chlorophyll reading over the growing season in 2002. However, little consistency between sampling date and N-rate is evident. Correlation coefficients are low ($R^2<0.25$) when comparing to N concentration in the leaf. Early season data shows a decrease in chlorophyll meter reading with increased N applied. Later sampling dates show a general trend towards higher chlorophyll meter reading with increased applied N. The possibility exists that this may have been caused by mildew on the leaf interfering with readings even though measurements were taken on what appeared to be unimpacted foliage. Consistency in getting chlorophyll meter readings was difficult in this study. Early readings were taken on very small leaves which were difficult to get aligned on the meter's lens. N in the plant was not well correlated with chlorophyll meter readings. The January sampling date would have the most utility for a grower to amend the crop with additional N prior to the spring growth flush. However the readings did not correlate well with leaf N (Figure 1). This data is also in Tables 4 and 5. This data would suggest that chlorophyll meters would have minimal benefit in Kentucky bluegrass production. Fertile tiller number was negatively correlated ($R^2=0.54$) with the may 29th chlorophyll meter reading.

Table 4. Chlorophyll meter readings during the 2002 growing season.

Treatment	Chlorophyll meter readings in 2002 25-Jan	1-Apr	25-Apr	9-May	14-May	22-May	29-May
1	51 a[1]	50 ab	44 ab	44 d	44 c	45 b	43 d
2	40 b	44 bc	48 b	48 b	48 b	47 a	45 cd
3	45 ab	49 abc	49 ab	49 ab	48 b	50 a	50 a
4	43 b	43 c	47 bc	47 bc	47 b	45 b	46 bcd
5	43 b	43 c	51 a	51 a	53 a	50 a	49 ab
6	41 b	47 abc	45 cd	45 cd	48 b	48 a	47 abcd
7	42 b	52 a	46 bc	46 bc	47 b	48 a	48 abc

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

Nitrogen uptake and concentration was influenced by N-rate (Fig 2, Table 5 and 6). Nitrogen uptake peaked at 140 lb N/a in 2002. Spring loading, like in treatment five (140 lb N/a uptake), where 200 lb spring N/a was applied was much more effective in getting nitrogen into the plant than where nitrogen was applied in the fall. Treatment 3 had similar N at harvest as treatment 5 where N was applied at 500 lb/a. Where nitrogen was applied in January, like in treatment 7, there was an intermediate amount of N taken up. Fall and winter N applications were not effective in getting N into the plant. Residual N in the soil top 3 feet was between 50 and 200 # N/a in July 2002. During January 2002 all treatments had over 80 lb N/a in the soil profile with treatments 3 and 6 over 200 lb N/a. Late season N is effective in increasing vegetative growth as well as increasing N concentrations, but not increasing seed yield. Treatment 5 with the 200 lb N applied in the spring had the highest biomass, N concentration and N-uptake but was second lowest in seed yield in 2002.

Summary

N-rate influenced biomass, seed yield, chlorophyll meter readings, N-uptake N-concentration and fertile tiller number. Maximum seed yield did not correspond to maximum dry matter or N-uptake. Seed yields were highest when N was applied in January. Chlorophyll meters appear to have minimal utility if for no other reason than the difficulty of getting consistent readings on small leaves.

Table 5. Nitrogen content in above ground biomass in 2002.

Treatment	2002 Harvest date				
	Jan-25	1-May	15-May	31-May	13-Jun
	(%)				
1	4.76	2.88 d[1]	2.16 e	1.74 b	1.55 b
2	3.65	3.18 cd	2.65 cd	1.87 b	1.40 b
3	4.97	3.85 b	3.03 b	2.55 a	2.15 a
4	4.42	3.38 c	2.28 e	1.94 b	1.56 b
5	3.80	4.43 a	3.49a	2.73 a	2.15 a
6	4.09	3.00 cd	2.33 ed	1.88 b	1.45 b
7	3.32	3.93 b	2.93 bc	2.57 a	1.96 a

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

Table 6. Nitrogen uptake by harvest date and N treatment in 2002.

Treatment	2002 Harvest date			
	1-May	15-May	31-May	13-Jun
	(lb/a)			
1	67.1 cd	89.5 bc	77.0 cd	66.5 b
2	47.7 d	73.86 cd	68.5 cd	57.2 b
3	89.8 ab	111.7 ab	139.4 a	131.5 a
4	69.5 bc	83.82 c	92.3 bc	78.9 b
5	72.7 bc	116.0 a	135.6 a	135.7 a
6	46.9 d	58.4 d	64.5 d	56.3 b
7	94.2 a	86.6 c	116.1 ab	86.3 b

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

Figure 1. Relation between total N in leaf and chlorophyll meter reading for the January 25 sampling date.

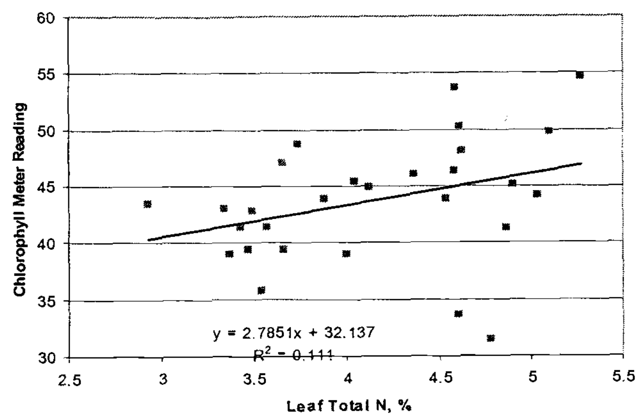
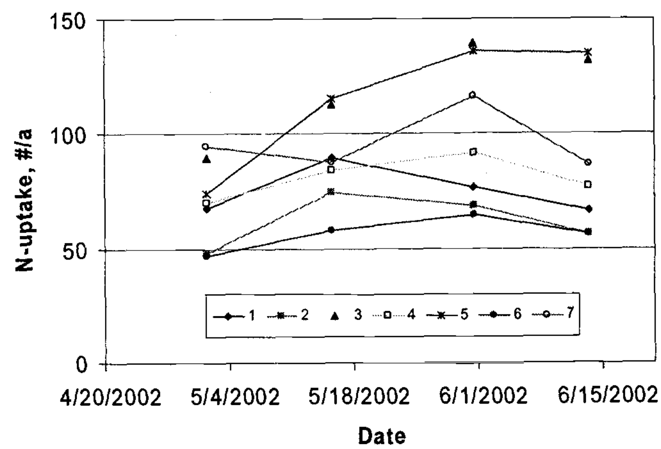


Figure 2. Nitrogen uptake for seven N treatments in 2002.



