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SEED PRODUCTION RESEARCH

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Edited by William C. Young III

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The following authors have contributed to this report. Use of a commercial or proprietary product in research does not constitute an endorsement of the product by the U.S. Department of Agriculture or Oregon State University.

Central Oregon Agricultural Research Center

F.J. Crowe, Superintendent, Associate Professor of Botany and Plant Pathology
D.D. Coats, Faculty Research Assistant

Cooperative Extension Service - OSU

M.D. Butler, Extension Agent, Jefferson County
G.H. Cook, Extension Agent, Union County
G.A. Gingrich, Extension Agent, Marion County
J.P. Leffel, Retired Extension Agent, Washington County
M.E. Mellbye, District Extension Agent, Linn, Benton and Lane Counties

Department of Botany and Plant Pathology - OSU

P.A. Koepsell, Professor and Extension Plant Pathologist

Department of Crop and Soil Science - OSU

R.P. Andrade, Former Graduate Research Assistant
T.G. Chastain, Assistant Professor Seed Crop Physiology
N.W. Christensen, Professor of Soil Fertility and Plant Nutrition
C.J. Garbacik, Senior Faculty Research Assistant
D.F. Grabe, Professor Emeritus Crop Science
J.M. Hart, Associate Professor and Extension Soil Scientist
W.R. Horwath, Faculty Research Associate
D.A. Horneck, Senior Faculty Research Assistant
B.M. Quebbeman, Faculty Research Assistant
M. Quereshi, Graduate Research Assistant
T.B. Silberstein, Former Faculty Research Assistant
W.C. Young III, Assistant Professor and Extension Agronomist

Eastern Oregon State College

G.L. Kiemnec, Associate Professor of Crop Science

National Forage Seed Production Research Center - USDA-ARS

S.C. Alderman, Research Plant Pathologist
D.M. Bilsland, Senior Faculty Research Assistant
D.B. Churchill, Agricultural Engineer
L.F. Elliott, Research Microbiologist and Research Leader
S.M. Griffith, Research Plant Physiologist
G.W. Mueller-Warrant, Research Agronomist
J.J. Steiner,Research Agronomist
R.E. Welty, Research Plant Pathologist

Other

P.K. Boren, Field Representative, Western Farm Service, Tangent, OR
G.A. Murray, Professor of Crop Physiology, University of Idaho, Moscow, ID
H.C. Olsen, Field Development Representative, Rhone-Pôulenc, Camas, WA

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CONTROL OF WHITE MOLD AND BLACK STEM IN CRIMSON CLOVER

J.P. Leffel, H.C. Olsen, P.A. Koepsell and W.C. Young III

From 1991 through 1993 Rovral brand iprodione fungicide was evaluated for disease control in crimson clover (*Trifolium incarnatum*)grown for seed to identify the potential for registration. There was severe disease in two of the three years. Both Rovral and Ronilan were included in the trials and both provided significant control of white mold (*Sclerotinia* sp.) and black stem (*Phoma* sp.) and also produced more seed than the nontreated control. Niether fungicide is currently registered for use in clover. Residue studies for Rovral are planned for 1994. All fungicide rates in this summary are listed as pounds active ingredient per acre.

In 1991 two trials were established in Washington County, Oregon. Both trials had the same design but application dates were different due to differences in crop and disease progression. Timing of single and double applications were evaluated. Rovral and Ronilan provided similar levels of white mold control at both sites (Figure 1 and Table 1), both were significantly (p=0.05) better than the check. Disease infection levels were rated based on a scale of 0 to 5, with 0 being no plants infected and 5 being 100% of the plants infected. Black stem control was better with Rovral as compared to Ronilan (Table 1) and the yield differences shown in Figure 1 between Rovral and Ronilan are apparently due to the improved black stem control seen with Rovral. Double application of Rovral had significantly less (p=0.05) black stem symptoms than any Ronilan treatments. Fungicides improved yields significantly (p=0.05) over the check and double application of Rovral improved yields significantly over Ronilan treatments (Figure 1).

Application timings are identified in the figures in alphabetical order. The first application timing, identified as A, was February 7. At this timing white mold symptoms were first being detected and the plants were 3 to 4 inches in diameter. The next application was made when plants were begining to touch across rows (Mar. 20- Fig. 1, Apr. 1- Table 1) and the last timing evaluated was when plants were in the early stages of forming a canopy over the row, about 8" tall (Apr. 10- Fig. 1, Apr. 19- Table 1).

Figure 1. Disease levels and yield effects associated with Rovral and Ronilan in crimson clover, site 1, 1991.

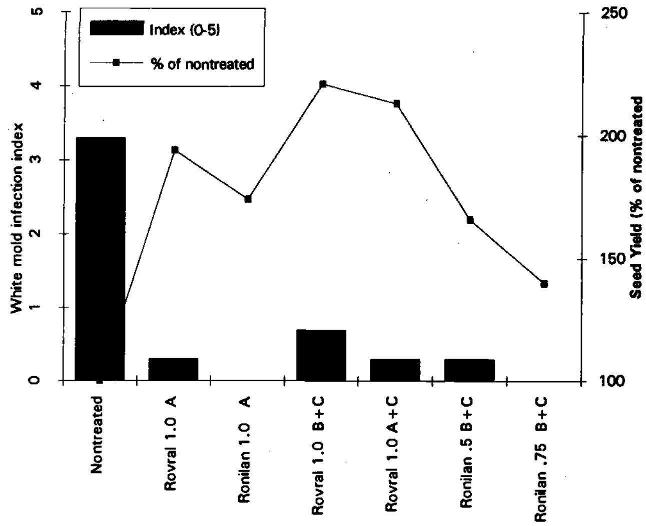


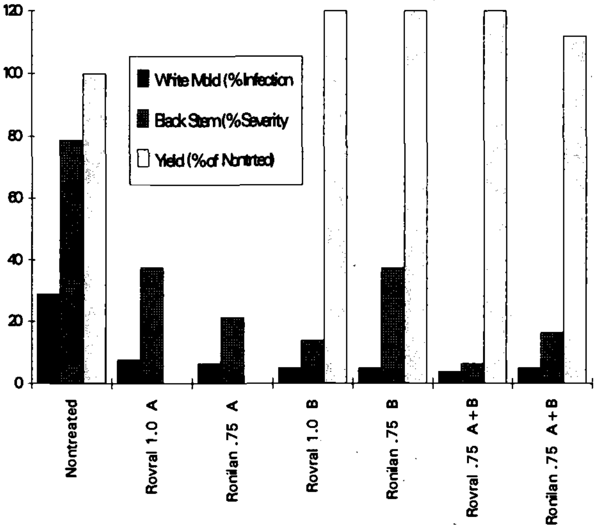
Table 1. Disease control in crimson clover, site 2, 1991.

Treatment	Black stem severity index		White mold infection index	
	---------------- (0-5) ----------------			
Nontreated	5.0	a	4.3	a
Rovral 1.0 A	2.0	de	1.0	cd
Ronilan 1.0 A	2.0	de	0	d
Rovral 1.0 A+C	1.0	f	0	d
Rovral 1.0 B+C	1.3	ef	0.3	d
Rovral 1.0 C	2.0	de	1.0	cd
Ronilan .75 B+C	2.5	cd	0.7	cd
Ronilan .5 C	3.7	b	1.7	c
Ronilan 75 C	2.5	cd	0.7	cd

Means within columns followed by a common letter are not significantly different (p=0.05).

Weather in 1992 was much drier than 1991, especially during the spring. As a result no disease was detected in the trial field until March, when the plants were 7 inches tall, much later than the previous year. Disease severity appeared to be much lower than the previous year. Application timings in 1992 were Feb. 5, March 9 and 26. The February timing was slightly less effective than the March timings apparently due to the length of time between treatment and disease expression. Results from March 9 (A) and March 26 (B) timings are shown in Figure 2, yields were not taken for A timing. The frequency of white mold symptoms was significantly (p=0.05) reduced with all treatments in these low severity conditions. Black stem symptoms were significantly reduced (p=0.05) with Rovral and Ronilan as compared to the check. Even with limited disease pressure yields were improved by 20% and the 3 highest yielding treatments were significantly (p= 0.10) better than the check.

Figure 2. Disease control and yield effects with Rovral on crimson clover, 1992.



Rates and timings were evaluated again in 1993 to confirm previous results. Though the late winter was dry, spring and early summer were extremely wet. April set a record rainfall level. White mold symptoms were seen on February 24 and the first application timing (A) was made, the rows were near touching and white mold was more common than desirable. The second application timing (B) was March 15, rows closed and plants 4" tall. The disease incidence had increased from 1 site per 20 paces to 1 site every 5-10 feet from Feb. 24 to March 15. Rovral did not perform quite as well as Ronilan for the control of white mold in this trial. Both products appeared to perform similarly on black stem in 1993 (Table 2).

Yields taken from this trial indicated a similar benefit with Rovral and Ronilan even though the white mold control was better with Ronilan. The nontreated check produced 1039 lb/a seed and was significantly less (p= 0.05) than the early application of Rovral (1692 lb/a) but not Ronilan (1384 lb/a). When an application was made at both timings, yields were not higher than a single application at the early timing as seen in Table 2.

Table 2. Treatment effects on disease and yield in crimson clover, 1993.

Treatments	Black stem severity		White mold infection		Seed yield	
	(0-5)		(%)		(lb/a)	
Nontreated	3.2	a	75	a	1039	b
Rovral .75 lb A+B	1.6	cd	25	c	1482	a
Ronilan .75 lb A+B	1.3	cd	0	d	--	
Rovral 1.0 lb A	1.8	cd	22	c	1692	a
Ronilan .75 lb A	1.9	bc	2	d	1384	ab
Rovral 1.0 lb B	2.7	ab	46	b	1270	ab
Ronilan .75 lb B	2.0	bc	3	d	--	

Means within columns followed by a common letter are not significantly different (p=0.05).

Conclusions

Over the last three years of testing, Rovral and Ronilan significantly reduced white mold incidence. Two trials were established in 1991 with nearly identical responses and one trial was conducted in each of the following two years. 1991 and 1993 were severe disease years while 1992 was a dry, low disease year.

In 1991 two applications of Rovral reduced black stem severity more than Ronilan. Rovral and Ronilan provided similar levels of white mold control except in 1993 when Ronilan provided a greater level of control. Over the three year period Rovral reduced the average level of white mold infection from the nontreated level by 76% with one application and 88% with two applications. Ronilan reduced the level of white mold infection by 83% with one application and 92% with two applications. Black stem infection responded similarly with a three year average reduction of 49% with one application of Rovral and 69% with two, while one application of Ronilan resulted in a 52% reduction and two applications with a 59% reduction as compared to the nontreated.

Based on the three year average of yield results both Rovral and Ronilan provide significant yield increases (p=0.05) over the nontreated check. The average seed yield of the nontreated check was 1031 lb/a, Rovral (1.0 lb ai/A) at first sign of disease resulted in an average increase of 556 lb/a and Ronilan (.75-1.0 lb ai/a) provided an increase of 403 lb/a. Ronilan provided slightly better white mold control with 83% less plants infected than the nontreated check, while Rovral provided a 76% reduction. When averaged over the 3 years, two applications of Rovral improved levels of disease control, especially for black stem, but did not increase yields over a single early application.

Rovral provided the best results when applied as soon as white mold infection was detected in the plot area. Applications made after the disease had spread were less effective. If only one application was made the 1.0 lb ai/a rate was more effective than the 0.75 lb ai/a rate. If two applications are made, the first application of 0.75 lb ai/A applied when the disease is first detected and the following application at the same rate at early canopy provided very good results. The two application approach has provided better black stem control than the 1 application regime. However, yield benefits of two applications versus one were only seen in one of the three years of testing. With Ronilan (0.75 lb ai/a), timing appeared to be less critical for white mold control, though two applications did improve levels of white mold and black stem control.

RED CLOVER SEED PRODUCTION WATER MANAGEMENT

J.J. Steiner

Red clover is a popular forage legume grown with grasses in pastures for livestock consumption. A majority of the red clover seed produced in the U.S. is grown in western Oregon. Little is known about the optimal cultural practices required to produce consistent amounts of high quality seeds yearly under varying environmental conditions. A major environmental factor that can limit seed production is the amount of soil-water available to the crop. This research has defined the optimum time to apply water to a red clover seed crop through a two-year cropping cycle.

Five supplemental irrigation treatments and a non-irrigated control were applied in 1990 and 1991 to first and second year red clover grown for seed on a Woodburn silt loam at Hyslop Research Farm. The irrigated treatments included applications of water that filled the soil profile to 100% of field capacity (1) at the time of hay removal, (2) at the time of full flowering, or (3) at both times; (4) which filled the soil profile to 50% of field capacity at full-flowering; and (5) which brought the soil to 100% of field capacity by twice-weekly water replacement. The effects of the irrigation treatments and the control on seed yield are given in Table 1.

Table 1. The effect of irrigation treatment on 'Kenland' red clover seed yield.

Treatment	Seed yield 1990	Seed yield 1991	2nd-year yield reduction
	--- (lb/acre) ---		(%)
1. Haying, 100%	908	472	48
2. Peak flowering, 100%	872	614	30
3. Haying/peak flowering, 100%	783	614	22
4. Peak flowering, 50%	757	490	35
5. Twice weekly, 100%	935	739	21
6. Not irrigated	507	240	53
LSD 0.05	125	116	--

Seed yields were substantially increased in all watered treatments compared to the non-irrigated control, especially in the second seed production year. Increased plant water stress reduced the length of time that the plants produced flowers. Seed yield losses due to root and crown root disease complex in the second year of seed production were greatly reduced by supplemental irrigation. The best irrigation treatment that can be practically used by seed growers was a single application of water that filled the soil profile at the time of peak flowering (6.9 and 4.7 inches in 1990 and 1991, respectively). The exact amount of water varied depending upon the amount of soil-water that remained from late-spring rains. The application of water soon after haying time was not as effective as irrigating at peak flowering because adequate soil water was still available from early-spring rains that could be used for plant regrowth after haying and for initial flowering. Only 5.3 and 1.7 inches of water needed to be applied after haying to fill the soil profile in 1990 and 1991, respectively. Contrary to a popular belief, it was shown that red clover seed production was not adversely affected by high application amounts of water (in a well-drained soil), as shown in the twice weekly irrigated treatment. However, this treatment is not practical for commercial seed growers. These findings can be used to improve red clover seed production efficiency so that water applications are optimally utilized by the crop and thus less water and energy are wasted. However, in a drought year such as 1992, it may be necessary to irrigate earlier in the growing season than at the time of peak flowering because soil water content may be low at the time of haying. Therefore, exact environmental conditions for a particular year should be considered in relationship to the recommendations reported in this research. The cost of a single water application is approximately $50.00 per acre.

For more detailed information about this research, see: R.N. Oliva, J.J. Steiner, and W.C. Young, III. 1994. Red clover seed production I. Crop water requirements and irrigation timing. Crop Science 34:178-184; and R.N. Oliva, J.J. Steiner, and W.C. Young, III. 1994. Red clover seed production II. Plant water status on yield and yield components. Crop Science 34:184-192; or write to: J.J. Steiner, National Forage Seed Production Research Center, USDA-ARS, 3450 SW Campus Way, Corvallis, OR 97331.

WHITE CLOVER SEED PRODUCTION WATER MANAGEMENT

J.J. Steiner

White clover seed yield is reduced by environmental conditions that favor vegetative growth and consequently reduce flower density. Supplemental irrigation water is needed to achieve the best balance between reproductive and vegetative growth under western Oregon climatic conditions to optimize seed yield. The objective of this study was to quantify the effects of soil and plant water status on 'Osceola' ladino-type white clover seed production. Five supplemental irrigation treatments were applied in 1990 and 1991 to first- and second-year white clover grown at Hyslop Research Farm. In the non-stressed treatment (1), the soil-water content was brought to field capacity by twice weekly replacement of water used since the last application. Four treatments had a single water replacement to 100% field capacity when 25 (2), 46 (3), 68 (4) and 84% (5) of the available soil-water was used in 1990 and 30, 57, 64 and 79% in 1991. A non-irrigated control (6) was also maintained. The seed yields for the six treatments are given in Table 1.

Table 1. The effect of irrigation treatment in 'Osceola' white clover seed yield.

Treatment	Seed yield
1990	(lb/acre)
1. Twice weekly, 100%	312
2. Once at 25% depletion	374
3. Once at 46% depletion	401
4. Once at 68% depletion	481
5. Once at 84% depletion	294
6. Not irrigated	285
LSD 0.05	98
1991	
1. Twice weekly, 100%	214
2. Once at 30% depletion	267
3. Once at 57% depletion	276
4. Once at 64% depletion	285
5. Once at 79% depletion	258
6. Not irrigated	267
LSD 0.05	53

For a first-year seed crop, a single water application when about 68% of the available soil-water has been used increased seed yields 70% compared to a non-irrigated control. This level of stress can be measured with an infrared irrigation scheduler and corresponds to a crop water stress index value of approximately 0.32. If single water applications are made before or after this level of stress is achieved, seed yield is lower than the optimum. The amount of water applied to the highest yielding treatment was 5.2 inches per acre.

None of the supplemental irrigation treatments increased seed yields in the second year of seed production compared to the unirrigated control because the vegetative stems that grow between plants reduced the number of flowers produced in all irrigated treatments. If second-year white clover seed is to be produced, then there may be no advantage to applying supplemental irrigation water. More research is needed in second-year seed crops to investigate the effects of aggressive vegetation management that reduces stolon density in conjunction with water management. Also, different white clover cultivars may not respond the same to different water management treatments.

For more detailed information about this research, see: R.N. Oliva, J.J. Steiner, and W.C. Young, III. 1994. White clover seed production I. Crop water requirements and irrigation timing. Crop Science 34:762-767; and R.N. Oliva, J.J. Steiner, and W.C. Young, III. 1994. White clover seed production II. Soil and plant water status on yield and yield components. Crop Science 34:768-774; or write to: J.J. Steiner, National Forage Seed Production Research Center, USDA-ARS, 3450 SW Campus Way, Corvallis, OR 97331.

BROADLEAF BIRDSFOOT TREFOIL GERMPLASM CLASSIFICATION

J.J. Steiner

Identifying new sources of genetic variation found in germplasm collection that may be useful for developing new forage and turf cultivars should be important consideration for plant breeders. However, to better utilize the valuable plant genetic resources found in germplasm collections, detailed knowledge about genetic differences among individuals or groups of accessions is needed. An approach was used to classify birdsfoot trefoil (*Lotus corniculatus*) accessions based on information about seed protein differences and the environments from which the accessions were collected. Birdsfoot trefoil is the third or fourth most-popular forage legume grown in the U.S.

One-hundred-twenty-eight of 335 birdsfoot trefoil accessions from the National Plant Germplasm Collection (NPGS)[1] which were collected from five continents and which represented 33 distinct ecoregions were analyzed. By using differences in seed proteins measured by electrophoresis, it was found that the birdsfoot trefoil accessions could be classified into seven genetic groups that were related to the ecological region in which they were collected. The seven groups that were identified were named: 1. Southern Euro highlands, 2. Southern Euro lowlands, 3. Trans-Euro lowlands, 4. Asia minor highlands, 5. West-European-North African, 6. Ethiopian, and 7. French-Mediterranean. Unique morphological characters that had not been previously described were associated with some of the groups.

It also was found that 79% of the cultivars that are now available to consumers were derived from a narrow germplasm base, therefore, much of the genetic variation in the NPGS birdsfoot trefoil collection is still available for unique germplasm and cultivar development. The biochemical and ecological classification approach used in this study may provide a useful way to examine other germplasm collections, and point to how different germplasm bases may be improved. Such biochemical and ecological analysis and interpretive methods may also show where accessions can be found that are less likely to be related to ones that have been previously collected, that are already in germplasm collections, and that are being utilized in present cultivars.

For detailed information about this research, see: J.J. Steiner and C.J. Poklemba. 1994. *Lotus corniculatus* classification by seed globulin polypeptides and relationship to accession pedigrees and geographic origin. Crop Science 34:255-264; or write to: J.J. Steiner, National Forage Seed Production Research Center, USDA-ARS, 3450 SW Campus Way, Corvallis, OR 97331.

[1] Inquiries concerning the acquisition of birdsfoot trefoil accessions should be addressed to: Dr. Stephanie Greene, Plant Genetic Resources, USDA-ARS, NYS Agricultural Experiment Station, Geneva, NY 14456.

GROWING WILLAMETTE VALLEY GRASS SEED CROPS WITHOUT OPEN-FIELD BURNING

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

Management of straw and stubble remaining after seed harvest is an important step in the production of cool-season grass seed crops. In addition to providing economical residue removal and pest control, open-field burning produced an environment that was conducive for crop growth and development and the production of high quality seed. Legislative requirements to incrementally reduce field burning have been rapidly adopted by seed growers; however, we need to ascertain whether nonthermal management practices maintain high seed yield and quality. Our goals are (i) to determine the effect of nonthermal management practices on crop growth and development, seed yield and seed quality, and (ii) to identify successful nonthermal management strategies for grass seed crops grown in the Willamette Valley. This report documents our research activities during the first cropping cycle (post-harvest residue management to seed harvest).