SECONDARY IMPACTS OF N IN A FIRST YEAR SEEDING OF KENTUCKY BLUEGRASS

D.A. Horneck

Introduction

Little information is available on the impact N has on other nutrients in Kentucky bluegrass. Accumulation of other essential plant nutrients such as K, Ca, Mg, Mn, Al etc. can be influenced by N-rate from competitive cations or anions, from improved plant health and increased root exploration or from changing soil acidity.

Nitrification means the plant is taking up its N as the anion nitrate. Charge balance must be maintained. One way for charge balance to be maintained is for every nitrate, or negative charge, the plants take up a K cation, a positive charge. This might be expected to have a similar influence on other cations such as Ca and Mg.

Nutrient concentrations and uptake can also change by changing a plant's health. For example when a plant is deficient, adding a nutrient can increase its rooting capabilities and there by increase its capacity to acquire a nutrient.

The addition of ammonia fertilizers has an impact on soil acidity. The conversion of ammonia to nitrate is called nitrification and creates hydrogen (acidity) in the soil. The increase in acidity would be expected to have an influence on availability of metals such as Mn and Al.

When nitrogen is added, additional growth can reduce nutrient concentrations in the plant. This is called the dilution effect. This effect is commonly observed when comparing the tissue level in a good vs. poorly growing plant. The good plant commonly has lower nutrient concentrations than poorly growing one.

Methods

A small plot experiment was established in the fall of 2001 with Midnight Kentucky bluegrass. N-rates varied from 40 to 500 lb N/a as shown in Table 1. Planting or early fall N was applied via a pivot as Solution-32. The remaining N was applied using urea with a dry spreader. The application of B, Ca and S was constant across the experiment, the only variable was N-rate and timing.

Dry matter samples were taken on May 1, May 15, May 31 and June 13 in 2002. Dry weight was measured and each sample was analyzed for weight and analyzed for N, P, K, Ca, Mg, S, B, Zn, Mn, Cu, Fe and Al.

Table 1. Nitrogen timing for 2002 and 2003 crop years.

Treatment	Planting	Oct.-Nov.	Jan	Spring	Sum
	-----------------------(lb N/a)-----------------------------				
1	40	0	0	0	40
2	40	200	0	60	300
3	100	300	0	100	500
4	40	100	0	60	200
5	40	0	0	200	240
6	300	0	0	0	300
7	40	0	200	0	240

Results

Nutrients influence each other and the resulting impact on plant growth. Potassium concentration and uptake were influenced by N-rate and timing (Tables 2 & 3, Figures 1 & 2). K uptake is a function of K concentration and dry matter accumulation. Dry matter data is presented in the previous article in this publication and was influenced by N-rate. Dry matter and N concentration increased with increased N-rate at the June harvest. Potassium concentration was increased with increasing N-rate (Table 2). With the increased K concentration and increased dry matter K uptake varied from 68 to 142 lb K/a depending on N-rate. Nitrogen and K concentration can be correlated across the five sampling dates (Figure 1). The effect N has on K uptake has consequences; where straw is removed, the K needs to be replaced with fertilizer.

Other nutrients such as P and S were impacted similarly as K, increased N resulted in increased concentration and dry matter and therefore increased uptake (Figure 3 & 4). P concentration in the plant increased through 3% N. Above 3% N there was no change in P concentration due to N (Figure 3). A sigmoidal model for the P data increases the correlation coefficient to 0.75. S concentration increased linearly across all N concentrations (Figure 4). The reason for increased uptake of P and S is unclear. Nutrients such as Ca and Mg that would be expected to behave like K were poorly correlated (R^2<0.05) with N concentration.

Uptake of nutrients such as Mn and Al that would most likely be increased due to the increased acidity from the urea and Solution-32 N applications was not influenced by N-rate. Manganese concentration did not correlated (R^2=0.02) with N in the plant. Tissue Mn varied between 50 and 140 ppm with significant treatment effects, but there appears to be no link with N-rate (Figure 5). Concentration of Al varied from 500 to

2000 ppm. Treatment 1, the check, had the highest Al concentrations for two of the 4 sampling dates.

Summary

Nitrogen had significant secondary impacts in Kentucky bluegrass in 2002, a first year seedling. Potassium, sulfur and phosphorous were all positively correlated to nitrogen concentration during the whole growing season. Nitrogen increased K concentration and K uptake. The reasons for some of these increases due to N-rate are unclear.

Table 2. Potassium concentration for the seven N treatments by harvest date in 2002.

Treatment	2002 Harvest Date 1-May	15-May	31-May	13-Jun
	---(%)---			
1	2.20 b	1.73 c	1.69 c	1.60 c
2	2.28 ab	2.11 b	2.11 b	1.97 b
3	2.43 ab	2.13 b	1.95 b	1.88 b
4	2.32 ab	2.06 b	1.91 b	1.79 b
5	2.53 a	2.60 a	2.69 a	2.26 a
6	2.21 b	1.98 b	1.96 b	1.86 b
7	2.47 a	2.08 b	2.11b	1.83 b

Table 3. Potassium Uptake for the seven N treatments by harvest date in 2002.

Treatment	2002 Harvest Date 1-May	15-May	31-May	13-Jun
	---(lb/a)---			
1	51.3 ab	70.0 ab	74.5 cd	68.5 c
2	34.0 c	59.0 bc	77.8 cd	78.9 c
3	56.8 ab	79.4 a	105.9 b	115.0 b
4	47.8 abc	75.8 ab	90.6 bcd	87.0 c
5	42.4 bc	85.6 a	133.8 a	141.8 a
6	34.9 c	49.3 c	66.8 d	72.4 c
7	59.4 a	60.7 bc	95.6 bc	79.6 c

Figure 1. Correlation of plant N with plant K over four sampling dates in 2002 and across N-rates and N timing.

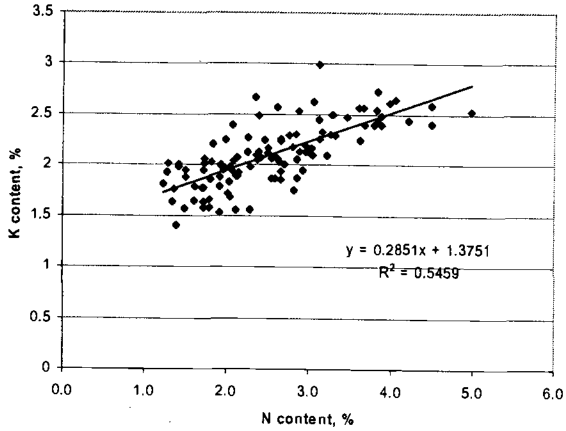


Figure 2. K uptake for seven N treatments in 2002.

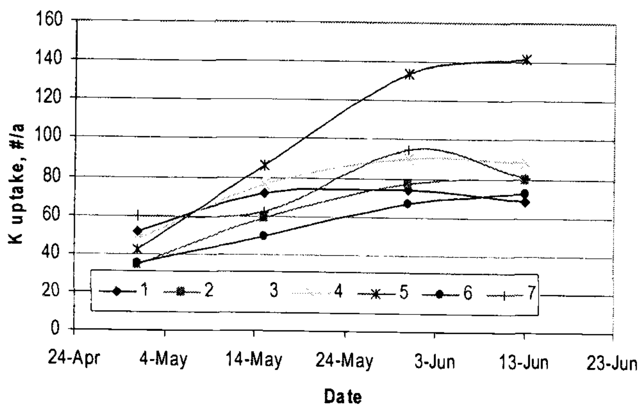


Figure 3. Correlation between N concentration in the plant and P over four 2002 sampling dates and across N-rates and N timing.

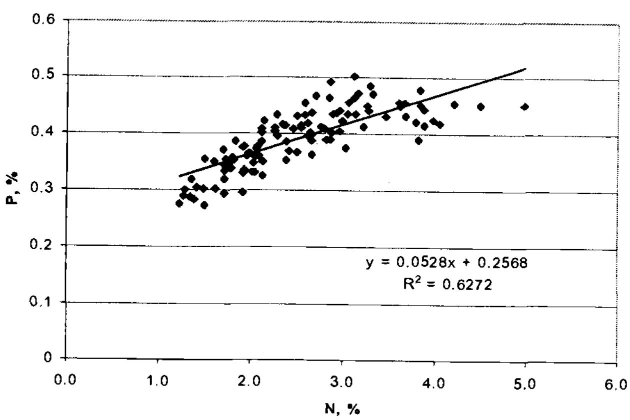


Figure 4. Correlation between N concentration in the plant and S over four 2002 sampling dates across N-rates and N timing

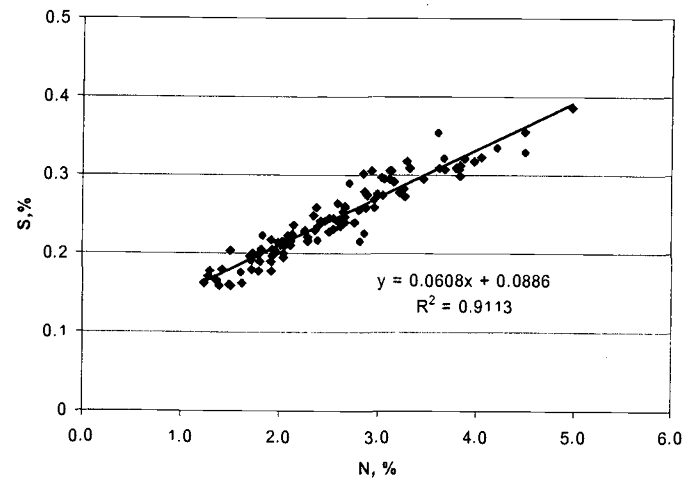
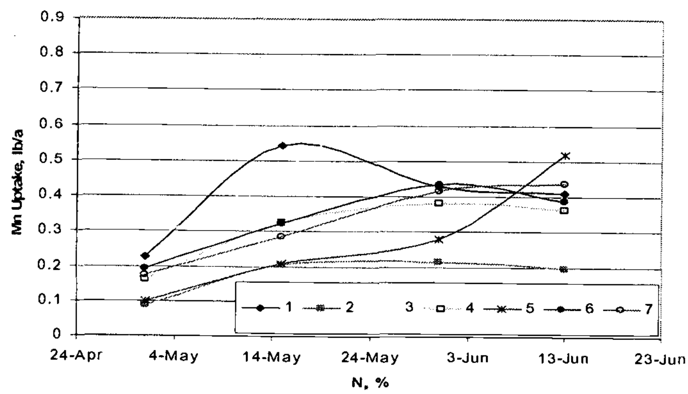


Figure 5. Manganese concentration for 7 treatments by date



EVALUATION OF ALTERNATIVE RESIDUE MANAGEMENT METHODS FOR KENTUCKY BLUEGRASS SEED PRODUCTION IN THE GRANDE RONDE VALLEY

D.L. Walenta, P.L. Diebel, L.R. Gow and G.L. Kiemnec

Introduction

The production of high quality grass seed is important to the agricultural economy of the Grande Ronde Valley (GRV) of eastern Oregon. The primary grass species grown for seed production in the GRV are Kentucky bluegrass and fine fescue. Historically, open-field burning has been an effective, economical means by which to remove residue and maintain seed yield and quality. The continued concern for air quality and public health have led to the adoption of alternative residue management methods that place less reliance on open-field burning of full straw-residue loads.

Past research conducted in Oregon identified potential alternative residue management strategies that maintain seed yield and quality in the absence of open field burning (Chastain et al. 1997, Chastain et al. 2000). Mechanical removal (baling) of residue followed by propane-flaming of stubble has been widely adopted, although this strategy was not included in previous research efforts in the GRV, as one alternative to open-field burning. Residue management efforts in the GRV which utilize the bale + propane-flame strategy have increased dramatically from 4% of the total harvested grass seed acreage in 1993 to 80% in 2003.