Our trials were initiated at 15 sites in spring 1992. Six perennial grass seed crop species were chosen for the study. These included perennial ryegrass (6 sites), tall fescue (5 sites), orchardgrass, Chewings fescue, creeping red fescue, and Colonial bentgrass. Residue management treatments included flail chop full straw (3X), bale only, bale + flail chop stubble, bale + flail + needle-nose rake, bale + vacuum-sweep, bale + propane, and open burn.

No residue was removed in the flail (3X) treatment; straw and stubble were chopped three times to facilitate decomposition in the field. Baling is the primary residue removal method, accounting for 75 to 82% of the straw removed. The bale + flail treatment reduced the height of stubble, but did not remove additional straw. The needle-nose rake and vacuum sweep are secondary methods that remove residue remaining in the field after baling. The needle-nose rake removed 50% of the residue remaining after baling, whereas the vacuum-sweep removed 85% of the straw remaining in the field.

The post-harvest regrowth, tillering, and leaf development responses to residue management was determined on samples taken in fall 1992 and early winter 1993. Total tiller number was not influenced by residue management in perennial ryegrass, but tiller number was reduced by bale and rake treatments in Rebel II tall fescue (Table 1). The number of large basal diameter tillers present in the population was not reduced by nonthermal residue management in tall fescue and perennial ryegrass. Tillers with large basal diameters are more likely to become fertile than smaller basal diameter tillers. Tiller height was somewhat increased by flail (3X) and bale in Rebel II tall fescue. Tillers sampled from Manhattan IIE plants were more mature (measured by tiller leaf number) when residue was managed by flail (3X), flail, and rake treatments. Tiller maturity was not affected by residue management in tall fescue. Residue management had no effect on fall tiller and leaf development in orchardgrass.

Tiller number in fine fescue was not influenced by residue management (Table 2), although more large basal diameter tillers were present in creeping red fescue when managed by thermal techniques. The number of large basal diameter tillers and total tiller number were increased by nonthermal management in Colonial bentgrass. Fall-formed tillers were elongated in Chewings fescue and somewhat elongated in creeping red fescue when residues were managed by nonthermal techniques. Leaf development in the fine-leaf fescues was not affected by residue management. The slowest rate of leaf development in Colonial bentgrass was observed on tillers sampled from open-burned plots. The significance of the reduction in tiller production and leaf development in Colonial bentgrass managed by thermal strategies is unclear.

Spring tiller production was determined on samples taken from all research sites during late spring and early summer 1993 (Tables 3 and 4). Fertile tiller production was not affected by residue management in perennial ryegrass, tall fescue, orchardgrass (Table 3), and in Chewings fescue and Colonial bentgrass (Table 4). However, the proportion of tall fescue tillers that became fertile in the spring tiller population was sometimes (two of five sites) lower when residue removal was less thorough. In creeping red fescue, flail and rake treatments produced only 38% and 57% of the fertile tillers observed in the open burn treatment, respectively (Table 4). Although vacuum sweeping resulted in just 64% of the fertile tillers produced by open burning, this value was not different from the 81% (of open burn) measured in propane burned plots.

Table 1. Residue management effects on fall tiller and leaf development in perennial ryegrass, tall fescue, and orchardgrass.

Treatment	Perennial ryegrass Linn	Perennial ryegrass Manhattan IIE	Tall fescue Rebel II	Tall fescue Crewcut	Elsie orchardgrass
	Tiller number (no./sq. ft.)				
Flail 3X	445	507	358 b**	474	101
Bale	427	433	234 a	632	89
Flail	500	439	361 b	614	107
Rake	374	503	226 a	591	100
Vacuum	485	529	313 ab	540	125
Propane	427	414	--	--	--
	Tiller height (cm)				
Flail 3X	11.0	15.1	14.3 bc*	14.7	20.6
Bale	12.1	18.9	15.0 c	16.8	19.5
Flail	11.5	16.4	13.9 ab	15.3	19.4
Rake	12.3	16.4	13.6 a	15.9	19.1
Vacuum	11.5	18.7	13.3 a	16.3	19.4
Propane	11.6	19.8	--	--	--
	Haun mean stage (leaf no./tiller)				
Flail 3X	1.7	2.4 bc*	3.3	2.9	3.8
Bale	1.7	2.0 a	3.3	2.9	3.8
Flail	1.5	2.6 c	3.4	3.1	3.6
Rake	1.4	2.5 bc	3.5	2.6	4.0
Vacuum	1.5	2.2 ab	3.5	2.6	4.0
Propane	1.6	2.3 b	--	--	--

*Means in columns followed by the same letter are not different by Fisher's Protected LSD Values ($P = 0.05$)
**FPLSD ($P = 0.10$)

Weigh wagons were used to determine the seed yield harvested from our plots using grower combines. The harvested area in each plot consists of one swather width and seed yields are based on this single windrow that is combined by the grower. Plot harvest in our trials is a two-step operation. First, the dirt weights are measured after the grower dumps the combined material harvested from each plot. Second, a sample is drawn from the combine's auger stream as it enters the weigh wagon. A subsample is drawn and sent to Dr. Steve Alderman (USDA-ARS) for detection of seedborne diseases. The remaining sample is cleaned to determine percent cleanout and subsamples are submitted to the OSU seed laboratory for purity and germination testing. Clean seed yield values account for percent cleanout and seed purity.

Seed yields were not reduced by nonthermal management in orchardgrass, tall fescue, and perennial ryegrass (Table 3); and in Chewings fescue and Colonial bentgrass (Table 4). No strong trends in seed yield were evident for any of these species except in Pennfine and Pennant perennial ryegrass where the propane burned treatment resulted in small reductions in yield. The propane-burned treatment may have introduced additional stresses in perennial ryegrass at sites where the crop was already stressed by last year's heat and drought conditions. Flail (3X) and rake treatments also reduced yield in Pennfine perennial ryegrass.

Creeping red fescue seed yields were reduced when higher levels of straw and stubble remained in the field after harvest of the previous seed crop (Table 4). Fall and fertile tiller production were reduced in the less thorough residue management treatments and were early indicators of the 1993 seed harvest results. The less thorough residue removal treatments such as flail and rake yielded only 68%

and 70% of the seed harvested when open-burned, respectively. Among nonthermal approaches, only the vacuum-sweep treatment was comparable to open-burning. The physiological causes of the sensitivity to nonthermal management in creeping red fescue need to be elucidated in order to systematically improve residue management techniques for this crop.

Table 2. Residue management effects on fall tiller and leaf development in fine fescue and Colonial bentgrass.

Treatment	Pennlawn red fescue		Banner Chewings fescue		Highland Colonial bentgrass	
	Tiller number (no./sq. ft.)					
Flail	741		1944		1063	bc*
Rake	692		2180		1090	bc
Vacuum	773		2217		1219	c
Propane	900		1892		906	b
Burn	748		1677		396	a
	Tiller height (cm)					
Flail	13.4		8.9	c	9.0	
Rake	10.7		7.7	bc	7.6	
Vacuum	9.2		6.3	a	7.7	
Propane	9.9		6.1	a	7.6	
Burn	10.0		7.2	ab	7.6	
	Haun mean stage (leaf no./tiller)					
Flail	2.1		2.2		2.8	b
Rake	1.7		2.9		2.4	ab
Vacuum	2.2		2.5		2.7	b
Propane	1.8		3.1		2.5	ab
Burn	2.3		2.7		2.0	a

*Means followed by the same letter are not different by Fisher's Protected LSD Values ($P = 0.05$).

Standard seed germination and purity tests were performed on seed harvested from all test plots. Fluorescence tests were conducted on perennial ryegrass seed lots to detect the presence of annual ryegrass. No significant increases in annual ryegrass contamination were observed in perennial ryegrass managed by nonthermal techniques. Seed germination and physical purity were not reduced by nonthermal management. A small increase in weed seed was evident when Chewings fescue was not burned, although vacuum sweep was comparable to burning in this crop.

Table 4. Residue management effects on fertile tiller production and seed yield in fine fescue and Colonial bentgrass.

Treatment	Pennlawn red fescue		Banner Chewings fescue	Highland Colonial bentgrass
	Fertile tiller (no./sq. ft.)			
Flail	78	a*	259	275
Rake	117	ab	217	374
Vacuum	132	bc	290	361
Propane	168	dc	262	254
Burn	207	d	266	254
	Seed yield (lb/a)			
Flail	694	a	1072	594
Rake	717	a	1075	590
Vacuum	914	b	991	587
Propane	876	b	1042	611
Burn	1023	b	1057	610

*Means in columns followed by the same letter are not different by Fisher's Protected LSD Values ($P = 0.05$).

Residue cover influences on soil water content were measured by time domain reflectrometry wave guides placed in the plant root zone. Prior to harvest, there were no differences in soil water content (Figure 1). Once the plant canopy was removed, the straw acted as a mulch and conserved water during the dry summer months. During late August, there was 20% more water available to tall fescue plants in flail (3X) plots than when most residue was removed by the vacuum-sweep treatment.

Soil samples obtained in October 1993 reveal that trends indicating the potential for reduction in pH, phosphorus, potassium, and magnesium have appeared after only one season of residue removal (Tables 5 and 6). Somewhat higher nutrient and pH levels were found when the full straw load remained in the field. The cumulative effects of annual residue removal are expected to cause further reductions, making non-nitrogen fertility practices a concern in systems that remove residue from the field. When grass seed crops were managed by open burning, nutrients were largely returned to the soil.

Table 3. Influence of residue management on fertile tiller production and seed yield in perennial ryegrass, orchardgrass, and tall fescue.

Crop	Flail 3X		Bale		Flail		Rake		Vacuum		Propane	
	Fertile tillers (no./sq. ft.)											
Perennial ryegrass												
Linn	246		197		225		238		187		168	
Oasis	138		196		180		191		212		183	
Manhattan IIE	227		185		225		275		273		245	
Pennfine	276		271		287		268		238		257	
Pennant	199		188		169		178		194		202	
Yorktown III	251		247		246		242		259		263	
Tall fescue												
Rebel II	57		70		67		87		91		--	
Rebel Jr. (Wilfong)	81		64		78		58		75		--	
Rebel Jr. (Glaser)	92		57		75		112		90		--	
Anthem	97		85		72		78		85		--	
Crew-cut	143		156		171		175		138		--	
Orchardgrass												
Elsie	41		45		56		32		43		--	
	Seed yield (lb/a)											
Perennial ryegrass												
Linn	932		881		928		906		958		906	
Oasis	1690		1855		1718		1778		1787		1831	
Manhattan IIE	2324		2354		2281		2309		2354		2196	
Pennfine	748	a*	866	b	863	b	742	a	820	ab	770	a
Pennant	1397	bc	1345	ab	1364	bc	1437	c	1359	bc	1259	a
Yorktown II	2262		2227		2341		2359		2348		2356	
Tall fescue												
Rebel II	1575		1434		1435		1547		1384		--	
Rebel Jr. (Wilfong)	1890		1925		2046		1899		1941		--	
Rebel Jr. (Glaser)	2110	d	1963	ab	1915	a	2017	bc	2078	cd	--	
Anthem	1692		1606		1662		1695		1668		--	
Crew-cut	1945		1897		1932		1887		1738		--	
Orchardgrass												
Elsie	921		961		926		946		914		--	

*Means in rows followed by the same letter are not different by Fisher's Protected LSD Values ($P = 0.05$).

Table 5. Influence of residue removal in perennial ryegrass, tall fescue, and orchardgrass on selected soil characteristics in 1993.

Species	Cultivar	Depth	Treatment	Soil characteristics pH	Phosphorus	Potassium	Magnesium
		(inch)			------------ (ppm)	----------------	(meq/100g)
Perennial ryegrass	Linn	0-2	Flail (3X)	5.2	36	297	2.53
			Vacuum	5.2	47	267	2.47
		2-4	Flail (3X)	5.4	37	187	2.47
			Vacuum	5.5	40	187	2.47
		4-6	Flail (3X)	5.4	42	223	2.43
			Vacuum	5.5	39	219	2.40
Tall fescue	Rebel II	0-2	Flail (3X)	6.2	18	128 *	0.88 **
			Vacuum	6.1	19	105	0.77
		2-4	Flail (3X)	5.5 **	12	62	0.71 *
			Vacuum	5.3	17	61	0.66
		4-6	Flail (3X)	5.2	12	62	0.79
			Vacuum	5.2	12	66	0.77
Orchard-grass	Elsie	0-2	Flail (3X)	5.9	19	194 *	8.30
			Vacuum	6.0	15	140	8.30
		2-4	Flail (3X)	6.2 *	14	125	8.47
			Vacuum	6.3	12	122	8.47
		4-6	Flail (3X)	6.2	15	121	8.50
			Vacuum	6.1	14	133	8.47

*Means within soil depth are different ($P = 0.05$)
**Means within soil depth are different ($P = 0.10$)

Table 6. Influence of residue removal in fine fescue and Colonial bentgrass on selected soil characteristics in 1993.

Species	Cultivar	Depth	Treatment	Soil characteristics: pH	Phosphorus	Potassium	Magnesium
		(inch)			------------- (ppm)	-----------------	(meq/100g)
Chewings fescue	Banner	0-2	Flail (3X)	5.6	23	234	0.70
			Vacuum	5.4	30	175	0.63
		2-4	Flail (3X)	5.5 **	9	87	0.60
			Vacuum	5.4	10	84	0.60
		4-6	Flail (3X)	5.4	5	81	0.83
			Vacuum	5.3	6	75	0.80
Creeping red fescue	Pennlawn	0-2	Flail (3X)	5.4	54	252 **	1.30
			Vacuum	5.3	45	192	1.37
		2-4	Flail (3X)	5.7	27	168	1.37
			Vacuum	5.6	23	146	1.37
		4-6	Flail (3X)	5.7	16	180	1.47
			Vacuum	5.7	17	156	1.43
Colonial-bentgrass	Highland	0-2	Flail (3X)	4.9	7 **	184 *	0.43
			Vacuum	5.0	4	175	0.40
		2-4	Flail (3X)	5.1 *	4	91	0.60
			Vacuum	5.1	3	83	0.60
		4-6	Flail (3X)	5.5	3 **	87	0.83
			Vacuum	5.2	1	80	0.80

*Means within soil depth are different ($P = 0.05$)
**Means within soil depth are different ($P = 0.10$)

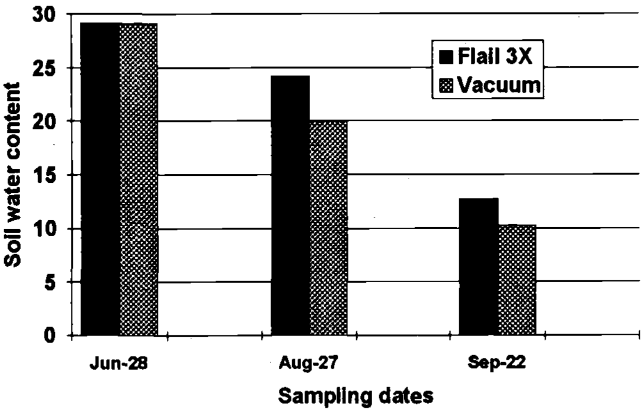


Figure 1. Influence of crop residue on soil water content at three sampling dates in Rebel II tall fescue.

The study will continue for two more cropping cycles (residue management to seed harvest). At the completion of the field study, the economic return from each residue management option will be determined so that growers can choose the management system that best fits their enterprise.

NITROGEN UPTAKE BY TALL FESCUE UNDER FULL STRAW LOAD MANAGEMENT

M.E. Mellbye, G.A. Gingrich, N.W. Christensen, J.M. Hart, W.C. Young III and Maqsood Qureshi.

Chopping back the full straw load is a promising option in tall fescue seed production. One of the benefits of this management approach is nutrient recycling. Higher levels of soil K, for example, have been measured under full straw chopping compared to vacuum-sweep treatments, indicating K from the decomposing residue on the soil surface was recycled for crop use (Young et al., 1993). Questions remain about N fertilizer management when straw is chopped back. Is N immobilized by the straw due to its high C:N ratio? Or, as the straw decomposes on the soil surface, does N mineralization take place at a rate adequate to supplement commercial fertilizer? Established field trials provided an opportunity to monitor the effect chopping back the full straw load had on N availability.

This study was conducted to evaluate N uptake in tall fescue seed fields where the straw had been chopped back. Flail chopping the full straw load was compared to thorough residue removal by bale and vacuum-sweep management. Four existing tall fescue residue management trials in Linn and Marion counties were selected for the study. Two of the trial locations were established in 1992 following harvest of the first year's seed crop. These had one year of full straw versus vacuum-sweep management and represented first-year sites. Two additional sites were established in 1990, and had been maintained for the last three years using the two residue management systems. These represented third-year sites.

Both first- and third-year sites were located on well drained and poorly drained soils. First-year fields consisted of: Rebel II on a Dayton silty clay loam (poorly drained), and Crewcut on a Willamette silt loam (well drained). The third-year fields were Cochise on a Woodburn silt loam (moderately well drained), and Arid on a Dayton silty clay loam (poorly drained). Standard fertilizer applications were made at each site by individual farmers. Spring N applications were applied between early February and mid April. While there were variations in materials used and application timings, all sites received split applications and received 140 to 145 lb N/acre.

Plant and soil samples were taken within each plot six times starting March 24 and ending at swathing time on July 1, 1993. Three replications were taken during each sampling period. Plant samples were dried to determine biomass accumulation and N content, which in turn were used to calculate N uptake. Soil samples were analyzed for ammonium and nitrate forms of nitrogen at the 0-1", 1-4", and 4-8" depths. Seed yields were obtained through grower swathing and combining large plots in the field by seed growers participating in on-farm research evaluating various post-harvest management options.

Nitrogen uptake and plant growth (biomass accumulation) through the season were affected by full straw chopping, but first-year sites responded differently than third year sites. On first-year sites, plant growth was slightly reduced where the straw had been chopped back. Uptake of N through the season was also less, suggesting that some N immobilization occurred. The difference in N uptake averaged 20 lb/acre less on the full straw treatments. The difference was more pronounced on the well-drained site, where N uptake was 32 lb/acre less (Figure 1). On the poorly drained field, the difference was only 9 lb N/acre.

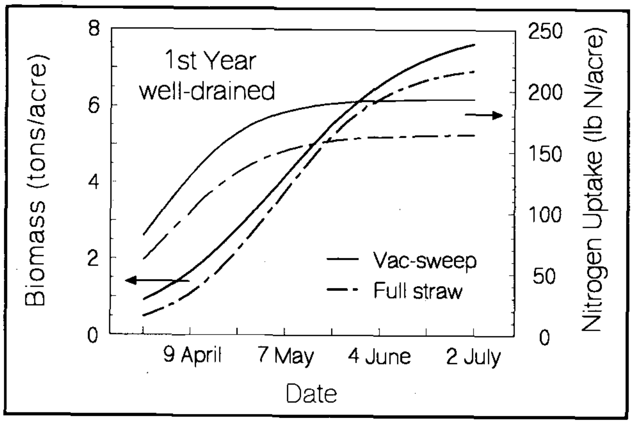


Figure 1. N uptake and plant growth (biomass accumulation) as influenced by residue management on a Willamette silt loam soil, 1993.

In contrast to the first-year sites, plant growth and N uptake were greater when the straw had been chopped back for three consecutive years. This suggested some N mineralization, or release, occurred from the decomposing straw. The increase in N uptake averaged 11 lb/acre more with full straw chopping after three years of leaving straw. Similar to the first-year sites, the differences in growth and N uptake were more pronounced on the well-drained field, where the increase in N uptake was 16 lb/acre (Figure 2). The difference was just 6 lb/acre on the poorly drained field. On both first- and third-year sites, differences in plant growth and N uptake on the poorly drained sites were small and not statistically significant.

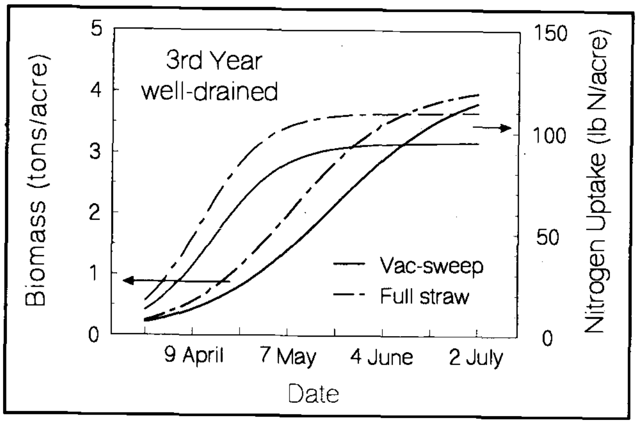


Figure 2. N uptake and plant growth (biomass accumulation) as influenced by residue management on a Woodburn silt loam soil, 1993.