Recently, a need was identified to conduct further research on alternative residue management methods currently used for Kentucky bluegrass seed production in the GRV. A large, on-farm study was established in 2001 to address the following objectives: 1) determine the effect of alternative residue management methods on seed yield and quality of Kentucky bluegrass; 2) conduct a cost-analysis of non-thermal and propane-flaming residue management methods over a period of three seed crop years; and 3) develop educational programs for dissemination of information obtained from this study to producers and the agricultural industry.

Materials and Methods

The study was established in the summer of 2001 in a commercial Kentucky bluegrass (var. Kelly) seed production field in the GRV. The experimental design of the study consisted of 4 residue management treatments arranged in a randomized complete block with 3 replications. Residue management treatments consisted of: 1) bale only; 2) bale + flail; 3) bale + propane early; and 4) bale + propane late. Individual plots are 25 ft by 400 ft. Production practices (e.g. fertilizer and chemical application) for the study site were managed by the cooperating producer according to common commercial production practices utilized in the GRV. Commercial production-sized equipment were used to make ag-chemical applications and to harvest the seed crop. Data collection consists of clean seed yield, purity, and germination. A weigh wagon was used to measure bulk seed harvested from each plot. Sub-samples were collected during harvest to determine clean seed yield and quality.

Residue management treatments were initiated in the summer of 2001 following the first commercial seed harvest. Bale only, bale + flail, and bale + propane early treatments were applied on August 8-9, 2001. The bale + propane late treatment was applied on September 12, 2001 to Kentucky bluegrass with approximately 2-3 inches of vegetative re-growth. For the first harvest of the study, plots were swathed on July 10, 2002 and seed harvested with a commercial-size combine on July 26, 2002. Sub-samples collected during the 2002 seed crop harvest were processed during the fall of 2002 by cleaning one time with a Clipper M2-B Cleaner with three screens. Clean seed samples were subjected to germination and purity analysis at the OSU Seed Laboratory. Post-harvest residue management treatments including bale only and bale + flail were applied on August 5, 2002. The bale + propane early treatment was applied on August 7, 2002 and the propane late treatment was applied on September 3, 2002.

For the second harvest of the study, plots were swathed on July 7, 2003 and seed harvested on July 25, 2003. Sub-samples of seed harvested from each treatment were collected, processed, and analyzed in the same manner as carried out in 2002. Post-harvest residue management treatments for 2003 were applied on August 8 (bale, bale + flail), August 9 (propane early), and September 19 (propane late).

Results and Discussion

Results from the first seed harvest following application of residue management treatments are shown in Table 1. Seed yields were significantly reduced when residue was baled off and stubble was left intact (bale only) when compared to baling followed by late thermal treatment. A slight increase in seed yield was observed when baling was followed by flailing or early thermal treatment of the remaining stubble, however, these yields were not significantly different. Early and late thermal reduction of stubble resulted in equivalent seed yields. Although the results indicate that mechanical residue removal followed by late thermal treatment produced greater seed yields than any other treatment, it is unclear at this time if the yield increase is a varietal response due to late thermal treatment. Seed purity and germination levels were not influenced by mechanical or thermal residue management methods.

Table 1. Residue management influence on seed yield and quality in Kelly Kentucky bluegrass, 2002.

Treatment	Seed yield	Purity: Pure seed	Purity: Inert	Purity: Weed seed	Germination
	(lb/acre)	(%)			
Bale only	1087 b[1]	96.1	3.9	0	91.0
Bale + Flail	1236 ab	97.0	3.0	<0.01	94.3
Bale + Propane Early	1256 ab	96.8	3.2	0	93.0
Bale + Propane Late	1416 a	98.1	1.9	0	93.3
LSD (P=0.05)	257	NS[2]	NS	NS	NS

[1] Means in columns followed by the same letter are not significantly different.
[2] NS = not significant.

Clean seed yield, purity analysis, and germination data for the 2003 seed harvest are presented in Table 2. Statistical analysis did not detect any significant differences in seed yield, purity, or germination due to residue management treatments. A late May frost affected seed yield and quality which, in turn, may have negated any differences due to residue management treatment. Analysis of seed samples from the 2003 harvest detected low levels of weed seed contamination, primarily rat-tail fescue, in all residue management treatments except in the bale + propane late treatment. Seed samples collected in 2002 did not contain any weed seed contaminants.

Table 2. Residue management influence on seed yield and quality in Kelly Kentucky bluegrass, 2003.

Treatment	Seed yield	Purity: Pure seed	Purity: Inert	Purity: Weed seed	Germination
	(lb/a)	(%)			
Bale only	855	92.8	7.2	0.06	93.0
Bale + Flail	790	94.5	5.3	0.17	94.3
Bale + Propane Early	911	91.4	8.6	0.05	94.0
Bale + Propane Late	881	95.8	4.2	0	92.0
LSD (P=0.05)	NS[1]	NS	NS	NS	NS

[1] NS = not significant.

The study will continue for one additional seed crop harvest to determine if locally adopted residue management methods will maintain seed yield and quality. An economic analysis will be conducted at the completion of the study to determine economic return from each of the residue management methods.

Acknowledgements
This research is supported by funds from the Agriculture Research Foundation. Appreciation is also expressed to Pete Nilsson for providing land, equipment, and labor necessary for conducting this study, to Bryon Quebbeman for technical assistance, and the CBARC-OSU for use of seed processing equipment..

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EVALUATION OF HERBICIDES FOR EFFECT ON SEED SET IN KENTUCKY BLUEGRASS AND ROUGH BLUEGRASS SEED PRODUCTION, 2002-2003

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

Previous research has evaluated a variety of fall-applied herbicides that included Axiom and Beacon alone and in combination with other herbicides. Treatments were applied to Kentucky bluegrass to determine crop injury and reduced seed set, and applied to rough bluegrass to evaluate control of seedling and established plants. Treatments that included Axiom provided the best seedling control (52-85%), depending on cultivar. Axiom treatments had the greatest effect on reducing crop height. Treatments with Axiom reduced seed set on 'Shamrock' by 83 to 88 percent at 11 oz/acre and 37 percent at 9 oz/acre, while 'Merit' and 'Geronimo' were generally unaffected.

Research was established during the 2002-2003 season to evaluate Axiom and Define on seed set in Kentucky bluegrass cultivars 'Merit', 'Shamrock' and 'Geronimo'. Plots were replicated three times in a randomized complete block design in three commercial Kentucky bluegrass seed fields north of Madras. Herbicide treatments were applied October 7 and November 11, 2002, February 18 and April 9, 2003.

Plots were also established at two locations to evaluate the effect of Beacon on crop injury and seed set in rough bluegrass cultivars 'Sabre' and Laser'. Treatments were applied on the same dates as Axiom and Define. Both sets of treatments were applied to 10 ft x 20 ft plots with a CO_2 pressurized, hand-held boom sprayer at 40 psi and 20 gal/acre water. Plots were evaluated May 8 for crop injury and June 11 for reduction in seed set.

Define did not provide an expected increase in margin of safety over Axiom when evaluating seed set reduction in Kentucky bluegrass (Table 1). It appears that the cultivar 'Shamrock' has the greatest sensitivity to both Axiom and Define, followed by 'Geronimo' and then 'Merit'. Applications made earlier in the fall may have less effect than late fall through early spring applications across the three varieties.

The most damaging Beacon application to seed set was on the rough bluegrass cultivar 'Sabre' following the April 9 application. This supports previous evaluations of Beacon on rough bluegrass where late applications in April had the greatest effect on seed head development.

No crop injury was observed following any of the Axiom and Define treatments during the May 8 evaluation of Kentucky bluegrass plots, except slight discoloration from the October 7 application of Axiom on 'Shamrock'. Beacon application to 'Laser' caused some stunting of established plants compared to the untreated plots. The most severe stunting and some burning were observed following the April 9 application.

Table 1. Effect of application timing for Axiom and Define on seed set in Kentucky bluegrass cultivars near Madras, Oregon, 2002-2003.

Treatment	Rate	Timing	Percent reduction in seed set		
	(product/a)		Merit	Shamrock	Geronimo
Axiom	9 oz	Oct 7	3.3 b[1]	8.3 c	26.7 bc
Define	9 oz	Oct 7	6.7 ab	23.3 c	3.3 d
Axiom	9 oz	Nov 11	3.3 b	75.0 a	50.0 a
Define	9 oz	Nov 11	13.3 ab	61.7 ab	28.3 bc
Axiom	9 oz	Feb 18	6.7 ab	55.0 ab	5.0 d
Define	9 oz	Feb 18	10.0 ab	50.0 b	16.7 cd
Axiom	9 oz	Apr 9	3.3 b	48.3 b	28.3 bc
Define	9 oz	Apr 9	18.3 a	20.0 c	40.0 ab
Untreated	----	----	0.0 b	0.0 c	0.0 d

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

Table 2. Effect of application timing for Beacon on seed set in rough bluegrass cultivars near Madras, Oregon, 2002-2003.

Treatment	Rate	Application date	Percent reduction in seed set	
	(product/a)		Sabre	Laser
Beacon	0.75 oz	Oct 8	0.0 b[1]	8.3
Beacon	0.75 oz	Nov 11	3.3 b	6.7
Beacon	0.75 oz	Feb 18	5.0 ab	5.0
Beacon	0.75 oz	Apr 9	15.0 a	3.3
Untreated	----	----	0.0 b	0.0
				NS

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

EVALUATION OF FUNGICIDES FOR CONTROL OF POWDERY MILDEW IN KENTUCKY BLUEGRASS SEED PRODUCTION IN CENTRAL OREGON, 2003

M.D. Butler and C.K. Campbell

Fungicides have been evaluated yearly for control of powdery mildew in Kentucky bluegrass seed production fields in central Oregon since 1998. Products have included the historic industry standard Bayleton, Tilt, Tilt plus Bravo, and new products such as Laredo, Folicur, and Stratego, numbered compounds like BAS500, alternative materials like Microthiol (sulfur) and sylet oil.

Fungicides were evaluated for control of powdery mildew in a commercial field of 'Merit' Kentucky bluegrass grown for seed near Madras, Oregon. The project consisted of two components. The first was a single-application comparison of products that included Bayleton, Laredo, Tilt, Folicur, Microthiol and sylet oil applied alone, and Laredo plus Microthiol.

The second component was evaluation of double fungicide applications that consisted of Tilt plus Bravo followed by various products alone or combination applied three weeks later. Second treatments included Tilt, Stratego, Quadris, Folicur, the numbered compounds A13705 and BAS500, and crop oil concentrate (COC). These materials were applied either alone or in combination.

All treatments were applied April 9 to 10 ft by 25 ft plots replicated three times in a randomized complete block design. Plots receiving a second application were treated April 30. Applications were made using Tee Jet 8002 nozzles on a 9-ft, CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal of water/acre. A silicon surfactant was included with all treatments at 0.25% v/v.

Plots were evaluated using a rating scale from 0 to 5, with 0 being no mildew present and 5 indicating total foliar coverage. The single-application portion of the study was evaluated April 28 (19 DAT), May 13 (34 DAT) and May 23 (44 DAT). The double-application treatments were evaluated April 28 (19 DAT) and May 23 (23 DAT).

Of the single-application treatments, all but Microthiol and sylet oil significantly reduced powdery mildew compared to the untreated plots. Nineteen days after treatment Laredo at 8 oz/acre plus Microthiol at 3 lb /acre provided the highest level of control, while Bayleton at 4 oz/acre provide the best control 34 DAT. It appears that Laredo, and perhaps other fungicides, applied in combination with Microthiol may have increased efficacy. By 44 DAT there were no differences in powdery mildew levels between any of the treated or untreated plots, despite the level of powdery mildew remaining nearly the same during that period in untreated plots.

Results from the first of the double-application treatments were the same, as indicated by no significant differences between treatments 19 DAT. However, there was significantly less powdery mildew in the treated plots compared to the untreated. Twenty-three days after the second applications, Stratego at 10 oz/acre provided the best control. Crop oil concentrate did not appear to increase fungicide efficacy.

Table 1. Severity of powdery mildew on Kentucky bluegrass near Madras, Oregon following fungicide application on April 9, evaluated on April 28 and May 23.