Nitrogen uptake preceded plant growth at all four sites in this study. By early May, uptake of N was 90% of the season total. At this point in time, biomass accumulation across all sites averaged 42% (range 35-46%) of the total seasonal growth. This pattern of growth and N uptake was consistent across residue management treatments.

There were no differences in soil nitrate or ammonium levels through the season between the two systems of residue management. The root systems of grasses are very efficient at absorbing nitrate from the soil. Differences due to immobilization or mineralization were probably masked by rapid uptake of nitrate as it appeared. At harvest, low levels of both ammonium and nitrate were measured. Ammonium levels in the surface eight inches were below 1 ppm and nitrate was below 5 ppm. These concentrations are lower than what's typically found after harvest for many cultivated crops in the Willamette valley.

While total N uptake was reduced some on the full straw treatment the first year, the rate of uptake and the total amount taken up were adequate to maintain seed yield. In fact, as shown in Table 1, seed yields were a little greater on these plots (although not statistically significant). Varieties at the two third-year locations responded differently to the residue management practices. There was no evidence that the full straw load treatment after three years had a consistent positive or negative effect on yields.

Table 1. Tall fescue clean seed yield, 1993.

			Residue Management	
Site Year	Variety	Soil Drainage	Full Straw Chop	Bale + Vacuum
			--------(lb/a)-----	
1	Crewcut	Well-drained	1945	1738
1	Rebel II	Poorly drained	1575	1384
3	Cochise	Mod. well-drained	1365	1059
3	Arid	Poorly-drained	1501	1617

Results of this study indicate that extra N is not needed after chopping back the full straw load. Some immobilization of N occurred following the first year of chopping, but reduced uptake of N did not reduce seed yields. Grower applications of 140 lb N/acre were apparently adequate to compensate for any immobilization that occurred. After three years of returning straw, some mineralization of N from the residue occurred, but the increase in N uptake was small and probably not enough to supplement commercial N applications. N mineralization could increase with additional years of flail chopping the full straw load, but N response trials would be required to determine if, and how much, N rates could be reduced. Based on the information we have, standard rates of fertilizer N applied in the spring appear adequate to maintain seed yields under full straw load management through the third year of production.

The pattern of N uptake suggests that adequate fertilizer should be applied in March to support the rapid uptake of N that occurs in April. This could be especially important on well-drained soils, following the first year of full straw management, where reductions in N uptake due to residue management seem to be the greatest.

Residual nitrate levels found at these four locations were low, regardless of residue management or soil drainage. Rates of N used by seed producers, and the timing of applications during the period of spring growth, were adequate to prevent the buildup of high residual nitrogen levels in the soil. Current fertilizer practices appear adequate to prevent nitrate contamination of groundwater.

Reference

Young III, W.C., T.B. Silberstein and D.O. Chilcote. 1993. An evaluation of equipment used by Willamette Valley grass seed growers as a substitute for open-field burning. Dept. of Crop and Soil Science, Ext/CrS 94.

Acknowledgment: This research was supported in part by a grant from the Oregon Seed Council.

EFFECT OF SOIL K ON PERENNIAL RYEGRASS AND TALL FESCUE

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

Historically, Oregon State University recommended and the grass seed industry fertilized, fine fescue, tall fescue, Kentucky bluegrass, orchardgrass and perennial ryegrass similarly with sulphur, phosphorous and potassium. OSU fertilizer guides for these grasses recommend P and K fertilization identically, with critical levels for Bray-P1 at 25 ppm and ammonium acetate K at 100 ppm. These critical levels were based on agronomic principles, response of other crops to P and K, familiarity with perennial ryegrass (PR) and tall fescue (TF) growth patterns and open field burning for straw disposal. Thus these critical levels do not account for differences between grass species or recent changes in straw management.

Soil tests are not effected where straw is burned or chopped back and left on the field because nutrients removed by plant uptake are returned to the soil. Harvesting residue will effect soil tests based on crop removal and the soil's buffer capacity to replenish nutrients. Harvesting residue and seed is in fact mining your soil of P, K, Ca, Mg. Phosphorous soil tests do not change much where residues are harvested because seed and straw combine to remove 5-15 lb/a P and soil P buffering capacity is high. Grass seed crops are efficient P users and can readily uptake soil P when soil tests are below 15 ppm.

Potassium, unlike P, is a much greater concern where residue is harvested because of K removal quantities and the resulting drop in soil K. Observed drops in soil K due to changes in residue management has generated questions and concerns about K management. A past article in this publication discussed effects of residue management on K soil test levels. The effect of soil K on tissue K and K uptake in PR and TF will be the basis for discussion in this article.

Methods

Sites planted to PR and TF with high and low soil test K were treated with; burn and vacuum sweep straw managements, in combination with potassium fertilization, K^0 and K^+. Initial 0-6 inch K soil test levels were 218, and 55 ppm K for TF and 164 and 78 ppm K for PR. Straw yield, seed yield and soils were sampled annually at each site. Sites were soil sampled at 0-1 and 0-6 inch depths, 1990 sampling included samples to a depth of 24 inches. Tissue and seed samples were analyzed for K. Soil samples were analyzed for pH, P, K, Ca and Mg. Annual burn plots at the 218 ppm K TF site were moved after the 1989 harvest as the result of the stand being destroyed. Experimental design comparisons between sites for factors such as seed yield have been confounded with location and variety.

Results and discussion

Seed yield was not directly effected by K application. When seed yield is averaged across grass type, fertility, straw management and years there is no difference between K^+ and K^0, 1335 lb/a and 1325 lb/a, respectively. Similarly, straw management did not effect seed yield. There was a tendency for the low fertility sites to respond to K but only where the straw was being harvested. Tall fescue was more likely to respond than PR to K fertilization, because of more residue produced with a higher K content. Think of open field burning or chopping back straw as a 25-300 lb/a K application that depends on grass type and K soil test level. This was emphasized by straw management having a significant effect on soil K where as K fertilization did not.

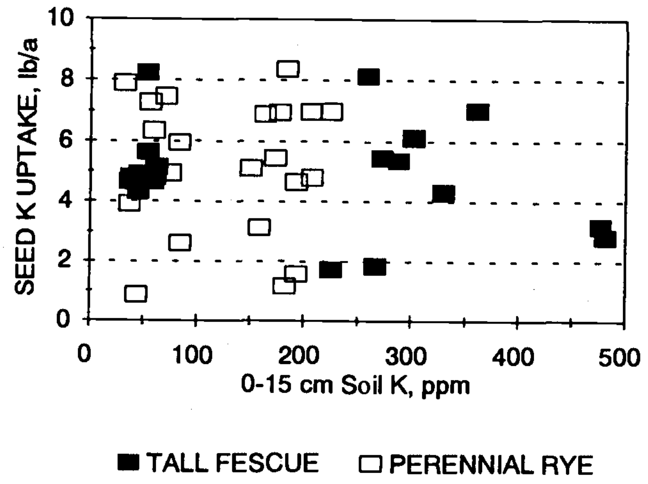


Figure 1. Seed uptake of K for perennial ryegrass and tall fescue.

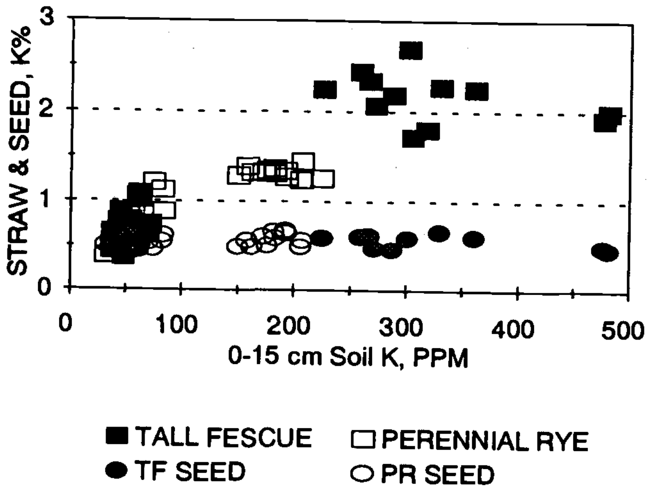


Figure 2. Response of seed and straw K to soil K for perennial ryegrass and tall fescue.

Percent potassium in the seed was effected by fertility, grass type and straw management. Seed K was not effected by K application. However, differences in K due to treatments were small. Mean K was 0.53% with vacuum sweep 0.54% K and open burn 0.52%. High K sites produced seed with 0.56% K and the low K sites produced seed with 0.50% K. These differences though statistically significant are of minimal importance when considering K removal. Potassium uptake in the seed averaged 5.12 lb/a with highs of 10 lb/a (Figure 1). Ten pounds per acre K would represent approximately 3% of the K utilized by a vigorous TF crop with K soil tests in excess of 250 ppm. Potassium uptake in the seed which is dependent on seed yield and K content was not effected by grass type, fertility and K application. Soil test K did not effect seed K% or K uptake (Figure 1 & 2).

Percent K in TF and PR straw, unlike seed, was effected by soil test level (Figure 2). Grass type, Straw management, fertility and K application all effected K% in the straw. Tall fescue and PR had similar K levels when soil tests were below 100 ppm. Where fertility was high PR leveled off at 1.25% K where as TF leveled off at 2.25% K (Figure 2) These figures are not exact and may be somewhat variety dependent. Turf-type PR and TF varieties are higher in K% than older pasture varieties as shown by previous work. Foliar K of 1.25% for PR and 2.25% for TF represents levels at harvest, K concentrations during winter and spring will be higher. Forage quality is effected by K% because K is balanced with Ca and Mg which influences animal health.

How these grasses respond to soil test K (Fig 3.) can be modeled from percent K in the straw (Figure 2). Clues as to how PR and TF respond to K can be derived from these models. Perennial ryegrass and TF both need 0.28% K to sustain any type of growth. To see straw K levels this low soil tests would need to be less than 40 ppm for TF and 30 ppm for PR. Figure 3 also shows foliar K in TF and PR respond similarly to soil K when soil tests are below 100 ppm. Perennial ryegrass and TF respond differently when soil K is greater than 100 ppm. Perennial ryegrass reaches maximum K level in straw at a lower soil K level than TF.

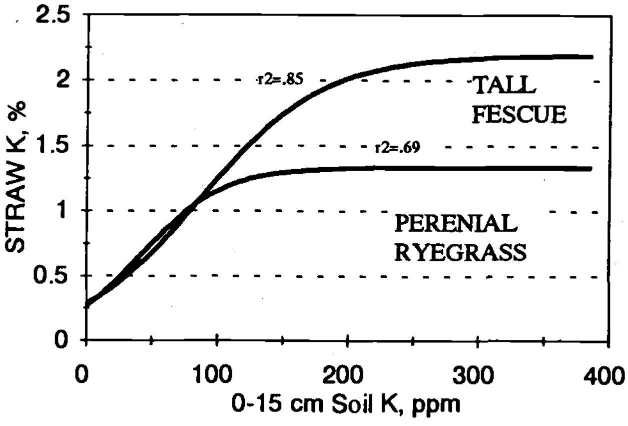


Figure 3. Model of straw K response to soil K.

Change in straw K relative to soil K is shown in Figure 4. Units (% straw K/ppm soil K) on the Y axis are not important, instead, keep in mind curve shape and at what soil test level maximums and minimums occur. First the maximums. Perennial ryegrass and TF peak at 45 ppm and 90 ppm K in the soil, respectively. These peaks are where soil K is increasing straw K% the most. Growth has stopped, therefore additional K to the plant either via fertilizers or increased soil test K is not being diluted in new growth but used to increase K% in the straw.

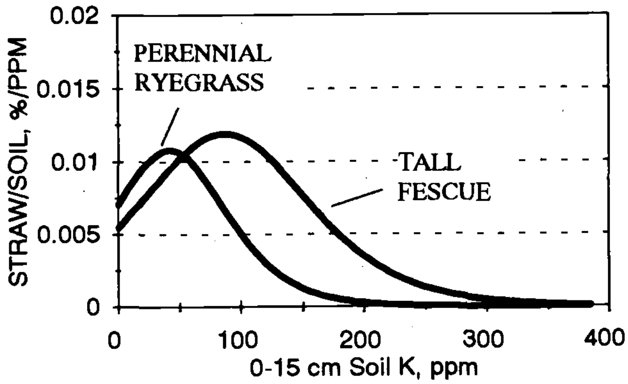


Figure 4. Change in straw K relative to soil K.

Secondly, we will discuss the slopes building up to and coming down from the peaks. The down slope exists because increasing soil K is raising foliar K% with decreasing efficiency. Dilution of K in additional growth is not occurring. In other words, as soil tests go from 45 ppm to 200 ppm K for PR and 90 to 325 ppm K for TF, higher soil K increases K% in the straw by smaller amounts. Decreased response to increased applications is the law of diminishing returns. Maximum K% occurs when soil K no longer has an effect on straw, minimum in Figure 4. Maximum K% for PR occurs at 200 ppm soil K and 325 ppm for TF. Luxury consumption, where the plant is taking up more K than is necessary for it to manufacture seed or straw, is associated with the down slope. Why grasses use variable amounts and what benefits or detriments occur in the plant is unclear.

The slope building up to the peak, in figure four, where the grass is increasing in K% but at a reduced rate until the peak is reached, results from some K being diluted in additional growth and part used to increase K% in tissue. As soil tests go from 0 to 45 ppm for PR and 0 to 90 ppm K for TF increases in growth due to increases in soil test K diminishes and more K is used to increase K% in straw.

Summarizing Figures 2, 3 and 4: When soil tests are low, K uptake is increasing but foliar K is relatively unchanged because new K is used to produce additional dry matter. At medium soil tests dry matter is constant but K uptake is increasing because K% in the straw is increasing. When soil tests are high dry matter is constant and K% in the straw is maximized resulting in K uptake being constant. Residue management systems where straw is removed need to manage soil and fertilizer K to maintain growth yet minimize K removal. For TF, 100 lb/a K should be applied when soil tests are below 100 ppm and 50 lb/a when below 150 ppm. Apply 50 lb K/a to PR when soil K is less than 75 ppm and 30 lb/a when below 100 ppm.

Potassium uptake by TF and PR in straw is effected by K level and dry matter production. Tall fescue not only has the potential to take up more K it also produces more dry matter than PR. Differences between PR and TF species are reflected in K uptake (Figure 5). Tall fescue can remove in excess of 300 lb K/a where PR has the potential to remove 100 lb K/a. Baling and vacuum-sweeping removes additional K since K uptake in Figure 5 is removal when straw is swathed. Because large amounts of K exist in PR and TF residue evidence exists that K soil tests should not be taken where straw load is chopped back until winter rains start (Table 1). This allows K in the straw to leach out and show up in soil tests, otherwise soil tests will be artificially low.

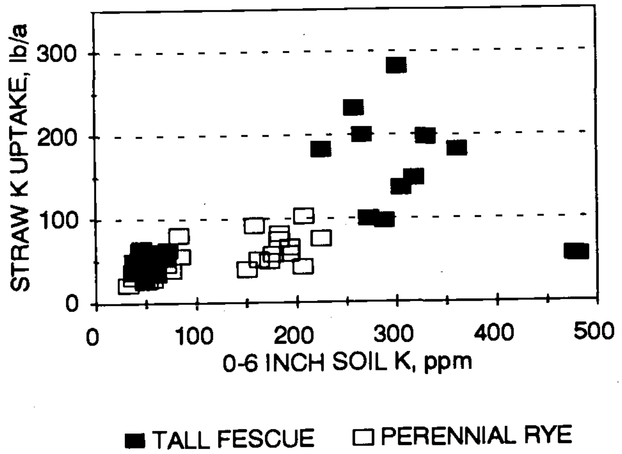


Figure 5. Straw K uptake vs. soil K.

Table 1. Effect of sampling date and residue management on 0-1 inch soil test K.

	Residue management			
	Flail chop full straw		Vacuum-sweep	
Location[1]	Aug.	Nov.	Aug.	Nov.
	(ppm)			
Wirth's	324	526	382	386
Pugh's	285	386	281	163
Falk's	246	280	129	144

[1]Trials in these three growers' tall fescue fields had evaluated post-harvest residue management treatments through three seed harvests. Soil test K samples were taken from the two treatments noted following harvest of the 1993 crop.

Conclusions

Seed K uptake and content are not dependent on soil K or K fertilization, thus a grower is not able to control K removed by harvesting seed. Potassium removal due to seed harvest is inconsequential when straw contains up to 300 lb K/a and 100 lb K/a for TF and PR, respectively.

Managing straw K% is of minimal importance where open field burning and chopping back straw are used to recycle nutrients unless forage quality is important. Perennial ryegrass can take up 100 lb K/a when soil tests are greater than 150 ppm K. When soil test are less than 100 ppm K, a K application of 30-50 lb/a K should supply enough K for vegetative and reproductive growth. A K application is unwarranted when K soil tests are greater than 100 ppm K.

Tall fescue can utilize 300 lb K/a when soil tests are in excess of 300 ppm K. Tall fescue utilizes more K and soil test level has a greater effect on K uptake than PR. Tall fescue and PR behave similarly in their response to K when soil tests are below 100 ppm. Fertilizer applications of 50-100 lb K/a should be considered for TF when soil tests are below 150 ppm. When soil K is above 150 ppm, fertilization will only increase K uptake in the straw.

EFFECT OF STUBBLE CLIPPING HEIGHT ON PERENNIAL RYEGRASS SEED CROPS

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

The amount of stubble left on fields following straw removal by baling can be considerable, and is known to interfere with fall tiller development. The balance between the amount of stubble remaining and the plant's ability to initiate efficient fall regrowth for the subsequent seed crop is not well understood.

Several methods of stubble reduction (e.g., raking, flail chopping, and vacuum sweeping) are currently used by growers to minimize the impact of stubble remaining around the crowns in the stand of baled fields. Thus, a preliminary study was established in 1991 following harvest of a second seed crop of Caravelle perennial ryegrass grown at the Hyslop Crop Science Field Laboratory near Corvallis. This one acre block was carbon-seeded in the fall of 1989 and used as a for two crop years (1990 and 1991) in a Cerone plant growth retardant experiment.

Following seed harvest of plots in July 1991, straw was immediately removed by flailing into a wagon for transport from the site. A uniform stubble condition similar to the aftermath of baling remained throughout the summer, with limited regrowth occurring prior to the establishment of the planned treatments. Two late-season stubble reduction treatments were applied September 12 using a vacuum-sweep machine developed by Rear's Manufacturing in Eugene, Oregon. Stubble was flailed to an above ground height of 1.0 or 2.0 inches and residue was removed using the brush and flail mechanism of the vacuum-sweep machine. Although post-harvest treatments were delayed seven weeks after seed harvest (July 25), very little regrowth had occurred due to the dry summer weather.

In our analysis, the two vacuum-sweep treatments were compared with a simulated bale-only management (stubble flailed to a height of 4.0 inches) accomplished after seed harvest. Treatments were arranged to provide four replications with 8 x 150 ft plots. Data collected from plots during 1991-92 crop year were analyzed using a randomized complete block analysis of variance.

The experimental area was managed for seed production with uniform applications of herbicide, fertilizer and fungicide during the 1991-92 crop year. Observations were made throughout the growing season in regard to the "fall die-back" phenomenon. Although this third-year stand was "weak" and lacked uniformity, there was no apparent association with residue management.

Shortly after peak anthesis, tiller population was assessed by sampling two uniform 12 inch sections of row from each plot. There was no difference in total, vegetative or fertile tiller number per unit area (Table 1). In the 1.0 inch vacuum-sweep treatment slightly fewer fertile tillers (and slightly more vegetative tillers) were observed, but this was not significant.

Table 1. Tiller population at maturity as influenced by stubble management in Caravelle perennial ryegrass, 1992.

Treatment	Tillers at maturity		
	Total	Vegetative	Fertile
	(number/sq yd)		
Flail chop 4.0 in.	3401	1577	1825
Vac-sweep 2.0 in.	3307	1446	1861
Vac-sweep 1.0 in.	3217	1607	1610
LSD 0.05	NS	NS	NS

Plots were harvested on July 25 using a small plot harvester equipped with a sickle bar cutter and draper to allow bagging of cut material into large burlap sacks. Each harvested sample was 3¼ x 20 ft; two observations were taken from each plot. The bagged material was air dried and threshed to remove the seed for cleaning and weighing. No significant difference in any harvest characteristics measured was observed (Table 2).

Table 2. Harvest characteristics as influenced by stubble management in Caravelle perennial ryegrass, 1992.