Treatments	Application April 9	Evaluation April 28 (19 DAT)	Evaluation May 13 (34 DAT)	Evaluation May 23 (44 DAT)
Bayleton	4 oz	1.25[1] bc[2]	1.08 c	1.64
Laredo + Microthiol	8 oz + 3 lb	1.00 c	1.17 c	1.28
Tilt	4 oz	1.06 bc	1.36 c	1.69
Laredo	8 oz	1.25 bc	1.42 bc	2.06
Folicur	6 oz	1.17 bc	1.86 bc	2.17
Microthiol	3 lb	2.00 ab	1.94 abc	2.50
Stylet oil	2 qt	1.39 bc	2.28 ab	2.39
Untreated	----	2.49 a	2.81 a	2.42
				NS

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

Table 2. Severity of powdery mildew on Kentucky bluegrass near Madras, Oregon following fungicide application on April 9, and April 30, 2003, and evaluated April 28 and May 23.

Treatments	Application Date		Evaluation	
	April 9	April 30	April 28 (19 DAT)	May 23 (23 DAT)
Tilt	4 oz	----		
Bravo	16 oz	---		
+ Strategp	----	10 oz	0.92 b[2]	0.14 d
Tilt	4 oz	----		
Bravo	16 oz	----		
+ A13705	----	30 oz	1.39 b	0.33 cd
Tilt	4 oz	----		
Bravo	16 oz	----		
+ A13705	----	20 oz	1.17 b	0.33 cd
Tilt	4 oz	----		
Bravo	16 oz	----		
+ A13705	----	30 oz		
COC	----	1% v/v	0.86 b	0.36 cd
Tilt	4 oz	----		
Bravo	16 oz	----		
+ Tilt	----	4 oz		
Quadris	----	4 oz	1.17 b	0.36 cd
Tilt	4 oz	----		
Bravo	16 oz	----		
+ A13705	----	20 oz		
COC	----	1% v/v	1.36 b	0.42 cd
Tilt	4 oz	----		
Bravo	16 oz	----		
+ Tilt	----	4 oz		
Quadris	----	4 oz		
COC	----	1% v/v	1.22 b	0.47 bcd
Tilt	4 oz	----		
Bravo	16 oz	----		
+ Tilt	----	4 oz	1.06 b	0.56 bcd
Tilt	4 oz	----		
Bravo	16 oz	----		
+ Folicur	----	6 oz	1.58[1] b	0.75 bc
Tilt	4 oz	----		
Bravo	16 oz	----		
+ BAS500	----	9 oz	0.89 b	1.06 b
Untreated	----	----	2.49 a	2.42 a

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

EVALUATION OF PLANT GROWTH REGULATORS ON KENTUCKY AND ROUGH BLUEGRASS, 2003

M.D. Butler and C.K. Campbell

Research to evaluate Palisade on Kentucky bluegrass has been conducted annually since 1999. Yields have been increased by 32 to 36 percent three of the four years compared to untreated plots when Palisade was applied at 22 oz/a from detection of the first and second node (Feekes 7) to when the head just becomes visible (Feekes 10.1). Late application when the heads extended just above the flag leaf (Feekes 10.4) produced the greatest reduction in plant size, while plants tended to out grow the effect of earlier Palisade applications. There have been no differences between treatments in weight per 1,000 seed. Percent germination for Palisade treated plots was equal to or better than the untreated plots.

Plots 10 ft x 25 ft were replicated four times in a randomized complete block design in commercial fields of 'Geronimo' Kentucky bluegrass and 'Laser' rough bluegrass near Culver and Madras, Oregon. Palisade was applied at 1.5 pt/acre, 2.1 pints/acre and 2.8 pint/acre, and Apogee was applied at 0.9 lb/acre. Treatments were applied May 9 (2^{nd} node detectable) to both Kentucky and rough bluegrass. Treatments were applied with a CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal/acre water using TeeJet 8002 nozzles. Prior to harvest, a Jari mower was used to cut three-foot alleyways across the front and back of each row of plots. A research-sized swather was used to harvest a 40-inch by 22-foot portion of each Kentucky bluegrass plot on July 1. Rough bluegrass plots were harvested July 7. Samples were placed in large canvas bags and hung in an equipment shed to dry, then transported to Corvallis for combining with a Hege 180 at the OSU Crop and Soil Science's Hyslop Farm. Thousand seed counts were conducted at the seed-conditioning lab with the National Forage Seed Production Research Center in Corvallis, and germination testing was done at the Central Oregon Agricultural Research Center near Madras.

At the 90 percent confidence level, Palisade increased seed yield on Kentucky bluegrass by about 30 percent at either 2.1 pt/acre or 2.8 pt/acre. Although not significantly different ($P \leq 0.10$), the trend on rough bluegrass was for Palisade at 1.5 pt/acre to increase seed yield by 19 percent, as good or better than the two higher rates. Seed yield from the Apogee plots was similar to the untreated for both Kentucky and rough bluegrass.

Palisade has been evaluated in central Oregon from 1999 to 2003. Seed yields averaged across these dates for the same application rates indicate that 2.1 to 2.8 pt/acre rates consistently give positive results. Increases in seed yield for the best treatments have generally been in the 30 percent range. At times it has appeared that lower rates can give similar results, but not consistently. Application at the two-node stage has been quite consistent in providing the best results.

Palisade evaluation on rough bluegrass began in 2001. It appears that the two-node stage is the best timing, while there has been variability as to the best rate and level of yield increase one can expect. Overall, it appears that the effects may be somewhat less than for Kentucky bluegrass.

Table 1. Effect of plant growth regulators on seed yield and germination of Kentucky bluegrass, Madras, Oregon, 2003.

Treatment	Rate	--------------- Seed yield ---------------		Germination
	(product/a)	(lb/a)	(% check)	(%)
Palisade	1.5 pt	1544 ab[1]	107	79
Palisade	2.1 pt	1891 a	131	76
Palisade	2.8 pt	1858 a	129	81
Apogee	0.9 lb	1438 b	99	84
Untreated	----	1441 b	100	83
				NS

[1]Mean separation with LSD $P \leq 0.1$.

Table 2. Effect of plant growth regulators on seed yield of rough bluegrass, Madras, Oregon, 2003.

Treatment	Rate	----------Seed yield----------	
	(product/a)	(lb/a)	(% check)
Palisade	1.5 pt	1445	119
Palisade	2.1 pt	1363	112
Palisade	2.8 pt	1382	114
Apogee	0.9 lb	1263	104
Untreated	----	1213	100
		NS[1]	

[1]Mean separation with LSD $P \leq 0.1$.