Treatment	Total dry weight	Seed yield	Harvest index	1000 seed weight
	(ton/a)	(lb/a)	(%)	(g)
Flail chop 4.0 in.	2.8	442	8.1	1.09
Vac-sweep 2.0 in.	3.1	469	7.8	1.13
Vac-sweep 1.0 in.	2.9	439	8.0	1.10
LSD 0.05	NS	NS	NS	NS

Late-season removal of stubble did not affect seed yield when compared to bale-only management. Removal of post-harvest stubble soon after harvest (earlier than our treatments were made) was not evaluated, but it is unlikely that any advantage would have been observed due to restricted growth under these conditions (weakened, third-year stand of a late-maturing variety in a dry summer). Seed yield in 1992 (grand mean 450 lb/a) was less than one half of the previous two seed crops (the grand mean from this experimental site was 1087 and 1373 lb/a for the 1990 and 1991 seed crops, respectively. Overall lower seed yield in 1992 likely reduced the opportunity to separate differences between post-harvest treatments.

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

W.C. Young III, G.A. Gingrich and B.M. Quebbeman

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

Results from two long-term post-harvest residue removal trials on fine fescue fields in Marion county are discussed here. Data are from a fifth seed harvest of creeping red fescue (cv. Cindy) and a fourth seed harvest of a Chewings fescue (cv. Center) collected in on-farm trials. Residue treatments have been applied each fall following seed harvest. Seed yield and crop development data was collected each year. The creeping red fescue trial was established in 1989 following the first seed harvest and has been continued through four years; the Chewings fescue trial was established in 1990 and has been continued through three years. The results of previous years data are reported in OSU Seed Production Research reports Ext/CrS 83 (1990), Ext/CrS 89 (1991), and Ext/CrS 93 (1992).

Plots were arranged in a randomized complete block design with four replicates. Plot size was fixed to accommodate standard commercial sized harvest equipment. On the creeping red fescue site plots are 23 feet by 150 feet and on the Chewings fescue site 22 feet by 120 feet. A full 12 foot swather width was cut down the center of each treatment. This center swath was combined to determine seed yield and quality. The harvested seed from each plot was collected in garbage cans, weighed and a sub-sample taken to determine seed yield, calculate clean out and determine seed quality.

Dates of post-harvest residue treatments applied during the late summer of the previous year are listed in Table 1. A complete description of experimental residue management procedures has previously been reported (Ext/CrS 83). Except for these treatments, all other production practices were performed by the growers.

Table 1. Post-harvest residue removal application dates on fine fescue, 1992.

Residue Treatment	Date of treatment: Cindy	Center
1. Early open burn	Aug. 3	Aug. 3
2. Late open burn	Sept. 22	not included
3. Propane burn	Sept. 3	Sept. 3
4. Crew-cut	Aug. 14	Aug. 17
5. Flail chop	Aug. 14	Aug. 17

Plots were swathed in the creeping red fescue trial on July 8, and on July 12 at the Chewings fescue site. Cool, wet weather delayed maturity and prolonged the seed filling period, making the determination of optimum swathing difficult. Persistent rainy weather following swathing delayed combining until August 8 and 9 for the Chewings and creeping fields, respectively. Rain, plus considerable regrowth growing through the windrow prior to combining, contributed to much greater than normal seed losses at harvest.

Creeping red fescue

Since the beginning of this trial, burn treatments have consistently yielded as well or significantly better than the non-burned treatments. In 1992 clean seed yields of non-burn treatments fell far below burned plots. However, in 1993 there was no difference between plots receiving thermal treatments or crew-cut plots (Table 2). Only the flail chopped treatment was significantly lower yielding than the burn plots. Fertile tiller number and total harvest dry weight however, were significantly reduced by both flail chop and crew-cut treatments.

Table 2. Effect of residue management on seed yield, fertile tiller number and total dry weight in Cindy creeping red fescue, 1993.

Residue Treatment	Seed yield	Fertile tillers	Total dry weight
	(lb/a)	(per yd^2)	(ton/a)
Early open burn	813	3312	3.6
Late open burn	826	3681	4.0
Propane burn	817	4077	3.7
Crew-cut	817	2574	2.8
Flail chop	661	1494	2.6
LSD 0.05	104	936	0.7

In addition to seed yield information the effect on seed purity was considered in 1993. The results of seed cleaning and purity analysis of the sub-samples taken at harvest time are listed in Table 3. Weed seed content was significantly reduced by open-field burning. Propane flaming and flail chopping gave intermediate results, and weed seed content was greatest in crew-cut treatments. The dominant weed species identified in seed purity analyses was rattail fescue (*Vulpia myuros*).

Table 3. Effect of residue management on seed purity in Cindy creeping red fescue, 1993.

Residue Treatment	Inert matter	Weed seed	Mean of all weed seeds
	---------- (%)	---------	(no./lb)
Early open burn	11.2	1.9	10194
Late open burn	14.2	1.7	9032
Propane burn	10.9	6.8	32920
Crew-cut	10.7	12.1	58524
Flail chop	6.2	8.7	11322
LSD 0.05	NS	6.8	--

Chewings fescue

In 1992 seed yields were significantly lower on the non-burn plots than on the burned ones. However, in 1993, no difference in seed yield between treatments was observed (Table 4). The combination of both a prolonged wet spring, which allowed additional reproductive tillers to reach physiological maturity, and excessive seed loss from panicles ripening during showery weather reduced treatment seed yield differential. A strong trend was seen for a greater number of fertile tillers in the thermal treatments, but adverse weather conditions prior to seed harvest may have contributed to greater seed loss from those tillers.

Table 4. Effect of residue management on seed yield, fertile tiller number and total dry weight in Center Chewings fescue, 1993.

Residue Treatment	Seed yield	Fertile tillers	Total dry weight
	(lb/a)	(per yd^2)	(ton/a)
Early open burn	563	1908	4.3
Propane burn	527	2250	4.5
Crew-cut	527	1467	3.9
Flail chop	560	1260	3.1
LSD 0.05	NS	NS[1]	NS

[1]Significant at $P < 0.1$; LSD 0.01 = 603

Seed purity analyses found a lower percent weed seed in the open burn and flail chop treatments, similar to that observed at the creeping fescue site (Table 5).

Table 5. Effect of residue management on seed purity in Center Chewings fescue, 1993.

Residue Treatment	Inert matter	Weed seed	Mean of all weed seeds
	---------------	(%)	--------------------
Early open burn	8.6	1.1	6342
Propane burn	7.5	12.6	75985
Crew-cut	8.3	6.8	38263
Flail chop	6.9	2.0	11777
LSD 0.05	NS	7.3	--

Summary

As mentioned previously, results from each years' data collection has been reported. Individual year effects and comparisons are important, however, where the accumulative results over the life of a stand is the ultimate concern when changing residue management practices. This was the last year for treatments and data collection at the creeping red fescue site. Figure 1 shows the accumulative effect on seed production of the various treatments during the past four years. Results of the combined three years seed yield data for the Chewings fescue site is shown in Figure 2. There will be seed yield and crop development data collected in 1994 from the Chewings fescue site..

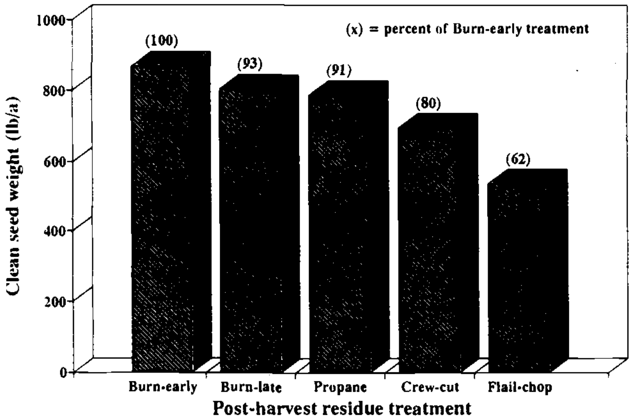


Figure 1. Four-year average (1990-93) seed yield of creeping fine fescue as influenced by post-harvest residue management.

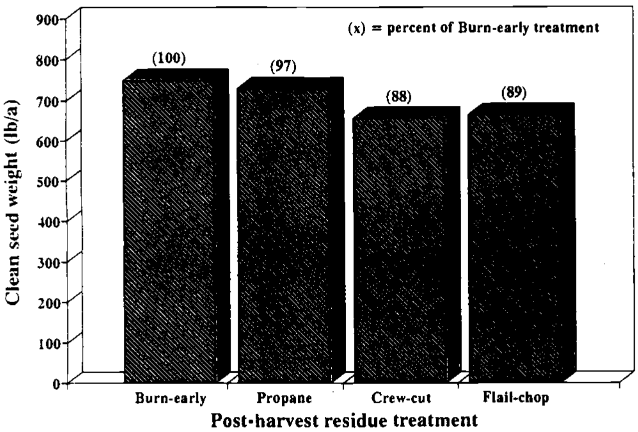


Figure 2. Three-year average (1991-93) seed yield of Chewings fine fescue as influenced by post-harvest residue management.

On the creeping red fescue field, using a thermal treatment following seed harvest resulted in significantly higher yield than the non-thermal treatments. In addition, seed quality has also declined over the course of the study where burning is not practiced. Although yield reductions have not been as dramatic on the Chewings fescue trial, lower yields have resulted from the non-burned treatments.

Rattail fescue has emerged as the dominate weed at both sites. The flail chop treatment had a lower amount of rattail fescue than the crew-cut vacuum sweep treatment. It appears that baling and flail chopping the stubble is as effective as open burning in suppressing rattail. The reason for flail chopping restricting rattail fescue or the crew-cut treatment increasing this weed, is not clearly understood. Rattail fescue is a most difficult weed to control, both in the field and to clean out of the seed crop. Due to the serious nature of this weed, more study should be done to better understand the relationship between residue management and rattail fescue suppression.

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WEED CONTROL AND SEED YIELD IN ESTABLISHED PERENNIAL GRASSES

G.W. Mueller-Warrant

Tall fescue under vacuum sweep and bale, flail chop and rake residue management: Vacuum sweep (VS) and bale, flail chop and rake (BFR) residue management methods in tall fescue were compared using ten herbicide treatment sequences in 1993 field tests (Table 1). Without any herbicide, volunteer tall fescue seedlings occupied 45% of the available open space in the BFR plots, and half that amount (22%) in the VS plots. As expected, herbicide treatments greatly reduced the density of volunteer tall fescue. A few annual bluegrass plants were present in the zero-herbicide checks, but none were seen in any of the herbicide-treated plots. The current industry standard treatment, postemergence application of Goal at 0.25 lb/a plus Diuron at 2.4 lb/a (# 9 in Table 1), provided excellent control of volunteer tall fescue, reducing the volunteer stand from 22% to 1.4% in VS and from 45% to 3.8% in BFR. Preemergence Dual followed by a lower rate of Goal plus Diuron provided even better control than the standard treatment in both VS and BFR. In BFR, preemergence Prowl at 2.0 lb/a shallowly incorporated by a rotary rake tedder and followed by postemergence lower-rate Goal plus Diuron (treatment # 5) also gave better control of volunteer tall fescue than the standard treatment. Average stands of volunteer tall fescue for the nine herbicide treatments were 7.3% in BFR and 3.3% in VS. Weed control was significantly better with VS than with BFR for six of the ten herbicide treatments, although similar trends existed for the other four treatments. Incorporated Prowl without any postemergence herbicide (treatment #2) provided what appeared to be adequate weed control without the injury associated with postemergence Goal plus Diuron, but it is not yet known whether this treatment will be satisfactory over the entire life of a stand. The possibility that annual bluegrass or other weeds might gradually increase in prevalence over time in some plots where the same treatment was re-applied annually is one reason that this test was designed to run for more than a single growing season. All of the herbicide treatments provided what appeared to be acceptable weed control during this first year of the study.

Herbicide treatments and VS versus BFR residue management had no significant effects on tall fescue seed yield in 1993. Even the contrast between the untreated control and the mean of all nine herbicide treatments was non-significant. Treatment # 7, preemergence Goal followed by postemergence Goal plus Diuron, was included both because it is registered and because it has been shown to sometimes reduce seed yield slightly. One factor that probably played a role in our inability to detect yield differences between any of the treatments was the rainfall that occurred after swathing and before combining this year. Losses due to seed shatter in the windrow were substantial, but may have tended to be slightly less severe in plots where tall fescue maturity had been slightly delayed by moderate herbicide injury, such as that caused by Goal. Seed yield variability was higher than average because of the problems with the weather at harvest time, and it would be premature to conclude that none of these treatments differed in their effects on tall fescue yield. We were, however, unable to demonstrate any differences in yield this year.

Tall fescue under full straw load residue management: A different group of herbicide treatments were applied to plots where the full straw load (FSL) was chopped in place (Table 2). Volunteer tall fescue seedling stand density was 70% without herbicides (#6 in Table 2). Application of granular Prowl raked into the straw reduced volunteer

Table 1. 1992-93 Growing Season at Glaser's Tall Fescue vacuum-sweep (VS) and bale, flail chop and rake (BFR) site.

#	Fall herbicide treatments and dates		Seed yield		Volunteer seedlings	
	Preemergence	Postemergence	VS	BFR	VS	BFR
	(lb/ai)		(lb/a)		(% of stand)	
1	Prowl 2.0 on Oct. 8	None	1976	1771	6.6 c	7.9 d
2	Prowl 2.0 inc. on Sept. 22	None	1781	1775	4.2 c	5.4 cd
3	Prowl 2.0 on Oct. 8	Goal 0.12 + Diuron 1.6 on Nov. 24	1864	1797	2.2 b*	4.3 c
4	Prowl 1.0 inc. on Sept. 22	Goal 0.12 + Diuron 1.6 on Nov. 24	1767	1910	2.0 b*	4.3 c
5	Prowl 2.0 inc. on Sept. 22	Goal 0.12 + Diuron 1.6 on Nov. 24	1826	1966	1.7 b*	2.1 b
6	Dual 2.0 on Oct. 8	Goal 0.12 + Diuron 1.6 on Nov. 24	1978	1903	0.3 a	0.5 a
7	Goal 0.25 on Oct. 8	Goal 0.12 + Diuron 1.6 on Nov. 24	1874	1827	1.4 b*	5.0 c
8	Prowl 2.0 on Oct. 8	Goal 0.12 + Diuron Metribuzin).56 on Nov. 24	1798	1990	1.7 b*	3.3 bc
9	None	Goal 0.25 + Diuron 2.4 on Nov. 24	1727	1856	1.4 b*	3.8 c
10	None	None	1730	1893	22.0 d*	45.2 e
	LSD (0.05)	261	261			
			VS vs BFR NS		VS vs BFR *	
	Mean of all herbicides		1847	1854	3.3	7.3
	LSD 0.05 (Mean vs #10 control)		193	193		

Table 2. 1992-93 Growing Season at Glaser's Tall Fescue Full Straw Load (FSL) site.

#	Fall herbicide treatments and dates: Early postemergence	Fall herbicide treatments and dates: Late postemergence	Seed yield: No-PRE	Seed yield: GR Prowl[1]	Volunteer seedlings: No-PRE	Volunteer seedlings: GR Prowl
	(lb/ai)		(lb/a)		(% of stand)	
1	Goal 0.25 + Dual 2.0 on Oct. 28	Diuron 2.4 on Dec. 16	1437 bc	1645 ab	4.4 a*	0.6 a
2	Goal 0.25 + Metribuzin 0.56 on	Diuron 1.6 on Dec. 16	1358 c*	1661 ab	21.3 b*	4.4 b
3	Goal 0.25 + Sinbar 1.0 on Oct. 28	Diuron 1.6 on Dec. 16	1657 ab	1656 ab	4.8 a*	1.0 a
4	Goal 0.25 on Oct. 28	Diuron 2.4 on Dec. 16	1563 ab*	1804 a	13.8 b*	3.1 b
5	Enquik + Diuron 0.8 on Oct. 28	Diuron 1.6 on Dec. 16	1339 c*	1646 ab	57.5 c*	23.1 c
6	None	None	1441 bc	1482 b	69.6 c*	20.5 c
7	None	Goal 0.38 + Diuron 2.4 on Nov. 24	1724 a	1609 ab	16.4 b*	3.0 b
	LSD (0.05)		222	222		
			Prowl vs No-Pre *		Prowl vs No-Pre *	
	Mean of all herbicides		1543	1661	14.2	3.3
	LSD 0.05 (Mean vs #6 control)		168	168		

[1]Granular (GR) Prowl herbicide applied Sept. 21 was an experimental formulation.

density to about 21% without any other (postemergence) herbicide, and to an average of 3.3% with postemergence treatments. For all postemergence treatments, weed control was better where Prowl granules had been applied than where they were not. Application of Enquik plus 0.8 lb/a Diuron on Oct. 28 followed by 1.6 lb/a Diuron on Dec. 16 failed to have any meaningful effect on volunteer tall fescue. Treatment # 7, a mid-postemergence application of maximum rates of Goal plus Diuron, represents one industry standard treatment. This treatment provided excellent control in blocks where Prowl granules had been raked into the straw, but was marginal without early treatment, still leaving a volunteer stand of 16.4%. As was mentioned in the discussion of the other tall fescue test, multiple applications of Goal and Goal-containing tank-mixes have sometimes been found to reduce tall fescue seed yield, so sequential herbicide treatments only included Goal in one of the application timings. Treatment # 4, where Goal was applied Oct. 28 and Diuron was applied Dec. 16, provided the same degree of control as # 7, where they were tank-mixed Nov. 24. The most effective treatments were # 1 and # 3, which reduced the volunteer tall fescue stands to 4.4% and 4.8%, respectively, without early granular Prowl, and to 0.6% and 1.0% following Prowl. In contrast to the other test conducted under VS and BFR conditions, more aggressive herbicide treatments are required to adequately control volunteer tall fescue in FSL conditions. Among the herbicide treatments employed in the FSL test, either

Prowl, Sinbar, or Dual (none currently registered on tall fescue grown for seed) would be needed in addition to Goal and Diuron (registered treatments in 1993) in order to obtain near-total weed control. Such a level of control could also be achieved by split application of Goal-containing tank-mixes (Goal plus Diuron or Metribuzin), but at a possible loss of some seed yield.

In contrast to results in the VS and BFR test, herbicide treatments in the FSL test did impact seed yield. In the Prowl granule blocks, addition of postemergence treatments increased yield an average of 179 lb/a compared to no postemergence herbicide. This contrast was not significant in the no-early preemergence blocks, where the difference was only 102 lb/a, less than the LSD for that comparison. Treatments # 2, # 4, and # 5 were all lower yielding without preemergence granular Prowl than with it. One possible explanation for these differences in yield is competition between the crop and the uncontrolled volunteer seedlings. However, it is also possible that the presence of Prowl near the soil surface may have reduced crop uptake of Diuron by restricting root growth and thereby have lessened crop injury associated with the Diuron application. Regardless of the reason, granular Prowl incorporated into the straw layer improved weed control while helping maintain seed yield near the level obtained under VS and BFR conditions.

Perennial ryegrass under vacuum sweep and bale, flail chop and rake management: Vacuum sweep (VS) and bale, flail chop and rake (BFR) residue management methods in perennial ryegrass were compared using ten herbicide treatment sequences at three sites in tests in 1993 (Table 3, 4, and 5). Without any herbicide, volunteer perennial ryegrass seedlings occupied 61, 43, and 50% of the available open space in the BFR plots at the three sites, and while occupying 22, 12, and 32% of the space in the VS plots (Tables 3, 4, and 5). As expected, herbicide treatments greatly reduced the density of volunteer perennial ryegrass. The current industry standard treatment, postemergence application of Goal at 0.25 lbs/acre plus Diuron at 1.6 lb/a (# 9 in Table 1), provided good control of volunteer perennial ryegrass in VS blocks, reducing the volunteer stands from the untreated levels of 22, 12, and 32% down to about 4% at all three sites. In BFR conditions, however, volunteer stands were only reduced to 16.5, 13.8, and 8.3% by this same herbicide treatment at the three sites. Two of those levels of control would be marginal for meeting seed certification rules governing the density of later generation plants in perennial ryegrass. Performance of specific herbicide treatments varied with site, probably because differences in the relative prevalence of early-germinating volunteers. At site 1, Lindsay's perennial ryegrass (Table 3), there was essentially no germination prior to the Oct. 7, 1992, application of preemergence herbicides. At both sites 2 and 3 (Tables 4 and 5), however, rainfall before application of the "preemergence" treatments meant that some of the perennial ryegrass had already begun to emerge by the Oct. 5 and Oct. 1 application dates, respectively. Despite some variation between sites in relative timing of seedling emergence and herbicide application, all treatments in which Prowl was followed by Goal-containing tank-mixes (# 3, # 4, # 5, and # 8) provided excellent volunteer control in BFR as well as in VS. Applications of Prowl without postemergence follow-up treatments (# 1 and # 2) provided excellent control in VS, but were marginal in BFR. In BFR, they provided control similar to that from the standard postemergence Goal plus Diuron treatment (# 9) at all three sites, although Prowl by itself was more effective than the standard treatment at site 1 (Table 3), where Prowl application was truly preemergence. Preemergence Dual followed by postemergence Diuron (treatment # 7) provided better control than the standard treatment (#9) in both VS and BFR conditions at sites 1 and 2 (Tables 3 and 4). Average stands of volunteer perennial ryegrass for the nine herbicide treatments were 6.4, 7.9, and 7.3% in BFR and 0.9, 2.5, and 3.3% in VS. Weed control was significantly better with VS than with BFR for all ten treatments at sites 1 and 2 (Table 3 and 4), and for two of the treatments at site 3 (Table 5), although a trend toward better weed control existed for all treatments at that site. Non-uniformity in spatial distribution of shattered seed at site 3 (Table 5) in summer 1992 probably contributed to relatively large error terms there, limiting our ability to statistically separate the treatments. All of the sequential herbicide treatments (# 3, # 4, # 5, # 6, # 7, and # 8) provided what appeared to be acceptable weed control in this first year of the study in BFR blocks. All nine treatments worked well enough to achieve this in VS blocks.

VS versus BFR residue management had no significant effects on perennial ryegrass seed yield in 1993 (Tables 3, 4, and 5). The untreated check was significantly lower yielding than the average herbicide treatment in BFR management at site 1 (Table 3) and in VS management at site 2 (Table 4). The nine herbicide treatments only differed in yield amongst themselves in a few cases. In BFR plots at site 1 (Table 3), treatment # 8 was significantly higher yielding than treatment # 2, possibly due to the poorer volunteer control from treatment # 2. The lower yields for treatments # 1 and # 2 compared to several other treatments in VS plots at site 3 (Table 5) may be an artifact caused by differences in maturity between the treatments. Treatments # 1 and # 2 would have ripened slightly sooner than the other treatments because of crop injury caused by postemergence Goal-containing tank-mixes in treatments # 3, #

4, # 5, # 6, # 8, and # 9. Treatments # 1 and # 2 would therefore have been subject to slightly greater seed shatter losses during swathing and drying/wetting cycles in the windrow. Because seed yield variability was higher than average due to problems with the weather at harvest time, it would be premature to conclude that the only treatments that will ever differ in their effects on perennial ryegrass seed yield were the few already mentioned as having occurred this year.

Table 3. 1992-93 Growing Season at Lindsay's Perennial Ryegrass vacuum-sweep (VS) and bale, flail chop and rake (BFR) site.

#	Fall herbicide treatments and dates		Seed yield		Volunteer seedlings	
	Preemergence	Postemergence	Vacuum	Rake/flail	Vacuum	Rake/flail
	(lb/ai)		(lb/a)		(% of stand)	
1	Prowl 2.0 on Oct. 7	None	1070	1138	1.1 b*	8.8 c
2	Prowl 2.0 inc. on Sept. 23	None	1157	1111	0.9 ab*	10.1 de
3	Prowl 2.0 on Oct. 7	Goal 0.12 + Diuron 1.2 on Nov. 20	1138	1198	0.8 ab*	4.8 abc
4	Prowl 1.0 inc. on Sept. 23	Goal 0.12 + Diuron 1.2 on Nov. 20	1116	1180	0.8 ab*	7.1 bcd
5	Prowl 2.0 inc. on Sept. 23	Goal 0.12 + Diuron 1.2 on Nov. 20	1141	1171	0.5 ab*	3.8 ab
6	Goal 0.25 on Oct. 7	Goal 0.12 + Diuron 1.2 on Nov. 20	1165	1147	0.9 ab*	8.3 cd
7	Dual 1.5 on Oct. 7	Diuron 1.6 on Nov. 20	1172	1196	0.9 ab*	6.5 bcd
8	Prowl 2.0 on Oct. 7	Goal 0.12 + Metribuzin 0.56 on Nov. 20	1137	1234	0.2 a*	2.7 a
9	None	Goal 0.25 + Diuron 1.6 on Nov. 20	1170	1124	3.6 c*	16.5 e
10	None	None	1099	1039	22.0 d*	61.2 f
	LSD (0.05)		107	107		
			VS vs BFR NS		VS vs BFR *	
	Mean of all herbicides		1140	1172	0.9	6.4
	LSD 0.05 (Mean vs #10 control)		79	79		

Table 4. 1992-93 Growing Season at Klopfenstein's Perennial Ryegrass Vacuum sweep (VS) and bale, flail chop and rake (BFR) site.

#	Fall herbicide treatments and dates		Seed yield		Volunteer seedlings	
	Preemergence	Postemergence	Vacuum	Rake/flail	Vacuum	Rake/flail
	(lb/ai)		(lb/a)		(% of stand)	
1	Prowl 2.0 on Oct. 7	None	1520	1767	2.6 bc*	12.2 e
2	Prowl 2.0 inc. on Sept. 23	None	1625	1808	2.8 bc*	8.9 b-e
3	Prowl 2.0 on Oct. 7	Goal 0.12 + Diuron 1.2 on Nov. 20	1777	1763	2.5 bc*	6.9 bcd
4	Prowl 1.0 inc. on Sept. 23	Goal 0.12 + Diuron 1.2 on Nov. 20	1827	1833	1.9 ab*	9.6 cde
5	Prowl 2.0 inc. on Sept. 23	Goal 0.12 + Diuron 1.2 on Nov. 20	1777	1735	1.4 a*	5.8 ab
6	Goal 0.25 on Oct. 7	Goal 0.12 + Diuron 1.2 on Nov. 20	1741	1777	2.8 bc*	10.7 de
7	Dual 1.5 on Oct. 7	Diuron 1.6 on Nov. 20	1698	1635	2.0 ab*	3.7 a
8	Prowl 2.0 on Oct. 7	Goal 0.12 + Metribuzin 0.56 on Nov. 20	1880	1838	3.0 bc*	6.4 bc
9	None	Goal 0.25 + Diuron 1.6 on Nov. 20	1740	1882	4.3 d*	13.8 f
10	None	None	1779	1689	11.8 d*	43.1 f
	LSD (0.05)		220	220		
			VS vs BFR NS		VS vs BFR *	
	Mean of all herbicides		1740	1779	2.5	7.9
	LSD 0.05 (Mean vs #10 control)		162	162		

Table 5. 1992-93 Growing Season at Scharf's Perennial Ryegrass vacuum-sweep (VS) and bale, flail chop and rake (BFR) site.

#	Fall herbicide treatments and dates		Seed yield		Volunteer seedlings	
	Preemergence	Postemergence	Vacuum	Rake/flail	Vacuum	Rake/flail
	(lb/ai)		(lb/a)		(% of stand)	
1	Prowl 2.0 on Oct. 7	None	1006	1094	3.7 abc*	11.9 b
2	Prowl 2.0 inc. on Sept. 23	None	1094	1140	6.0 c	11.8 b
3	Prowl 2.0 on Oct. 7	Goal 0.12 + Diuron 1.2 on Nov. 20	1037	1103	3.6 abc	7.8 ab
4	Prowl 1.0 inc. on Sept. 23	Goal 0.12 + Diuron 1.2 on Nov. 20	972	996	5.7 c	5.9 ab
5	Prowl 2.0 inc. on Sept. 23	Goal 0.12 + Diuron 1.2 on Nov. 20	1078	993	3.1 abc	7.9 ab
6	Goal 0.25 on Oct. 7	Goal 0.12 + Diuron 1.2 on Nov. 20	1056	1054	1.2 a*	6.5 ab
7	Dual 1.5 on Oct. 7	Diuron 1.6 on Nov. 20	1010	1065	2.2 abc	4.8 ab
8	Prowl 2.0 on Oct. 7	Goal 0.12 + Metribuzin 0.56 on Nov. 20	1037	1080	1.9 ab	3.6 a
9	None	Goal 0.25 + Diuron 1.6 on Nov. 20	1112	1064	4.1 bc	8.3 ab
10	None	None	873	987	31.5 d	50.1 c
	LSD (0.05)		190	190		
			VS vs BFR NS		VS vs BFR *	
	Mean of all herbicides		1043	1072	3.3	7.3
	LSD 0.05 (Mean vs #10 control)		140	140		

Perennial ryegrass under full straw load management: More aggressive herbicide treatments were applied to plots where the full straw load was chopped in place (Tables 6, 7, and 8). Volunteer perennial ryegrass seedling stand density in FSL conditions without herbicides was 96, 89, and 79% at sites 1, 2, and 3 (Tables 6, 7, and 8). Application of granular Prowl raked into the straw reduced volunteer density to 71, 80, and 44% without any other postemergence herbicides, and to averages of 6.5, 13.1, and 5.3% with postemergence treatments at the three sites. At site 1 (Table 6), weed control was significantly better where Prowl granules had been applied than where they had not been for all treatments except the no-postemergence herbicide check, and the same trend existed even for the check. At site 2 (Table 7), granular herbicide application significantly improved weed control only for treatment # 5, Enquik plus 0.8 lb/a Diuron on Oct. 27 followed by 1.6 lbs/acre Diuron on Dec. 17. However, at this site the granular herbicide applied had been a Goal plus Prowl mixture (2:1 ratio) rather than the full rate of Prowl. At site 3 (Table 8), a trend in favor of Prowl granule preemergence treatment existed for all postemergence herbicides, but differences were statistically significant only for treatments # 1, # 2, and # 7. Difficulties in obtaining significant differences between treatments at site 3 (Table 8) may have been due to patterns of the positions of the grower's windrows (i.e., shattered seed concentrations) in the summer of 1992 before initiation of the test. A much more uniform distribution of shattered seed is expected to exist for the second year of the test because 5-foot wide windrows were swathed lengthwise through each plot. At sites 1 and 3 (Tables 6 and 8), all postemergence treatments except # 5 gave acceptable volunteer control in concert with preemergence Prowl granules, although treatments # 1 and # 4 were best. Without early Prowl application, only some of the treatments achieved satisfactory control of volunteer ryegrass. Only treatment # 1 was fully successful at all three sites, while treatment # 4 ranged from marginal at sites 1 and 2 (Tables 6 and 7) to fully successful at site 3 (Table 8). Treatments # 2 and # 3 were marginal to successful at sites 2 and 3 (Tables 7 and 8), but not good enough at site 1 (Table 6). Among treatments employing the standard herbicides of Goal plus Diuron, treatment # 7 was less successful than treatment # 4 at sites 1 and 2 (Tables 6 and 7), with the same trend existing at site 3 (Table 8), although not statistically significant. This advantage to treatment # 4 over treatment # 7 illustrates the value to split-application of Goal plus Diuron tank-mixes in perennial ryegrass. Unlike the case in tall fescue, sequential applications of Goal-containing tank-mixes with Diuron and/or Metribuzin are useful treatments in perennial ryegrass because they increase the total amount of herbicide the crop can tolerate in a growing season, but do so without the negative effects on seed yield seen in tall fescue from multiple applications of Goal. In contrast to the other tests in VS and BFR conditions, more aggressive herbicide treatments are required to adequately control volunteer perennial ryegrass in FSL conditions. Among the herbicide treatments employed in the FSL tests, registrations of Prowl or Dual would be extremely helpful additions to the currently available treatments of Goal, Diuron, and Metribuzin. Satisfactory volunteer perennial ryegrass control can be achieved with combinations and sequential applications of Goal, Diuron, and Metribuzin, but only with a small safety margin.

The no-postemergence herbicide checks were significantly lower yielding than the average for the herbicide treatments at site 1, both with and without Prowl granules, and with granular herbicide at site 2 (Tables 6 and 7). The same trend existed in the other three cases without achieving statistical significance. The postemergence treatments did not differ in yield amongst themselves when applied following granular Prowl at site 1 (Table 6) and when applied without granular herbicide at site 2 (Table 7). Without incorporated Prowl granules at site 1 (Table 6), treatment # 2 outyielded treatments # 1 and # 3, and all treatments except the check outyielded treatment # 5, probably due to the failure of the Enquik treatment to control the volunteers. Treatment # 1 was lower yielding than treatment # 2 without granular Prowl at site 1 (Table 6) and with granular herbicide at site 2 (Table 7). At site 3 (Table 8), treatment # 3 was lower yielding than treatment # 4 when averaged over the with and without granular Prowl factor.

Some of the yield effects seen in FSL perennial ryegrass are probably a result of competition from uncontrolled seedlings, such as with treatment # 5, the Enquik plus Diuron followed Diuron sequence. Other yield effects are probably direct results of herbicide injury and/or indirect results of changes in crop maturity and seed shatter caused by moderate herbicide injury. Long-term effects of weed competition and annually-repeated herbicide applications need to be evaluated under FSL conditions before this production technique can recommended. However, first year results are reasonably encouraging, and yields are comparable to those achieved in VS and BFR conditions. Incorporation of granular Prowl seems to be a very useful technique for reducing the volunteer problem in full straw load perennial ryegrass without causing serious crop injury. Without use of incorporated granular Prowl, the expectations placed on Goal, Diuron, and Metribuzin for control of volunteer perennial ryegrass are quite exacting, and require the grower to accept serious visible crop injury if weed control meeting seed certification standards is to be achieved.

Table 6. 1992-93 Growing Season at Lindsay's Perennial Ryegrass Full Straw Load (FSL) site.

#	Fall herbicide treatments and dates: Early postemergence	Late postemergence	Seed yield: No-PRE	GR Prowl[1]	Volunteer seedlings: No-PRE	GR Prowl
	(lb/ai)		(lb/a)		(% of stand)	
1	Goal 0.25 + Dual 1.5 on Oct. 28	Diuron 1.6 on Dec. 18	1225 b	1262 a	8.4 a*	1.3 a
2	Goal 0.25 + Metribuzin 0.25 on Oct. 28	Goal 0.12 + Diuron 1.2 on Dec. 18	1370 a	1297 a	20.7 bc*	5.1 c
3	Goal 0.25 + Sinbar 0.5 on Oct. 28	Goal 0.12 + Diuron 1.2 on Dec. 18	1273 b	1335 a	22.4 c*	7.3 cd
4	Goal 0.25 + Diuron 0.8 on Oct. 28	Goal 0.12 + Diuron 1.2 on Dec. 18	1300 ab	1288 a	13.8 b*	2.7 b
5	Enquik + Diuron 0.8 on Oct. 28	Goal 0.12 + Diuron 1.2 on Dec. 18	1124 c*	1296 a	71.4 d*	28.0 e
6	None	None	988 d*	1151 b	95.6 d	70.6 f
7	None	Goal 0.38 + Diuron 1.6 on Nov. 20	1281 b	1296 a	23.4 c*	9.2 d
	LSD (0.05)		90	90		
			Prowl vs No-Pre *		Prowl vs No-Pre *	
	Mean of all herbicides		1265	1296	21.6	6.5
	LSD 0.05 (Mean vs #6 control)		68	68		

[1]Granular (GR) Prowl herbicide applied Sept. 23 was an experimental formulation.

Table 7. 1992-93 Growing Season at Klopfenstein's Perennial Ryegrass Full Straw Load (FSL) site.

#	Fall herbicide treatments and dates: Early postemergence	Late postemergence	Seed yield: No-PRE	Granular[1]	Volunteer seedlings: No-PRE	Granular
	(lb/ai)		(lb/a)		(% of stand)	
1	Goal 0.25 + Dual 1.5 on Oct. 27	Diuron 1.6 on Dec. 17	1646 a	1583 bc	4.4 a	3.2 a
2	Goal 0.25 + Metribuzin 0.25 on Oct. 27	Goal 0.12 + Diuron 1.2 on Dec. 17	1639 a	1817 a	7.5 ab	8.2 b
3	Goal 0.25 + Sinbar 0.5 on Oct. 27	Goal 0.12 + Diuron 1.2 on Dec. 17	1619 a	1765 ab	12.9 cd	9.5 b
4	Goal 0.25 + Diuron 0.8 on Oct. 27	Goal 0.12 + Diuron 1.2 on Dec. 17	1684 a	1737 ab	11.1 bc	10.3 b
5	Enquik + Diuron 0.8 on Oct. 27	Goal 0.12 + Diuron 1.2 on Dec. 17	1673 a	1613 bc	68.3 e*	39.5 d
6	None	None	1544 a	1508 c	89.4 e	79.5 e
7	None	Goal 0.38 + Diuron 1.6 on Nov. 18	1642 a	1637 bc	19.5 d	23.5 c
	LSD (0.05)		201	201		
			Granular vs No-Pre NS		Granular vs No-Pre *	
	Mean of all herbicides		1649	1684	14.6	13.1
	LSD 0.05 (Mean vs #6 control)		152	152		

[1]Early-Pre granular herbicide applied Sept. 24 was a Goal + Prowl mixture.

Table 8. 1992-93 Growing Season at Scharf's Perennial Ryegrass Full Straw Load (FSL) site.

#	Fall herbicide treatments and dates: Early postemergence	Late postemergence	Seed yield avg.[1] No-PRE & GR Prowl[2]	Volunteer seedlings: No-PRE	GR Prowl
	(lb/ai)		(lb/a)	(% of stand)	
1	Goal 0.25 + Dual 1.5 on Oct. 27	Diuron 1.6 on Dec. 17	1125 ab	7.1 a*	2.6 a
2	Goal 0.25 + Metribuzin 0.25 on Oct. 27	Goal 0.12 + Diuron 1.2 on Dec. 17	1118 ab	13.3 ab*	5.2 a
3	Goal 0.25 + Sinbar 0.5 on Oct. 27	Goal 0.12 + Diuron 1.2 on Dec. 17	994 bc	11.8 ab	6.4 ab
4	Goal 0.25 + Diuron 0.8 on Oct. 27	Goal 0.12 + Diuron 1.2 on Dec. 17	1207 a	7.8 a	3.6 a
5	Enquik + Diuron 0.8 on Oct. 27	Goal 0.12 + Diuron 1.2 on Dec. 17	995 bc	23.1 b	15.4 b
6	None	None	971 c	79.2 c	44.4 c
7	None	Goal 0.38 + Diuron 1.6 on Nov. 17	1086 abc	11.7 ab*	4.7 a
	LSD (0.05)		145		
			Prowl vs No-Pre NS	Prowl vs No-Pre *	
	Mean of all herbicides		1087	11.6	5.3
	LSD 0.05 (Mean vs #6 control)		109		

[1]Yield data is averaged over treatments of granular Prowl and No-Pre herbicide.
[2]Granular (GR) Prowl herbicide applied Sept. 18 was an experimental formulation.

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

D.D. Coats, F.J. Crowe and M.D. Butler

Introduction

The intermountain region of Idaho, Washington and Oregon are stable suppliers of high quality Kentucky bluegrass (*Poa pratensis L.*) seed. The cool winter climate and hot dry summers favor Kentucky bluegrass seed production. Since the 1950s the industry has increased from a few acres of the cultivar 'Marion' to production of over 100,000 acres and over 100 cultivars. This intermountain region has produced a stable supply of over 60 million pounds annually, which makes this region the primary producer for the world.

Post-harvest open-field burning has been responsible for maintenance of yield and high quality seed production in the Pacific Northwest. However, increased concern for air quality has pressured growers to find alternative ways of removing debris after harvest.

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

Materials and Methods

Two on-farm sites were established in 1991 in central Oregon to evaluate the full compliment of the latest technology for mechanical post-harvest residue removal on Kentucky bluegrass seed production. Additionally two more fields were added in 1992 and in 1993 (for a total of six fields) for a comparison over time.

Because the primary focus for the study was to evaluate the most advanced technology in post-harvest residue equipment, we needed to identify what extent of residue removal was desired. The most common practice of open field burning leaves the field absent of any non-combustible debris and also eliminates debris around the crown of the plant. This cleansing of the soil surface allows maximum light penetration as well as allowing maximum efficiency for pesticide applications. Mechanical residue removal can be accomplished by using various methods. Each method varies in the amount and efficiency of soil cleansing. New equipment used for the study included a Wheel Rake, which has stiff tines to scratch the residue, thatch and remove debris from around the crowns, and a redesigned Grass Vac, both developed by Rear's Manufacturing in Eugene, Oregon. The Grass Vac machine enabled us to clip and vacuum remove the stubble to a 1 inch height. With the Wheel Rake, the bulk of the residue is windrowed, which is baled or otherwise disposed of. Other equipment utilized included a flail mower and a propane flamer with conventional nozzle spacing at 40 psi. Propane flaming after vacuum sweep or wheel rake results in relatively little smoke.

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

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

Results and Discussion

Significant differences in seed yield resulted from the various management treatments. The highest yields consistently were produced where the residue was removed completely either by mechanical means or by burning. Bale-only treatment resulted in the least seed yield as well as the lowest number of fertile tillers. Differences in seed yield by variety type were observed in our study. In 1992 the aggressive variety showed a significant need for a more complete residue removal. However, in 1993 the aggressive variety did not need complete residue removal. The winter of 1992 was dryer than the winter of 1993, which may have effected the need for completeness of residue removal.