PERFORMANCE OF POSTEMERGENCE HERBICIDES ON EIGHT NATIVE GRASS SPECIES GROWN FOR SEED IN CENTRAL OREGON, 2000-2002

M.D. Butler and C.K. Campbell

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

Big bluegrass, bluebunch wheatgrass, squirreltail, great basin wildrye, streambank wheatgrass, and Idaho fescue were planted at the Central Oregon Agricultural Research Center April 20, 2000 at a rate of 45 seeds per foot. Indian ricegrass was planted at a rate of 90 seeds per foot and prairie junegrass was planted at 135 seeds per foot. A four-row small-plot cone planter (Almaco Inc.) was used, with a planting depth of 0.25 inches. Plots were a single row 80 feet long with a 2 foot row spacing placed in a randomized complete block design. Plots were irrigated as needed to keep the seed zone moist for two weeks following planting. Prior to treating the plots, weeds were controlled by hoeing and cultivation.

Herbicide treatments were fall-applied at both 1x and 2x label rates October 18, 2000 and October 4, 2001. Treatments were applied with a CO_2-pressurized, hand-held boom sprayer at 40 psi and 20 gal/acre water in a band perpendicular to the grass rows. A non-ionic surfactant was not included with applications in 2000, but was added at 0.5 % v/v in 2001.

Evaluations were conducted using a rating scale from 0 (no negative effect) to 5 (maximum negative effect). Plots were evaluated for stunting, chlorosis, and mortality on March 27 and 28, 2001 and May 15, 2002. Reduced heading was evaluated June 16-19, 2001 and June 10, 2002. Stand reduction was evaluated following the first season on November 2, 2001 and during the second season on May 15, 2002. Statistical analysis was conducted using least significant difference (LSD) for mean separation at $P \leq 0.05$. No comparisons were made between grass species.

The average effect of herbicide treatments at 1x label rate on stand reduction and reduced heading over the two seasons on eight native grass species is provided in Tables 1-4. Treatments that consistently caused the most damage across grass species were 2x rates of Sinbar at 1.5 lb/a and Kerb at 0.80 lb/a. Treatments with the least effect on both stand reduction and reduced heading across grass species were 1x rates of Diuron at 1.8 lb/a, Goal at 10 fl oz/a and Sencor at 0.4 lb/a. An additional product with little effect on stand reduction was a 1x rate of Surflan at 3 qt/a. Products that had the least effect on heading across species were 1x rates of Axiom at 11 oz/a, Clarity at 4 pt/a, Maverick at 0.67 oz/a, and a 2x rate of Frontier at 64 fl oz/a. The safest herbicide at the 2x rate across grass species was Goal at 20 fl oz/a.

Overall, stand reduction was the least for great basin wildrye, and was the greatest for prairie junegrass and squirreltail. Treatments least affected heading on great basin wildrye and streambank wheatgrass. Both species were largely unaffected by the various herbicide treatments except 2x rates of Sinbar at 1.5 lb/a and Kerb at 0.8 lb/a. Species where herbicides generally had the most effect on reducing heading were squirreltail and prairie junegrass.

Table 1. Effect of herbicides on stand reduction of native grass species grown for seed, Madras, Oregon, 2000-2002.

Herbicide	Rate per acre	Great basin wildrye	Bluebunch wheatgrass	Streambank heatgrass	Big bluegrass
Axiom	11 oz	0.4 ab	0.9 ab	0.9 cd	0.4 a
Beacon	0.76 oz	0.5 ab	1.3 bc	0.8 bc	0.4 a
Clarity	4 pt	0.31 ab	0.8 ab	0.4 abc	0.4 a
Diuron	1.8 lb	0.3 ab	0.8 ab	0.3 ab	0.5 a
Frontier	32 fl oz	0.3 ab	0.6 ab	0.3 ab	0.3 a
Goal	10 fl oz	0.3 ab	0.8 ab	0.3 ab	0.3 a
Kerb	0.4 lb	1.8 c	2.2 c	0.5 bc	1.7 b
Maverick	0.67 oz	0.6 b	1 b	0.4 abc	0.6 a
Sencor	0.4 lb	0.5 ab	0.8 ab	0.3 ab	0.5 a
Sinbar	0.75 lb	0.3 ab	1.6 bc	1.3 d	1.9 b
Surflan	3 qt	0.3 ab	1.1 b	0.3 ab	0.4 a
untreated	---	0.0 a	0.0 a	0.0 a	0.0 a

[1]Rating scale from 0 (no negative effect) to 5 (maximum negative effect).
[2]Mean separation with least significant difference (LSD) $P \leq 0.05$.

Table 2. Effect of herbicides on stand reduction of native grass species grown for seed, Madras, Oregon, 2000-2002.

Herbicide	Rate per acre	Idaho fescue	Indian ricegrass	Squirreltail	Prairie junegrass
Axiom	11 oz	0.5 bc	0.5 ab	2 bc	0.8 abc
Beacon	0.76 oz	0.8 bcd	0.6 abc	2.6 bcd	1.6 cd
Clarity	4 pt	0.8 bcd	0.7 abc	3.1 bcde	1.4 de
Diuron	1.8 lb	0.6 bc	0.9 bc	3.1 bcde	3.8 e
Frontier	32 fl oz	0.8 bcd	1.4 c	1.6 b	0.8 abc
Goal	10 fl oz	0.4 ab	0.5 ab	3.5 cde	0.4 ab
Kerb	0.4 lb	1.9 e	1.1 bc	4.4 e	1.6 cd
Maverick	0.67 oz	1.2 d	1 bc	3.1 bcde	1.1 bc
Sencor	0.4 lb	0.5 bc	0.6 abc	2.2 bc	1.1 bc
Sinbar	0.75 lb	0.9 cd	0.4 ab	4.2 de	2.1 d
Surflan	3 qt	0.8 bcd	0.9 bc	2.5 bcd	1.1 bc
untreated	---	0.0 a	0.0 a	0.0 a	0.0 a

[1]Rating scale from 0 (no negative effect) to 5 (maximum negative effect).
[2]Mean separation with least significant difference (LSD) $P \leq 0.05$

Table 3. Effect of herbicides on reduced heading of native grass species grown for seed, Madras, Oregon, 2000-2002.

Herbicide	Rate per acre	Great basin wildrye		Bluebunch wheatgrass		Streambank heatgrass		Big bluegrass	
Axiom	11 oz	1.1	ab	0.8	ab	1.1	bc	1.6	bc
Beacon	0.76 oz	0	a	0.6	ab	1.2	bcd	0.3	a
Clarity	4 pt	1.81	b	1.3	bc	1.6	cd	1	ab
Diuron	1.8 lb	0	a	0.7	ab	1.2	bcd	0.6	ab
Frontier	32 fl oz	1.8	b	0.6	ab	1	bc	0.6	ab
Goal	10 fl oz	1	ab	0.7	ab	0.9	bc	0.3	a
Kerb	0.4 lb	1.8	ab	2.3	c	1.7	cd	3.8	d
Maverick	0.67 oz	1.3	ab	0.6	ab	0.2	ab	0.5	a
Sencor	0.4 lb	0.8	ab	1.1	b	0.3	ab	0.8	ab
Sinbar	0.75 lb	1.6	ab	1.7	bc	2.1	d	2.3	c
Surflan	3 qt	0.3	ab	1.1	b	0.5	ab	0.5	a
untreated	---	0.0	a	0.0	a	0.0	a	0.0	a

[1]Rating scale from 0 (no negative effect) to 5 (maximum negative effect).
[2]Mean separation with least significant difference (LSD) $P \leq 0.05$

Table 4. Effect of herbicides on reduced heading of native grass species grown for seed, Madras, Oregon, 2000-2002.

Herbicide	Rate per acre	Idaho fescue		Indian ricegrass		Squirreltail		Prairie junegrass	
Axiom	11 oz	1.5	bcd	1.8	bcd	2.4	bc	3.5	d
Beacon	0.76 oz	1.6	bcd	1.1	abc	2.4	bc	2.4	bcd
Clarity	4 pt	2.9	e	2.4	cd	5	e	2.4	bcd
Diuron	1.8 lb	1	b	1	abc	1.8	b	2.6	cd
Frontier	32 fl oz	2.4	de	2.9	d	1.4	ab	2.7	cd
Goal	10 fl oz	0.9	b	1.9	bcd	3.9	cde	1.3	abcd
Kerb	0.4 lb	2.3	de	2	bcd	4.6	de	2	bcd
Maverick	0.67 oz	2.1	cde	2.3	cd	3.1	bcd	2.3	bcd
Sencor	0.4 lb	1	b	1.3	abc	2.7	bc	1.1	abc
Sinbar	0.75 lb	1.3	bc	0.6	ab	5	e	2.6	cd
Surflan	3 qt	1	b	1.6	bcd	2.2	bc	0.3	ab
untreated	---	0.0	a	0.0	a	0.0	a	0.0	a

[1]Rating scale from 0 (no negative effect) to 5 (maximum negative effect).
[2]Mean separation with least significant difference (LSD) $P \leq 0.05$

THE INFLUENCE OF NITROGEN APPLICATION ON CARROT SEED YIELD

J.M. Hart, M.D. Butler and C.K. Campbell

Central Oregon is the major hybrid carrot seed production area supplying the domestic fresh market carrot industry. Hybrid carrot seed yield is low, typically less than 500 lb/a. However, the price paid to the grower is $8 - 15/lb. Relatively small changes in yield make a substantial difference to income, often making the difference between breaking even and a profit. Nitrogen is needed for carrot seed production and has been given credit for both increasing and decreasing seed yield. No record of replicated N rate evaluation is known for Central Oregon. Our objective was to measure carrot seed yield when 0, 50, and 90 lb N/a were applied to a commercial field of Nantes type hybrid seed carrots in the spring.

Three replications of the nitrogen rates were applied to four rows (15 ft wide) 1325 ft long areas of a commercial seed carrot field near Madras, Oregon in a completely randomized manner. Cleaned seed yield is given in Table 1.

Table 1. Nantes type hybrid carrot seed yield influence to nitrogen fertilizer rates in a commercial field near Madras, OR in 2003.

N Rate	Seed Yield
(lb/a)	
0	223 b[1]
50	331 a
90	242 b

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

Application of 50 lb N/a produced significantly more carrot seed than apply 0 or 90 lb N/a. For most crops, 50 lb N/a is a low application rate and would not be sufficient for optimum yield. Verification that a low rate of N is appropriate in this situation was found in the reminder of the commercial field. Approximately 15 acres of the field received 75 lb N/a and produced a seed yield of 328 lb/a, approximately the same yield attained when 50 lb N/a was applied. These data demonstrate the need for only a low rate of N, and that an over application of N can be detrimental. The addition of only 15 to 40 lb N/a above the amount needed for maximum yield, reduced yield 89 lb/a, which would have cost the producer approximately $1,000/a.

To support the data in Table 1, we used measurements of aboveground N accumulation measured by previous studies and soil test measurements. Between 150 and 225 lb N/a were found in the carrot seed crop at harvest in 2001 and 2002. The hybrid grown in 2003 was similar to the hybrid accumulating only 150 lb N/a. Table 2 provides a ledger approach to the crop N needs and the amount supplied by the soil.

Soil from the plots was sampled from the surface foot in early May. Data from 2001-02 nutrient accumulation measurements were used to estimate the amount of N in the crop when the soil was sampled. The previous crop was roughstalk bluegrass. Crops following grass grown for seed in the Willamette Valley typically receive 50 to 100 lb N/a from the decomposing perennial grass roots. The "Balance Needed" by the carrot crop in Table 2 should be easily supplied by the decomposing grass roots.

Table 2. A ledger approach to carrot seed N supply in 2003.

System Component	Amount of N
	(lb/a)
Crop Use	175
In crop on May 1	-25
Amount needed for remainder of season	150
Amount available in soil on May 1	-50
Amount needed for remainder of season	100
From fertilizer	-50
Balance needed	50

Carrots grown for seed benefit from N fertilizer application. Following a roughstalk bluegrass crop, application of 50 to 75 lb N/a was sufficient for optimum carrot seed yield. The N rate is critical since a small, 15 to 40 lb/a, over application depresses seed yield and can cost growers $1,000/a.

The amount of N supplied by the previous crop is difficult to estimate. A site and year specific test at predicts the amount of N needed for a spring application for carrot seed production is desirable.

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