<u>Tiller development:</u> The general trend of fertile tiller numbers was the same as the trend for seed yield. Fall and spring vegetative tiller numbers showed no differences

among treatments, with the exception that in the bale-only treatment there were fewer tillers.

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

Our results support general grower experiences with respect to open-field burning vs bale-only treatment. The bale only treatments showed etiolated regrowth in the fall, which is in agreement with Canode and Law (1975, 1977) as well as Ensign, et al. (1983), who conducted a study with shading of Kentucky bluegrass. They concluded that seed yield from plants shaded at 62 percent for 150 days did not differ from plants where the residue was only baled off. Field burning encouraged higher fertile tiller numbers and yield. This increase was true for the older stands, but was even more pronounced on younger stands.

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

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RESIDUE MANAGEMENT STRATEGIES FOR KENTUCKY BLUEGRASS AND FINE FESCUE SEED CROPS IN THE GRANDE RONDE VALLEY

T. G. Chastain, G. L. Kiemnec, G. H. Cook, C.J. Garbacik and B.M. Quebbeman

The predominant grass seed crops grown in the Grande Ronde Valley are Kentucky bluegrass and the fine fescues. The adoption of nonthermal management practices has been slower than in the Willamette Valley because these seed crops have historically exhibited a greater need for open-field burning to maintain high seed yield and quality. Nevertheless, continued public concern over air quality has prompted research on economical nonthermal management options for Kentucky bluegrass and fine fescue in the Grande Ronde Valley.

Three on-farm research sites were established in spring 1992 to investigate nonthermal management effects on Kentucky bluegrass and Chewings fine fescue seed production. Treatments included bale only, bale + flail + needle-nose rake, bale + vacuum-sweep, flail-chop (3X), and open burn. In Kentucky bluegrass, flail chopping operations were done by using a rotary scythe. The following is a report of our research activities during the first cropping cycle (post-harvest residue management to seed harvest).

Residue management effects on fall tiller growth and development are outlined in Table 1. The rake, vacuum-sweep, and burn treatments were more thorough in straw and stubble removal, resulting in an environment that was more favorable for post-harvest regrowth and development of tillers. Consequently, more tillers having large basal diameter were present in Kentucky bluegrass at the commencement of inductive conditions that promote flowering. Tillers with large basal diameters are more likely to become fertile than smaller basal diameter tillers. Nonthermal management had no effect on total tiller number or large basal diameter tiller number in Chewings fescue. Fall-formed tillers in both crops were taller when managed by nonthermal techniques. Tillers of Abbey Kentucky bluegrass exhibited somewhat greater maturity (measured by leaf number) when residue was managed by rake and vacuum treatments. Leaf development in Bristol Kentucky bluegrass and in Chewings fescue was not influenced by residue management.

Table 1. Residue management effects on fall tiller and leaf development in Kentucky bluegrass and chewings fine fescue.

Treatment	Kentucky bluegrass Abbey		Kentucky bluegrass Bristol		Barnica Chewings fine fescue	
	Tiller number (no./sq. ft.)					
Flail 3X	377	ab*	217	a	1945	
Bale	351	a	279	ab	1954	
Rake	600	c	360	bc	1865	
Vacuum	562	bc	427	c	1785	
Burn	524	abc	406	c	1794	
	Tiller height (cm)					
Flail 3X	13.4	b	14.0	c	17.5	c
Bale	11.9	b	9.8	b	14.0	b
Rake	8.6	a	6.8	a	12.8	ab
Vacuum	8.0	a	8.0	ab	14.5	bc
Burn	8.9	a	6.6	a	10.2	a
	Haun mean stage (leaf no./tiller)					
Flail 3X	2.3	ab	2.1		2.1	
Bale	1.9	a	2.2		2.4	
Rake	2.8	c	2.3		2.0	
Vacuum	2.7	bc	2.3		2.0	
Burn	2.3	ab	2.2		2.1	

*Means in columns followed by the same letter are not different by Fisher's Protected LSD values ($P = 0.05$).

We found that fertile tiller production in Kentucky bluegrass was influenced by residue management strategy and cultivar (Table 2). Abbey Kentucky bluegrass produced fewer fertile tillers only when the residue was managed by flail chop (3X). Bristol was more sensitive to nonthermal management since both flail chop (3X) and bale only treatments caused reductions in fertile tiller number. No differences in fertile tiller production were detected among raked, vacuum-swept, and open-burned treatments in Bristol. Fertile tiller production in both bluegrass cultivars largely mirrored the production of large basal diameter tillers observed after regrowth in the previous fall. Fertile tiller production in Chewings fescue was not affected by residue management.

Table 2. Influence of residue management on fertile tiller production and seed yield.

Treatment	Kentucky bluegrass Abbey		Kentucky bluegrass Bristol		Barnica Chewings fine fescue	
	Fertile tillers (no./sq. ft.)					
Flail 3X	90	a*	100	a	626	
Bale	190	b	167	ab	545	
Rake	211	b	193	bc	547	
Vacuum	195	b	240	c	589	
Burn	193	b	239	bc	526	
	Seed yield (lb/a)					
Flail 3X	836	a	431	a	801	a
Bale	1100	b	600	b	931	ab
Rake	1242	b	642	bc	965	b
Vacuum	1170	b	627	bc	1032	b
Burn	1224	b	674	c	1021	b

*Means followed by the same letter are not different by Fisher's Protected LSD ($P = 0.05$).

Plots were harvested by using grower combines and the combined material from each plot was dumped into a weigh wagon for a dirt weight measurement. The harvested area in each plot consists of one swather width. A sample was drawn from the combine's auger stream as it enters the weigh wagon. This sample was cleaned to determine percent cleanout and subsamples were submitted to the OSU seed laboratory for purity and germination testing, and to Dr. Steve Alderman (USDA-ARS) for detection of ergot. Clean seed yield values account for percent cleanout and seed purity.

Seed yields were affected by the amount of straw and stubble remaining in the field after the previous seed crop (Table 2). In Barnica Chewings fescue and Abbey Kentucky bluegrass, seed yield was only reduced when managed by the least thorough residue removal treatment, flail chop (3X). All other nonthermal treatments produced yields that were not different than open-burning. Flail chop (3X) was poorer than all other treatments in Bristol Kentucky bluegrass, but unlike Abbey, the yield harvested from bale-only plots was not comparable to burning. Fall and fertile tiller production were reduced in the less thorough residue management treatments and were early indicators of the 1993 seed harvest results. It is unclear at this point whether seed yields in nonthermal treatments will be maintained at their present levels respective to open-burning or decline over the years.

Standard seed germination and purity tests were performed on seed harvested from all test plots. Seed germination and physical purity in both species were not reduced by nonthermal management.

Soil testing was done in October 1993 to determine the effect of residue management on soil characteristics. Soil test values for phosphorus and potassium tended to be lower when crop residues were removed from the field by vacuum-sweeping than when they were flailed and not removed (Table 3). Field burning crop residues returns nutrients to the soil so that they are available for the next seed crop. If residues are removed from the field each year it is possible that deficiencies may develop.

The research will continue for two more cropping cycles (residue management to seed harvest). At the completion of the field investigation, the economic return from each residue management option will be determined.

Table 3. Influence of residue removal in Kentucky bluegrass and Chewings fine fescue on selected soil characteristics in 1993.

				Soil characteristics			
Species	Cultivar	Depth	Treatment	pH	Phosphorus	Potassium	Magnesium
		inch			(ppm)		(meq/100g)
Kentucky bluegrass	Abbey	0-2	Flail (3X)	6.0	79	704 *	1.33
			Vacuum	5.9	85	602	1.43
		2-4	Flail (3X)	6.0	102	483	1.37
			Vacuum	6.0	87	469	1.30
		4-6	Flail (3X)	5.9	101	388	1.37
			Vacuum	6.0	89	375	1.40
Chewings fescue	Barnica	0-2	Flail (3X)	5.7	84	581 *	1.10
			Vacuum	5.5	79	408	1.13
		2-4	Flail (3X)	5.8	72 **	427 *	1.23
			Vacuum	5.9	62	382	1.33
		4-6	Flail (3X)	5.9	56	391	1.30
			Vacuum	6.0	47	362	1.33

*Means within soil depth are different ($P = 0.05$)
**Means within soil depth are different ($P = 0.10$)

AGRONOMIC PRACTICES FOR REDUCED SMOKE AND IMPROVED NITROGEN UTILIZATION FROM KENTUCKY BLUEGRASS SEED PRODUCTION

G.A. Murray and S.M. Griffith

Objective: To improve environmental quality through the elimination of burning of Kentucky bluegrass (*Poa pratensis* L.) seed crop residue and through improved nitrogen use efficiency (Murray and Griffith, 1992). Combined economic effectiveness of a vacuum-sweep machine, the most complete mechanical after-harvest residue removal technique, enhanced ammonia nutrition, and bluegrass variety growth response will be measured as a production package needed to eliminate burning and to improve nitrogen use efficiency of Kentucky bluegrass.

Progress:

Idaho. First-year seed yields were obtained from sixteen Kentucky bluegrass cultivars established at Worley, Moscow and Rathdrum Prairie, Idaho in 1992. After seed harvest, residue was removed mechanically by a vacuum-sweeping machine. The first seed yields after mechanical residue removal will be available in July-Aug. 1994. Kentucky bluegrass does not produce seed during the establishment year and no residue removal practices are used or needed during the establishment year. The first year of residue removal treatment occurs after the first seed harvest when burning is normally used. At this time vacuum-sweeping was used as a potential replacement for burning. To provide earlier information on variety response to vacuum-sweeping, vacuum-sweeping was tested on variety trials established by Jacklin Seed Company and on commercial farm trials.

Cooperative Variety Trial-Jacklin Seed Co., Rathdrum Prairie. Eight varieties were selected for vacuum-sweeping from a large variety trial established by Jacklin Seed Company in 1989. Half of the plot area of each variety had been either mowed or burned for the previous three years. In August 1992, plot areas within the mowed and burned areas for each variety were vacuum-sweep to compare seed yields from the burned, mowed, and mechanically removed areas.

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

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

"On Farm Trials". Preliminary "on farm" residue removal tests were conducted in commercial fields at Worley, and Nezperce, Idaho. These trials were developed to give growers an opportunity to observe and evaluate the vacuum-sweeping system. These trials also provided a means to gather yield responses of Kentucky bluegrass to vacuum-sweeping in the 2.5 year period between establishment and vacuum-sweep responses in the variety trial work established with funds from this project.

Residue was removed mechanically from one-acre sites with a vacuum-sweeper machine. Panicle numbers and seed yields from the vacuum-sweep areas were compared with yields from burned adjacent areas. At Worley, seed yield was 682 pounds per acre for the vacuum-sweep area. The burned portion of this field averaged 547 pounds per acre. At Nezperce, the variety 'Classic' produced 720 pounds per acre when vacuum-sweep and 563 pounds per acre when burned. The panicle numbers also reflected this trend. Both of these fields were in the second year of seed production. Areas vacuum-swept in 1992 were similarly treated again in 1993. In addition, new one-acre sites adjacent to the 1992 vacuum-sweep areas were established in 1993. Seed yield will be monitored for three consecutive years on these commercial farm trials.

Plant Sampling. Plants have been collected at two week intervals from the variety trial at Moscow for examination of growth and development. Of particular interest is detection of the transition from a vegetative stage to a reproductive stage. Our data suggests that varieties that require a long fall induction period for floral development will not produce good seed yields when residue is removed mechanically. Classifying the floral induction requirements of varieties in our trials along with the seed yield response when residue is removed mechanically may allow a more rapid method of classifying varieties not currently in our trials. Plant samples are also being taken from the Rathdrum Prairie and Worley locations, but at less frequent intervals than at Moscow to verify the responses observed at Moscow.

Oregon. The results of a preliminary experiment at La Grande, Oregon examining the effect of N-source on Kentucky bluegrass (KBG) growth and components of seed yield are shown in Table 1. Calcium nitrate and ammonium nitrate treated plots produced higher seed yields, tillers per unit area, and total final shoot dry mass per unit area than ammonium sulfate and urea-DCD treated plots (Table 1). Seed yield of plots treated with calcium nitrate or ammonium nitrate were not significantly different. Estimated check plot (grower's field) seed yield was 1,380 lb/a (determined from a 1 m^2 sampling). Ammonium sulfate and urea-DCD fertilization reduced seed yield by approximately 23% and 10%, respectively, and total shoot mass was reduced by 11% and 27%, respectively, compared to nitrate-N treated plots. Changes in shoot mass and seed yield reflected changes in harvest index (HI) for each treatment. Urea-DCD fertilization increased HI by 22% over nitrate treated plots, whereas ammonium sulfate reduced HI by 13%. Urea-DCD increased total cleaned seed mass per tiller. Mean tiller mass was 0.37 g per tiller for calcium nitrate and ammonium nitrate treatments and 0.39 g per tiller for ammonium sulfate and urea-DCD treatments.

Data support laboratory hydroponic findings that 'Coventry' Kentucky bluegrass growth and tillering was greater under high nitrate conditions opposed to high ammonium (Griffith, unpublished). This contrasts with ryegrass, where it has been reported that ryegrass favors enriched ammonium nutrition (Griffith and Streeter, 1994; Griffith et al., in preparation). Data also indicate the potential of N management to alter the HI in favor of reducing total post-harvest straw residue while still maintaining high seed yields. Ammonium based fertilizers can result in more efficient N utilization resulting in greater N conservation and lower fertilizer cost than nitrate fertilizers. Soil and plant chemical analysis to determine N use efficiency are underway, therefore plant-soil relationships could not be addressed at this time.

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Table 1. Effect of calcium nitrate ($Ca(NO_3)_2$), ammonium nitrate (NH_4NO_3), ammonium sulfate (NH_4SO_4), and urea-DCD (urea+dicyandiamide) fertilization on components of seed yield in KBG (c.v. Conventry). Fertilizer was applied in the fall to plots in an existing two-year crop located on the de Lint Farm at La Grande (Alicel), OR. Plots measured 12 m^2. A completely randomized block design with four replications was used. Sulfur was balanced among treatments. Seed harvests were taken from a 1 m^2 area within each plot.

N-Source	Tiller number	Shoot dry wgt	Seed yield	Harvest index	Seed wgt per tiller
	(no./m^2)	(ton/a)	(lb/a)	(%)	(mg)
$Ca(NO_3)_2$	3666 a	6.0 a	1397 a	11.7 a	42.8 a
NH_4NO_3	3256 a	5.8 a	1344 a	11.5 a	46.4 a
NH_4SO_4	3439 b	5.3 b	1059 b	10.1 b	34.6 b
Urea-DCD	2841 b	4.3 b	1228 b	14.2 c	48.6 c

Means followed by the same letter are not significantly different based on Fisher's protected LSD ($P < 0.1$).

PERFORMANCE OF KENTUCKY BLUEGRASS SEED CROPS TREATED WITH METHANOL

F.J. Crowe, D.D. Coats and M.D. Butler

Abstract

Foliar-applied methanol was purported to enhance growth and yield for C_3 crop plants in Arizona, possibly by inhibition of photorespiration. In central Oregon, Kentucky bluegrass in plots treated in the spring of 1993 with methanol or glycine showed a statistically significant ($P<0.05$) reduction in number of vegetative tillers, and a trend for reduced fertile tillers and seed yield when compared to plants in untreated plots. These results support the hypothesis that methanol may actively alter physiological processes, but suggest an opposite effect than that reported from Arizona.

Introduction

In 1992, Nonamura and Benson reported that foliar-applied methanol increased crop production of C_3 plants. Under high light intensity, methanol may have reduced photorespiration, increasing the efficiency of carbon utilization. In the Arizona desert in the summer, methanol in aqueous solution increased crop yield. Phytotoxicity was reported between about 15 and 50 percent methanol, depending on plant species; optimal effects were seen for concentrations just below phytotoxic levels. Plants appeared to require less water as maturity was shortened.

We applied methanol to Kentucky bluegrass (*Poa pratensis*) to determine if growth and seed yield responses might be gained. This species of C_3 plant grows optimally during cool temperatures during the fall and spring. Floral induction of vegetative tillers to fertile tillers occurs in the fall. Following winter dormancy (with periodic growth during warmer winter days), tillers mature in the spring, anthesis occurs around the first week of June, seed matures during June, and seed may be harvested during early July. It is uncertain how much effect on crop yield and quality that inhibition of photorespiration might have after anthesis.

The primary factor reported to favor responses to methanol was high light, presumably total daily flux, which is a combination of daylength and solar intensity. Lack of general plant responses to methanol in Arizona in the winter were attributed to less light flux, rather than to reduced temperature. Lower limits for effective light intensity were not defined, but the response was seen in the summer rather than in the winter in Arizon. Central Oregon encompasses an arid, high altitude (2,500-4,000 ft) area, and daylengths for much of the growing season are longer than Arizona daylengths. At the spring equinox (March 20, 1993) the daylengths in central Oregon begin to exceed those in Arizona. This period would extend through the fall equinox (September 23, 1993). Thus, pending variation due to cloudiness, total light flux normally would be as high or higher through much of the growing season in central Oregon vs Arizona. However, for many plant species, plant growth during much of the season in central Oregon may be inhibited by cooler temperatures; the relationship between temperature and light flux with respect to methanol-induced growth responses is not known. Further, minutes of daylight do not directly translate into light flux, as light flux is moderated by cloudiness and perhaps other factors.

Typically, for central Oregon, cloudiness is not extensive during the growing season.

Specifically, then, with respect to Kentucky bluegrass, for much of its early growth in the fall, late winter, and early spring, total light flux for Kentucky bluegrass might not be as great as in Arizona, and perhaps not great enough for a response to methanol application. But for growth in the late spring and early summer, total light flux for Kentucky bluegrass would be higher than in Arizona, so methanol application might have significant opportunity to elicit plant responses.

There maybe two different opportunities for treatment of Kentucky bluegrass: fall and spring. In 1993, we treated only through the spring, on a field which until then had been handled in a commercial manner.

Materials and Methods

No toxicity determinations were made on Kentucky bluegrass. The concentration of methanol was held at 25 percent, as recommended by A. Nonamura as a non-toxic but effective concentration for most crops. Methanol was applied in three replications in a randomized complete block design. Plots were 9 ft wide x 32 ft long. Materials were applied using a CO_2-powered backpack sprayer. Spray was applied at 40 PSI, 20 gal/ac. The spray boom was held at 18 inches high, and six Teejet 8002VS were spaced at 18 inches along a 9 ft boom.

Treatments were as listed in Table 1. A glycine plus phosphate treatment was included upon the recommendation of A. Nonamura, as a potential alternative to methanol. As methanol was purported to increase plant growth, a minimal nitrogen solution as urea was included to supply needed supplemental nitrogen for such additional growth. This required that a second experimental control treatment (MEM) be added to the list of treatments. Triton X100 was included as a spreader-sticker wetting agent.

The variety of Kentucky bluegrass was 'Adelphi', and management was as per standard commercial practice for the region with respect to fertility, irrigation, weed control, etc. Treatments were applied on May 11, May 26, June 8 (late anthesis) and June 24 (during seed maturity). On July 7, all vegetation above 1 inch was removed from 2 ft^2 of each plot. Total weight and numbers of fertile tillers were counted. Uncleaned and cleaned seed weight for each sample was determined by standard seed separation methods.

Table 1. Treatments used in the Kentucky bluegrass methanol trial located at the Central Oregon Agric. Res. Center, Madras, OR, 1993.

Treatment	Materials Used
Untreated	none
MEM	1 g/l urea and 0.05 g/l Triton X100
Methanol + MEM	25% methanol + MEM
Glycine	1% glycine + 0.1% phosphate + 0.05 g/l Triton x100

Results

Weather in the spring of 1993 was much cloudier and cooler than normal. These data are not summarized here, but likely accounted for less light flux than normal for this period. The extent to which this may have influenced plant responses is not clear, but could be significant based on Arizona reports.

Foliage height differences during May and June were only scanned visually; but no differences were noted. There was no obvious difference in timing of anthesis, or in crop maturity as the season progressed.

Means of data for vegetative tiller number, fertile tiller number, and cleaned seed weight are shown in Table 2, as are the proportion of tiller which were fertile. Statistically significant differences were found only for vegetative tiller number, although means for fertile tiller number and seed weights follow the same trends. For all measured parameters higher mean values were found for Kentucky bluegrass in the experimental controls (untreated and MEM treated plots) compared to methanol and glycine treatments.

Discussion

The extent to which increased cloudiness in the spring of 1993 may have affected the results above is uncertain, but there were fewer sunny hours in 1993 than in normal seasons. Additionally, the spring was cooler than normal, which extended the season by one to two weeks, but with no net effect on bluegrass yields for the region.

These data support the conclusion that methanol and glycine influenced plant growth and yield, but the data are not as clear or strong as is needed to support strong statistical statements. Whether more replications would have resulted in greater statistical separation among treatments is a question that may be pursued in future trials.

The number of both vegetative and fertile tillers was higher for Kentucky bluegrass in untreated and MEM treated plots than in methanol and glycine treated plots. Similarly, there was a trend for higher seed yield in the experimental control treatments. Because the proportion of fertile tillers was roughly constant among treatments, these responses suggest greater overall productivity for plants in the untreated plots, and are the opposite of the results anticipated. Nevertheless, any responses are noteworthy, and suggest that such treatments might serve as management or research tools in some manner. It may well be worthwhile to further investigate the response of Kentucky bluegrass in central Oregon to foliar-applied methanol, both for fall and spring application.

Table 2. Performance data (means) for methanol-treated Kentucky bluegrass at the Central Oregon Agric. Res. Center, 1993

Treatment	Vegetative Tillers		Fertile Tillers	Proportion Fertile Tillers	Clean Seed Weight
	---- (no./ft²) -----			(%)	(lb/a)
Untreated	874	a*	567	39	1045
MEM	821	ab	429	34	873
Methanol	713	b	470	40	873
Glycine	675	b	371	35	566

*Means followed by the same letter were not significantly different (P<0.05) for both the F-Test and Duncan's Multiple Range Test.

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

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

Ergot, caused by the fungus *Claviceps purpurea*, is an important flower-infecting pathogen in grass seed production regions of the Pacific Northwest. The pathogen produces an elongated, black sclerotia that replaces seeds in infected florets and causes a reduction in yield. These sclerotia are the primary means of survival and source of inoculum. In the spring, during flowering, spores from the sclerotia infect the grass flower and produce secondary spores, which causes exudate (honeydew) and makes harvest difficult. These secondary spores can be spread by water, wind and insects prior to sclerotia formation.

Of the grass species grown for seed in Oregon, Kentucky bluegrass is particularly affected by ergot. Surveys conducted in central Oregon, where Kentucky bluegrass is the dominant variety being grown, indicate strong regional variation with high levels in the Culver and Metolius areas contrasted to low incidence on the Agency Plains.

Because there are no fungicides registered for ergot, the only method of controlling the disease has been through open field burning. This practice has partially suppressed the disease in the past, as indicated by research conducted by John Hardison, plant pathologist at Oregon State University. Pressure to decrease burning may leave grass seed producers with no effective tools.

Research was conducted on two first-year Coventry Kentucky bluegrass fields in central Oregon. One was with a grower cooperator in the Trail Crossing area and the other was at the Central Oregon Agricultural Research Center, Powell Butte site. The Powell Butte location was inoculated with one pound of ergot sclerotia on December 18, 1992 and February 10, 1993 to insure a high inoculum level. Three fungicides, flusilazole (Punch, Dupont), propiconazole (Tilt, Ciba Geigy), and tebuconazole (Folicur, Mobay), in combination with and without Penaturf surfactant were applied to 10 x 20 ft plots replicated four times in a randomized complete block design. Materials were applied with a CO_2 pressurized boom sprayer. Following local standard procedure for fungicide application to grass seed, one pint/100 gals of LI 700 penetrant and 1 pint/a of 17% oil were applied in combination with all fungicides, except one of two 28 oz/a Punch treatments. Applications were made at Trail Crossing on June 7 and June 19, and treatments at the Powell Butte site were made on June 10 and June 19.

One hundred panicle samples were collected from each plot at Trail Crossing on July 6 and at Powell Butte on July 9. Samples were evaluated for percent of panicles with sclerotia and total sclerotia per plot. As of this reporting, evaluation of seed weight per plot, weight per 1,000 seed, and percent germination have not been completed.

There were statistically significant differences between treatments for all variables evaluated at Trail Crossing (Table 1) and Powell Butte (Table 2). Disease levels at Powell Butte, where the trial was inoculated with sclerotia, were much more severe than at Trail Crossing.

Table 1. Evaluation of fungicide treatments for ergot control on Coventry Kentucky bluegrass in the Trail Crossing area of central Oregon, 1993.

Fungicide Treatments	Rate June 7	Rate June 19	Panicles with sclerotia	Total Sclerotia per plot
	(oz /a)		(%)	(no.)
Punch 25EC	28 [1]		1.8 ab	3.3 ab
Punch 25EC	56		0.3 a	0.3 a
Punch 25EC	28		0.5 ab	1.0 a
Punch 25EC, Punch 25EC	28	28	0 a	0 a
Punch 25EC, Penaturf	28	87	0 a	0 a
Folicur 3.6F	8		1.0 ab	1.3 a
Folicur 3.6F, Folicur 3.6F	4	4	2.5 ab	8.8 b
Folicur 3.6F, Folicur 3.6F	8	8	1.3 ab	1.5 a
Folicur 3.6F, Penaturf	8	87	0.5 ab	0.5 a
Tilt 3.6E	8		2.5 ab	4.0 ab
Tilt 3.6E, Tilt 3.6E	4	4	1.3 ab	3.5 ab
Tilt 3.6E, Tilt 3.6E	8	8	0.5 ab	0.5 a
Tilt 3.6E, Penaturf	8	87	0.5 ab	1.3 a
Penaturf, Penaturf	87	87	2.5 ab	4.3 ab
Untreated			3.5 b	16.5 c

[1] Fungicide treatment without LI 700 penetrant and 17% oil
[2] Means in column followed by the same letter are not statistically different by Duncan's Multiple Range test at $P \leq 0.05$

Table 2. Evaluation of fungicide treatments for ergot control on Coventry Kentucky bluegrass at the COARC Powell Butte location in central Oregon, 1993.

Fungicide Treatments	Rate June 7	Rate June 19	Panicles with sclerotia	Total Sclerotia per plot
	(oz /a)		(%)	(no.)
Punch 25EC	28 [1]		41 def	121 abcde
Punch 25EC	56		8 a	12 a
Punch 25EC	28		22 ab	51 ab
Punch 25EC, Punch 25EC	28	28	17 ab	31 a
Punch 25EC, Penaturf	28	87	15 ab	24 a
Folicur 3.6F	8		45 def	184 bcde
Folicur 3.6F, Folicur 3.6F	4	4	57 fg	224 de
Folicur 3.6F, Folicur 3.6F	8	8	30 bcd	78 abcd
Folicur 3.6F, Penaturf	8	87	24 abc	52 ab
Tilt 3.6E	8		45 def	212 cde
Tilt 3.6E, Tilt 3.6E	4	4	50 ef	191 bcde
Tilt 3.6E, Tilt 3.6E	8	8	31 bcde	97 abcde
Tilt 3.6E, Penaturf	8	87	32 bcde	73 abc
Penaturf, Penaturf	87	87	56 fg	244 e
Untreated			70 g	466 f

[1] Fungicide treatment without LI 700 penetrant and 17% oil
[2] Means in column followed by the same letter are not statistically different by Duncan's Multiple Range test at $P \leq 0.05$

All treatments significantly reduced the total number of sclerotia per plot when compared to the untreated check. Punch provided the best ergot control, with exception of the treatment without the LI 700 and 17% oil. Double treatments of all three materials at the higher rate out performed single treatments of the same rate or double application at half the rate. This was true whether the second application was a fungicide or the wetting agent, penaturf. Effectiveness of the double treatment of Penaturf at Powell Butte or the LI 700 and 17% oil treatment at Trail Crossing was well below that of the double fungicide treatments at the higher rates. Results for percent panicles with sclerotia were similar to total sclerotia per plot.

These same treatments were evaluated during 1992 at a Trail Crossing location. There were low levels of ergot throughout the area, and no statistical difference was discerned between treatments. However, the trend was for double fungicide treatments at the high rates to provide the greatest crop protection. It also appears from the 1992 data that Penaturf may have reduced seed weight, while the single Punch application without the surfactant Silwet-77 produced the highest weight. Germination tests from the 1992 study indicate that double applications of Folicur significantly reduced seed germination, while there were no significant differences between the untreated plots and those treated with Tilt, Punch and Penaturf.

LIME SULFUR APPLICATIONS FOR SUPPRESSION OF STEM RUST IN PERENNIAL RYEGRASS GROWN FOR SEED

G.A. Gingrich and M.E. Mellbye

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

Lime sulfur is a product that has been used for many years to control foliar diseases of various crops. There is increased interest by persons in the seed industry in exploring the possibility of using sulfur products to improve rust control programs in grass seed crops.

In 1993 four trials were established to determine the effect that lime sulfur, applied alone and in combination with other fungicides, had on the suppression and control of stem rust on perennial ryegrass. Trial plots were established on four commercial fields of perennial ryegrass in the Willamette Valley. The replicated trials were established prior to the appearance of stem rust, with the first application of fungicides applied during early head emergence in late May. A second application was made approximately 21 days after the first. Table 1 lists selected treatments and rates of application. The varieties of perennial ryegrass were Legacy, Saturn, Accolade and Regal. Information included in this report covers the results on the Legacy and Accolade field locations. Individual plot size was 8 x 30 ft. replicated three or four times. Fungicide and lime sulfur applications were made to the plot area using a hand-held, CO^2 powered backpack sprayer. On the two trials in Marion county the surfactant Sylgard, at 3/8% by spray volume, was added to each treatment. On the Linn county sites crop oil concentrate was added at the same rate. No fungicides were applied to the plot area by the grower. Fertilizers and herbicides were applied according to the normal field practice.

Table 1. Lime sulfur trial. Product rates and application dates for rust control in perennial ryegrass trials at Ryan Farms, Marion county and Steve Glaser Farms, Linn county. 1993

Treatment	Application Dates	
	May 20/26	June 14/16
	------ (Product rate/acre) ---	
Check	0	0
Lime Sulfur/Lime Sulfur	1 gal	1 gal
Tilt/Tilt	6 oz	6 oz
Lime Sulfur + Tilt/Lime Sulfur + Tilt	1 gal + 6 oz	1 gal + 6 oz
Lime Sulfur/Tilt	1 gal	6 oz
Tilt/Lime Sulfur	6 oz	1 gal

Evaluation of rust infection levels was determined by using the Modified Cobb Scale to rate each treatment for rust control. Evaluations were made on three dates between application and seed harvest. Tables 2 and 3 show the level of rust infection for the various treatments at two of the four locations on the three evaluation dates. There was rust at each location, however, the level of infection was much greater on the Marion county sites than in Linn county. Seed yields were not taken from any of the plots in 1993.

Table 2. Rust infection in perennial ryegrass. Variety: Legacy. Ryan Farms, Marion County, 1993.

Treatment	Rust evaluation date		
	June 9	June 23	July 8
	------ (% infection) ---------		
Check	0	30.0	90.0
Lime Sulfur/Lime Sulfur	0	13.0	66.0
Tilt/Tilt	0	0.7	1.2
Lime Sulfur + Tilt/L.S. + Tilt	0	0.1	1.6
Lime Sulfur/Tilt	0	2.9	6.4
Tilt/Lime Sulfur	0	4.2	54.0
LSD 0.05	NS	15.0	22.0

Table 3. Rust infection in perennial ryegrass. Variety: Accolade Steve Glaser Farms, Linn County, 1993

Treatment	Rust evaluation date		
	June 10	June 28	July 5
	------ (% infection) ---------		
Check	0	29.0	52.0
Lime Sulfur/Lime Sulfur	0	4.3	17.0
Tilt/Tilt	0	0.9	0.9
Lime Sulfur + Tilt/L.S. + Tilt	0	0.7	1.3
Lime Sulfur/Tilt	0	0.6	1.0
Tilt/Lime Sulfur	0	0.5	3.1
LSD 0.05	NS	9.9	12.0

Results of the various treatments were similar and consistent across the four field locations. Making an early application of lime sulfur and following with a Tilt fungicide treatment or combining the lime sulfur with Tilt provided good rust control. Lime sulfur provides only contact disease control and is not systemic within the plant. It must be used in conjunction with other fungicides to effectively provide acceptable levels of disease control during the growing season. The inclusion of lime sulfur in the rust control program may reduce the potential for the development of resistant strains of stem rust. Additional trials are planned for the 1994 season.

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FOLIAR DISEASE SEVERITY OF GRASS SEED CROPS IN THE ABSENCE OF BURNING

R.E. Welty

The impact of foliar diseases, including leafspots, stem blights, crown rots, and rusts in the absence of burning is complicated by a lack of quantitative data that specifically tests the interaction of fire and the more than 20 foliar diseases in the major grass crops grown for seed in the Willamette Valley. Because of this absence of data, generalizations are based on: a) observations on how foliar diseases have occurred, shifted, or been controlled in recent years; b) a general knowledge of disease epidemiology; c) data obtained in a single replicated experiment evaluating disease/seed yield interaction; and d) what might be expected when carry over inoculum from foliar disease fungi is not reduced by common cultural practices, (such as no burn, no till, or no rotation).

Current Disease Status:
Stripe rust in Kentucky bluegrass and stem rust in perennial ryegrass are serious foliar diseases. In the 1960's, when field burning was a common practice, neither of these diseases were controlled or reduced by fire or flame. Now, as then, fungicides are the most effective way to control both stem rust and stripe rust.

In the Willamette Valley, stripe rust was first discovered in orchardgrass in 1983 and stem rust was first discovered in tall fescue in 1987. Both diseases developed when field burning was widely used and was a common seed production practice. Open field burning and propane flaming apparently had no affect on the introduction, presence, or spread of either of these two important rust diseases.

It is generally accepted that development and spread of some leaf, stem, and crown diseases of grasses for forage and turf are influenced by temperature and moisture. In orchardgrass grown for seed in the Willamette Valley, cool and wet weather during late April and May were found to have an important influence on yearly changes in the severity of eyespot, scald, and leaf streak (all leaf diseases) and on seed yield losses.

In another field study with orchardgrass, disease severity and seed yield were compared in whole-plots where stubble was propane flamed to simulate open field burning vs. nonburned stubble, with split-plots receiving fungicide treatments. Results showed that propane burning did not significantly (P = 0.05) change seed yield or leafspot disease severity the following crop year. However, seed yields and disease control were significantly improved in fungicide treated plots compared to nontreated controls.

Data from ongoing studies with tall fescue and perennial ryegrass, and in other studies with other grass crops, indicate temperatures in April through June have a major influence on stem rust severity in late June and July. In any particular year, temperature can control the extent of disease severity. Stem rust epidemics start at different times in different years and carry-over inoculum between years does not appear to influence the epidemic. Field observations with perennial ryegrass support this observation; stem rust severity was mild in 1991, very severe in 1992, and about average in 1993.

Future Disease Outlook
When any common agricultural practice is eliminated or reduced, (no-till, crop rotation, field burning, etc.), not all diseases react the same way. For some, the disease inci-

dence and severity may change, or a new disease may appear. A foliar disease in orchardgrass (caused by a species of *Drechslera*) was found for the first time in the winter of 1990-1991. We are continuing to watch this disease and so far, it has not become a major threat to seed production. This illustrates that when cultural practices change, diseases may also change. However, generalities about how these changes affect disease severity should be avoided, or approached with caution.

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HARVEST TIMING IN TURF-TYPE TALL FESCUE

R.P. Andrade and D.F. Grabe

Lack of uniformity in tiller and seed head development in tall fescue seed crops leads to non-uniform seed maturation and difficulty in determining the optimum time to harvest. Before the optimum harvest time, seeds are immature and low in weight, while with delayed harvest, lower yields result from natural shedding and shattering. These losses add to the soil seed bank and increase the population of volunteer plants in the following seed crop. Therefore, correct harvest timing not only provides maximum seed yield and quality, but is also an effective, inexpensive, and environmentally safe method of reducing volunteer plants in succeeding crops.

Seed moisture content has become an accepted index of optimum harvest time in cool-season grasses. However, a survey of 19 harvest-timing studies in grasses world-wide indicated that many of them did not consider the effects of cultivar and yearly weather variations, and conclusions were frequently based on hand-harvested experiments that neglected machine-shatter losses. The objective of this study was to determine the seed moisture content at windrowing for achieving maximum seed yield and quality in tall fescue cultivars with differing seed maturity dates.

The experiments were conducted in 1990, 1991 and 1992 with Chesapeake, Bonanza and Emperor tall fescue, which are early, medium and late cultivars, respectively. Seed moisture content was determined daily. A plot-size windrower and a plot combine with a special pick-up attachment were used for windrowing and threshing the plots. Plots were harvested six times at successively lower moisture contents. Natural seed shedding and total seed losses were evaluated for each harvest.

Maximum yields were obtained by windrowing at moisture contents of 35 to 41% (Figure 1). For Chesapeake, the optimum seed moisture contents were 38, 34 and 31% during 1990, 1991 and 1992, respectively. For Bonanza, the optimum moisture varied from 41% in 1990 to 35% in 1992. For Emperor, optimum seed moisture was 36% in 1992. Lodging of plants increased the variability of the yield data, preventing a clear determination of optimum moisture content in one year for Bonanza and in two years for Emperor, and did not allow comparison between cultivars within those years.

These optimum moisture levels differ from previous reports of 43% in Oregon (Klein and Harmond, 1971) and 48% in New Zealand (Hare et al., 1990) for forage-type tall fescues. Other researchers have found as we did that maximum yields of cool-season grasses occur when harvested over a range of moisture contents instead of at a sharply-defined single average value. The year-to-year variation that exists, and the relative flatness of the yield curves associating yield and moisture content, prevent recommending a single average moisture percentage. These factors, plus differential lodging and the considerable plant-to plant variation within cultivars made it impossible to discern cultivar differences in optimum moisture contents for harvesting.

Maximum dry seed weight and germination percentage were achieved and natural seed shedding was minimal when the seeds were harvested within the moisture ranges indicated. When harvested at approximately 40% moisture content, average harvest losses were 27 and 12% of the yield in 1991 and 1992, respectively. Seed losses may have been smaller than with traditional farm and windrowers and combines because of the slower operating speeds and gentler action of the plot-size harvesting equipment.

The precision of seed moisture as a harvest-timing index can be improved by the accompanying use of other seed maturity indicators such as endosperm consistency, color of seed heads, and degree of seed shattering.

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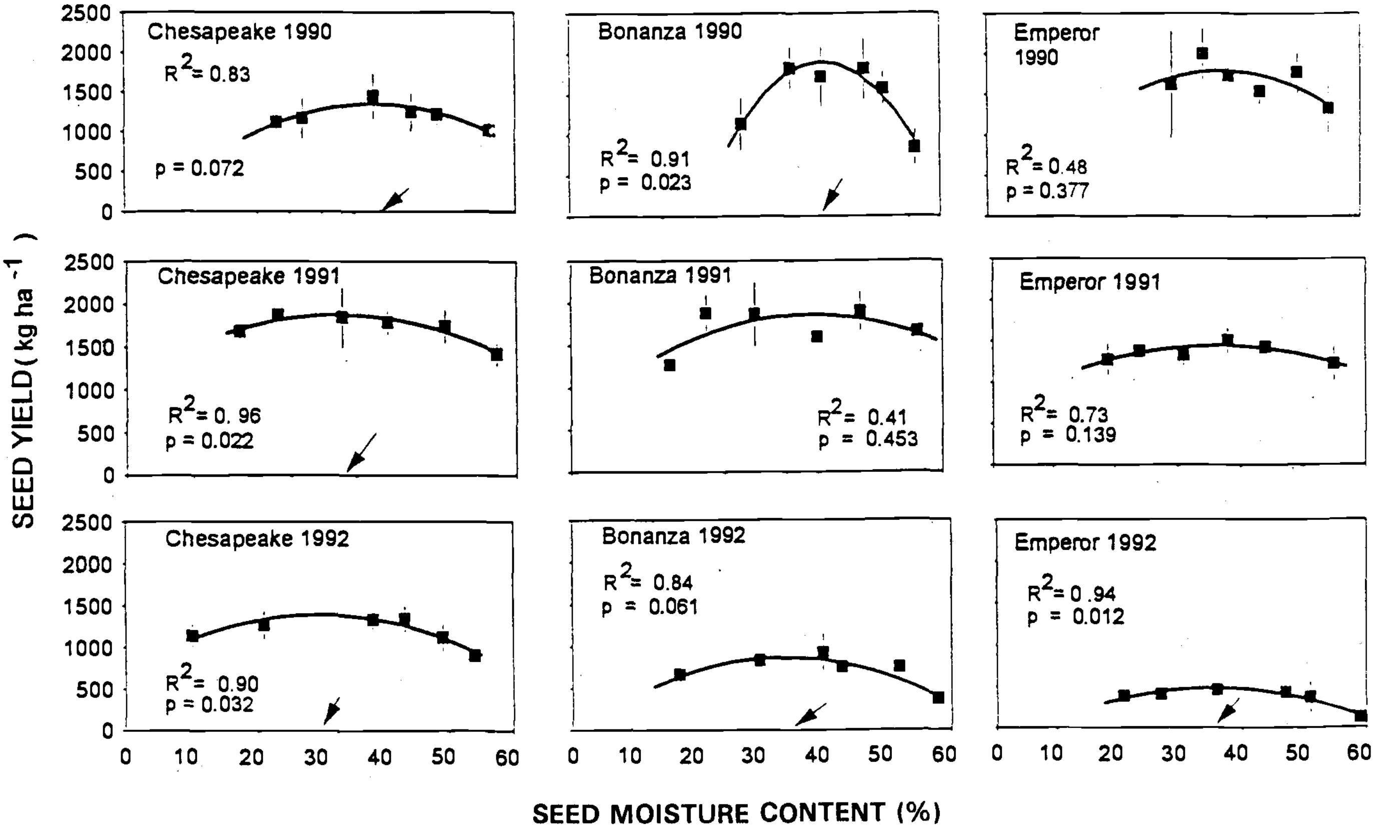

Figure 1. Effect of seed moisture content at windrowing on seed yield in tall fescue cultivars. Arrows indicate moisture content for maximum seed yield. Vertical lines represent the mean standard error for each harvest (n=4). For some harvests the mean standard error was smaller than the symbol.

ROW SPRAYING VOLUNTEER ANNUAL RYEGRASS SEED CROPS

W.C. Young III, P.K. Boren, M.E. Mellbye and B.M. Quebbeman

Annual ryegrass (*Lolium multiflorum*) seed crops are grown on poorly drained soils in the Willamette Valley because few other crops are adapted to these conditions (Youngberg, 1980). Currently, annual ryegrass is grown on 117,000 acres, primarily in the southern part of the valley. Historically, elimination of post-harvest residue of annual ryegrass seed crops has been accomplished by open-field burning. Unlike in perennial grass seed crops where open-field burning was justified largely on the basis of disease control and stimulation of seed yield (Chilcote et al., 1980), the primary reasons for burning annual ryegrass was inexpensive removal of large volumes of residue for seed bed preparation and elimination of weed seeds. However, political pressures resulting from reduction in air quality caused by open-field burning of all seed crop residues has led to a legislative agreement to phase-down the practice.

Historically, growers have used no-till establishment methods to direct seed annual ryegrass crops into the unplowed soil following open-field burning. Typically, growers would use conventional tillage and planting methods one year, and then annual ryegrass seed crops would be replanted for three to five years using a no-till management. This was a low input and low cost approach to growing annual ryegrass. Typical costs and returns of producing annual ryegrass in the Willamette Valley of Oregon have been estimated using open-field burning (Taylor et al., 1990). In general, annual ryegrass has been the grass species with the lowest profit margin. Thus, while relative profitability among perennial species can and does change over time, producers of annual ryegrass have been less able to absorb cost increases associated with non-burning alternatives.

The most common nonthermal residue management strategy used by annual ryegrass growers is flail chopping and plowing under the crop residue before conventional preparation of a seed bed for the next crop. Microbial decomposition of incorporated straw on soils where annual ryegrass is grown is greatly reduced by wet (anaerobic) conditions during winter and by protracted drought in summer. Thus, it is important that straw length be reduced by flailing prior to incorporation by moldboard plow, albeit at additional expense.

Another strategy that has evolved in response to growers shifting to nonthermal management in annual ryegrass is to produce a new seed crop with seed lost from the previous crop (volunteer establishment) without any straw removal. The producer's objective in choosing this option is to cut the production costs over standard seed bed preparation. Growers using the volunteer system, however, have reported yield reductions of 100 to 400 lb/a, thought to result from increased interplant competition. As no rows are present in a volunteer stand of annual ryegrass, the idea of creating rows by banding herbicides (row spraying) is being considered.

On February 15, 1993, a band sprayed herbicide treatment resulting in 6 inch "rows" with a 14 inch inter-row spacing (nozzles on 20 inch centers) was made to a volunteer established common annual ryegrass field near Tangent, OR. A tank mix of Paraquat and Sencor at 1.0 qt/a and 3/8 lb/a, respectively, was applied using 8004 flat fan nozzles at a pressure of 25 psi. By April 1, the row-sprayed area was clearly distinguished from the untreated solid stand. Treatments were arranged to provide four replications; a randomized complete block analysis of variance was used to test for differnces between treatment means.

Plant samples taken on May 3 were timed with canopy closure in the row-sprayed area; the objective was to assess the vegetative tiller population. Total number of vegetative tillers in the row-sprayed area was about half that found in the solid stand (Table 1). Total tiller dry weight, however, was not different; that is, if one would have harvested the "forage" as green chop on May 3 both treatments would have yielded just under 1½ ton/a (dry weight). This is because tillers were larger in the row-sprayed plots. Forty percent of the tillers in the row-sprayed area had stem base diameters of 3mm (Table 1). Thus, the tiller population in the row-sprayed area was comprised of a smaller number total tillers, but a greater proportion of them were larger in size.

Table 1. Vegetative tiller data collected May 3, 1993, at about first canopy closure in the row-sprayed treatments. (Canopy closure is defined as when the leaves of two adjacent rows overlap such that soil between the rows is no longer visible.)

	Total tillers	Total tiller dry weight	Tiller size 1mm	2mm	3mm
	(no./ft^2)	(ton/a)	---------(%)---------		
Row-spray	512	1.47	2	58	40
Unsprayed	1088	1.41	6	69	25
	*	NS	NS	*	**

* significant at P<0.5 probability level
** significant at P<0.01 probability level

A second sampling on June 9 coincided with peak anthesis and quantified both reproductive and vegetative tiller numbers (Table 2). No difference in total, fertile, or vegetative tillers was present. In both plot areas there was a large reduction in the total number of tillers first observed on May 3, which is a result of tiller mortality - the death of small vegetative tillers low in the crop canopy. Tiller mortality was much higher, however, in the solid stand; only 17% survived (190 of 1088) versus 40% survival (206 of 512) in the row-sprayed area. Regardless of the effects of tiller competition, there was no difference in the number of fertile tillers. In addition, there was no difference in total dry weight.

Table 2. Vegetative and reproductive tiller data collected June 9, 1993, at about peak anthesis.

	Total tillers	Fertile tillers	Vegetative tillers	Total tiller dry weight
	------------(no./ft^2)------------			(ton/a)
Row-spray	206	135	71	4.63
Unsprayed	190	125	65	3.99
	NS	NS	NS	NS

Final harvest data was determined from four-foot sections of swaths taken from the field for air drying and stationary threshing at Hyslop Farm. No significant difference in total harvest dry weight, clean seed yield, harvest index, or 1000 seed weight was observed (Table 3). These results may have been affected by the extremely wet weather experienced during spring 1993. Annual ryegrass lodged earlier than normal (prior to anthesis) and may have resulted in higher tiller mortality than if the stand could have grown upright longer. Additional studies are planned.

Table 3. Final harvest data collected on July 7, 1993, by removing four-foot sections of swaths from the field, air drying samples is large burlap bags, and "combining" with a stationary thresher and cleaner.

	Total harvest dry weight	Clean seed yield	Harvest index	1000 seed weight
	(ton/a)	(lb/a)	(%)	(g)
Row-spray	3.94	1766	22.4	2.88
Unsprayed	4.11	1870	22.8	2.88
	NS	NS	NS	NS

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COMPOST RESEARCH

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

Grass seed growers are faced with disposal of unburned straw amounting to two to five tons per acre. Roughly one-half of the annual world supply of several important turf and forage grass species is produced in this region along with over one million tons of straw residue on roughly 400,000 acres of grass seed production fields. Since it is unaffected by market conditions, on-farm composting in combination with other uses of straw, may benefit growers by creating a more balanced market while reducing the straw load on grass seed crops. Additionally, some long term benefits in soil nutrient levels, texture and moisture holding capacity may result from composted grass straw being returned to fields.

The conventional procedure for compost formation is to mix a low nitrogen, high carbon material such as sawdust or straw with a high nitrogen, low carbon material such as manure, cannery waste or sewage sludge in portions to adjust the carbon/nitrogen ratio near 30:1. Addition or exclusion of water to achieve a moisture content wet basis near 60% by weight, adjustment of pH to be relatively neutral if necessary and aeration by turning to provide oxygen are also helpful in effective composting . In the presence of certain bacteria and fungi, this combination of materials is reduced to simpler compounds available for plant growth while heat given off in the process kills seeds, insects and pathogens and renders the product safe for other agricultural uses.

Grass seed straw is a high carbon, low nitrogen material with C/N ratio near 75:1. However, since high nitrogen materials are not readily available on most grass seed farms and bringing these materials to the site is expensive and impractical in many cases, composting in the absence of a high nitrogen component is more advantageous for the region's seed growers. Addition of water beyond ambient rainfall is also considered too expensive for most grass seed farms since few have irrigation equipment.

The first year of an experiment to determine the effects of straw collection method and number of turns on internal windrow temperature and windrow volume has been completed. Weekly, replicated measurements of internal temperature and volume were made over a 33 week monitoring period from October 1992 to June 1993 on two types of straw residue turned a varying number of times. Composting both long and short straw was examined since growers produce these two distinctly different types of straw residue. Long straw is similar to bailed straw in texture and method of collection. Short straw is material brushed and vacuumed from fields after the long straw has been removed. Each type of straw presents different composting problems. Long straw is present in much larger quantities and its sheer volume creates a handling and storage problem. Since windrows created from long straw are of low density, heat necessary for the composting process is easily lost. Stacks created from short straw are of much smaller total volume than long straw, contain larger amounts of seed and soil and higher moisture content but are tightly packed and can effectively exclude additional water necessary for composting.

In this experiment, windrows composed of long and short straw were turned either zero, two, four or six times over the nine month period with a straddle-type compost turner. Although it had been originally planned to turn windrows on a schedule of specific times and temperatures, wet field conditions made scheduling turns difficult. Actual turning was unevenly spread over the season. Because of the anticipated high volume reduction for long straw, three windrows were initially created during July with the intent of combining these into a single windrow sometime during the season. This was done on January 13 with a front-end loader and, because of the mixing that occurred, was counted as one of the turns.

Figure 1 shows the reduction in volume of short straw windrow plots related strongly to number of turns and to a lesser extent over time within groups with the same number of turns. Figure 2 shows the very strong relationship between volume reduction of long straw windrow plots to number of turns and strongly over time within groups with the same number of turns. Volume measurements over 100% were the result of additional air space after turning.

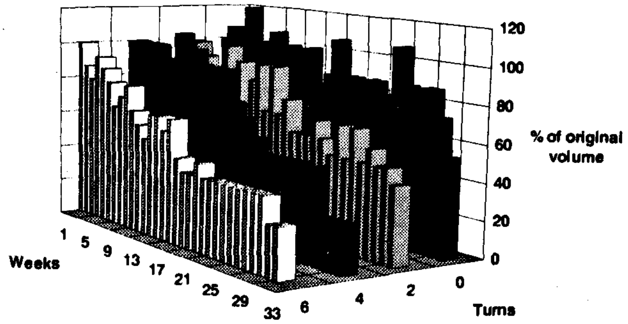

Figure 1. Percent of original volume remaining in short straw windrows with zero to six turns.

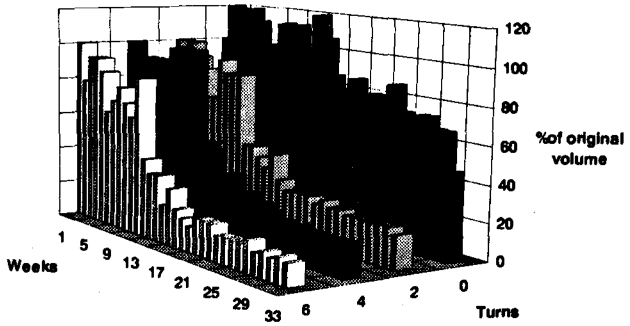

Figure 2. Percent of original volume remaining in long straw windrows with zero to six turns.

Table 1 shows the percent of original volume remaining after 33 weeks of composting for long and short straw. Statistical analysis of the final volume data (after 33 weeks) of both types of straw showed a significant difference ($p=0.05$) existed between volume remaining of compost windrows turned zero times and compost windrows turned two, four, and six times. No significant differences were found between final volume remaining of windrows turned two, four or six times. The rate of change in volume remaining however was significantly related to the number of turns. Volume reduction occurred significantly faster in windrows with four or six turns compared to two and zero turns. These results suggest that growers interested only in final volume reduction, and not seed survival, ease of spreading or the rate of reduction, may be able to get near-maximum volume reduction with as few as two turns for either type of straw. Growers interested in more rapid and complete composting of grass seed straw should consider planning for four to six turns. A study is underway to characterize differences in particle size distribution of straw compost turned zero, two, four and six times. Particle size is considered the best indicator of ease of spreading and completeness of the composting process.

Table 1 Percent of original volume remaining after 33 weeks of composting.

Turns	Long straw volume	Short straw
0	47	53
2	18	42
4	17	25
6	12	20

Packets containing blind seed, ergot, and weed seed were inserted in all the windrows at different depths and then analyzed to determine viability. Viable ergot were observed only in the 0 turn long straw plot. This study suggests that the composting process that includes one or more turns is effective in destroying propagules of ergot and blind seed. Weed seed viability was extremely low averaging less than 0.1% in the turned treatments.

Cost Computations for Grass Straw Composting

Data concerning a complete energy and cost input analysis for the composting operation were collected and analyzed to give a comparison with other methods of straw utilization such as leaving full straw in the field, raking and baling, flail chopping directly after combining or after baling.

An accounting method used by OSU Extension's agricultural economist has been adopted to estimate the material handling expenses of composting. These are cost estimates for owning and operating the required machinery. Total costs for short straw windrow composting, including preparation and turnings range from $24/acre to over $31/acre. Total costs for full straw load composting range from $19/acre to over $25/acre. These are estimated values we believe realistically indicate the correct order of magnitude of composting costs. Of course actual costs will vary as operator and machinery effect capacity, as will weather and field conditions.

Laboratory Composting Studies

Utilization of agricultural by-products such as straw is becoming a priority issue because disposal practices such as open field burning are no longer environmentally acceptable. On-farm utilization of these residues will likely aid the development of sustainable cropping systems. Utilization of these residues will require development of management systems such as low-input composting. Composting is a microbially-mediated exothermic process that occurs in an aerobic thermophilic environment. It is felt that successful grass straw composting requires a combined substrate C/N ratio of 25:1 or less to proceed. The composting system provides an excellent model to study the decomposition of plant materials having low substrate quality. The decomposition of high C/N ratio plant residue, such as perennial ryegrass (*Lolium perenne*) straw, will depend on the magnitude and rate of microbial and by-product production. Under the correct conditions of temperature, moisture and bulk density, the decomposition of high C/N ratio ryegrass straw proceeds rapidly in the field with low-input management. The residue undergoes chemical and physical transformation to yield an end-product consisting of microbial products, secondary residue decomposition products and humic materials. The product is a potential resource with value as an organic amendment that can improve soil quality.

The rate of lignin degradation is the slowest of plant residue components. The association of lignin with cellulose and hemi-cellulose, collectively called lignocellulose, is thought to make the cell wall carbohydrate fraction resistant to decomposition. The acid insoluble lignin method has been used extensively to determine lignocellulose loss during decomposition. Many ecological and agriculture field studies have used the acid insoluble method to determine lignin loss because of its simplicity. The acid insoluble lignin procedure is a gravimetric approach measuring acid insoluble material. The acid insoluble material is broadly defined as lignin. The technique is suitable for comparative purposes and estimation of lignin in undecomposed plant material. The precipitation of other plant components, especially proteins, can interfere with the acid insoluble method. Lignin is modified through its isolation from cell wall polysaccharides during plant residue decomposition. Lignin phenolic structures are modified through utilization of branch and ring components. In addition, the biosynthesis of microbial aromatic compounds during decomposition can interfere with the gravimetric analysis. For these reasons the acid insoluble lignin determination may have limited value in plant residue decomposition studies.

Our acid insoluble lignin analysis of ryegrass straw incubated at mesophilic and thermophilic conditions showed significant lignin loss (Table 2.). Significantly more lignin C was lost than was indicated by changes in acid insoluble gravimetric lignin content in both temperature treatments. An estimate of unaltered lignin, based on elemental ratios was 6% for both temperature treatments. The elemental ratios of the decayed lignin fraction closely resembled those of soil organic matter. It was doubtful that the majority of the lignin fraction was completely contaminated with humic substances. More probable, was that the analyzed lignin fraction was both chemically altered and contaminated with microbial products and humic substances.

Table 2. Ryegrass straw cell wall components remaining (%) after incubation at 25°C and 50°C for 25 days.

Treatment	Cellulose*	Acid insoluble lignin	Lignin C
Day 0	100	100	100
25°C	53	90	75
50°C	42	71	61

* Cellulose defined as total cell wall polysaccharides.

The differentiation between plant residue chemical fractions and microbial production during decomposition is rarely studied. The obvious lack of analytical methods, especially in field research, has only contributed to the dearth of information concerning the processes occurring during plant residue decomposition. This research and other studies that have probed lignin degradation and humus production pathways have raised questions concerning the actual processes occurring during plant residue decomposition. The change in the chemical nature of lignin during decomposition has generally been ignored. It was demonstrated here that the alteration, degradation and mass of lignin determined using the acid insoluble lignin method provides an underestimate. Future research should delineate between microbial production and plant residue decomposition and alteration to give a more realistic interpretation of decomposition dynamics. The extensive decomposition of lignin during this study provides evidence why the straw composts successfully in the field without co-composting. The breakdown of lignin likely increases the availability of cellulose and related compounds for microbial degradation.

SEED CONDITIONING RESEARCH

D. B. Churchill and D. M. Bilsland

Comparison of Machine Vision with Human Measurement of Seed Dimensions. Physical property measurements of crop seed and contaminant particles from a seed lot are made before conditioning to determine the screen and indent pocket sizes to be used for making the separation. Current practice is for human operators to take a sample from the seed lot and make these measurements using a microscope equipped with a reticle. A comparison of the distributions of physical property measurements to opening sizes of screens and indent cylinder or disk pockets is then made. This information is then used for selection of equipment that partitions the material based on dimensional differences.

The machine vision system (MVS) provides an alternative to microscopic measurement of seed by human operators. For applications where a large number of seeds must be measured, e.g., seed laboratories and conditioning plants, the MVS would provide distinct advantages over the standard method. Presently, the MVS remains untested for its comparison with the standard method using human operators.

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

After the 72 seeds were measured by four individuals using the microscope, the same seeds were then measured four times using an MVS system. For this work, each seed was replaced into its numbered cell after measurement so that it could be traced through later replications. For each of the four replications, individual seeds were hand-placed into a funnel which dropped the seed onto the slider-bar assembly to simulate seed placement with a mechanical arm so that variations in position would be apparent in the resulting measurements.

Means, coefficients of variation (CV) and confidence levels from paired t-tests of 24 measurements of length, width and thickness for each species and method of measurement were made. Consistency of MVS measurement of seed was slightly higher than that of human measurement. Six of nine comparisons of CV values showed significant differences ($P<0.10$) for human versus MVS measurement. Five of these favored machine vision as having significantly lower CV values. One comparison, orchardgrass length, showed CV of human measurement to be significantly less than that of MVS. This was thought to be the result of inability of the MVS to consistently measure seed awns present on some orchardgrass seeds. Significantly smaller CV values for machine vision occurred at least once for each measured dimension. Outlying CV values (>10%) occurred 14 times with human measurements and only once with the MVS measurements. Significant ($P<0.10$) differences were found in all nine comparisons of mean dimensions. Human measurements of length averaged 4.3% larger than MVS. Human width and thickness measurements averaged 2.1% and 12.4% smaller, respectively, than those of MVS.

Selection of indent cylinder pocket sizes based on either MVS or human measurements of length from this research would result in recommendation of pockets of the same size or of one size (0.25 mm) larger or smaller. Based on an average difference of 2.2% in the mean widths measured by MVS and human operators, screens of the same or one size difference will be recommended by either method. Differences between means of human and MVS thickness measurements were the largest of the three dimensions. As a result, recommendations for screens with rectangular openings (for separations based on thickness differences) may vary by two or three sizes for the two methods. The relatively large difference in the average thickness measurements was thought to be due to the method used to create a scaling factor. Measurements of MVS thickness were approximately 9% larger than those of human measurements because the mark used to create the factor was at a greater distance from the camera than the seed and parallax causes an error that is dependent on the position of the seed. However, for both screening and indenting operations, the degree of accuracy found in this study was acceptable because few seed conditioning plants maintain complete sets of screen and indent sizes, and the closest size to the recommended is usually selected.

Each system of seed measurement has some advantages over the other. For this research, human measurers complained of eye fatigue. An average of 104 minutes per human measurer were spent on 72 seeds. This was equivalent to 1 minute 27 seconds per seed compared with 31 seconds per seed with MVS.

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Tom Burns, Second Vice President
Don Hector, Treasurer
David S. Nelson, Executive Secretary

Business Address

Oregon Seed Council
1193 Royvonne, S., Suite 11
Salem, OR 97302

Tel: (503) 585-1157
FAX: (503) 585-1292

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