Post-Harvest Residue Management Effects on Seed Yield in Perennial Grass Seed Production
II. The Effect of Less Than Annual Burning When Alternated with Mechanical Residue Removal[1]

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ABSTRACT

This study was designed to determine the effect of alternating burning with mechanical residue removal on seed yield of perennial grasses over a period of several years. The seed yields and yield components of 'Manhattan' perennial ryegrass (*Lolium perenne* L.), 'Encota' fine-leaf fescue (*Festuca rubra* L.), and 'Newport' Kentucky bluegrass (*Poa pratensis* L.) were measured. Mechanical straw and stubble removal techniques were used in the year(s) of non-burning. Open field burning was simulated with a mobile field sanitizer.

Species responded differently to alternating residue removal treatments. Alternate-year residue removal treatments resulted in a reduction of seed yield in perennial ryegrass, but had no significant effect on fine-leaf fescue. In bluegrass, no significant effects were observed when seed yields were averaged across four years; however, yields declined in the fourth year of study.

Additional index words: Lolium perenne, Festuca rubra, Poa pratensis

INTRODUCTION

Annual post-harvest residue burning of perennial grass seed fields has proven to be beneficial to subsequent seed production under Pacific Northwest conditions (Young et al., 1984). However, smoke pollution from the large acreage burned in the Willamette Valley of Oregon each year has promoted an evaluation of alternate-year burning as a means of reducing the total acreage burned each year. This concept involves post-harvest burning of perennial grass seed crops on a less than annual basis with mechanical removal of straw and stubble in the year of non-burning.

Chilcote and Youngberg (1975) investigated alternate-year burning over a three-year period for several perennial grass species in western Oregon. Residue was burned in the first and third seasons. They showed that annual burning resulted in the highest seed yield. However, yield reduction was less where burning was alternated with mechanical removal as compared to mechanical removal alone.

Canode and Law (1977), working with Kentucky bluegrass (*Poa pratensis* L.) in eastern Washington, reported that alternate-year burning with mechanical removal of straw, stubble, and thatch in the year of non-burning increased seed yields over straw removal alone. However, seed yields were less than for annual burning.

The research reported here was designed to evaluate the effect of alternating burning with mechanical residue removal over several years. In the years of mechanical removal post-harvest residue was removed at heights of 2.5 and 7.5 cm, using field-size equipment soon after harvest. The effects on seed yield and components of yield were determined. Straw and stubble removal treatments were alternated with early burning using a mobile field sanitizer, either every second or third year. Locations were selected within the Willamette Valley of Oregon to represent the soil types characteristic of commercial grass seed production. Species selected for study were perennial ryegrass (*Lolium perenne* L.) cv. 'Manhattan', fine-leaf fescue (*Festuca rubra* L.) cv. 'Encota', and Kentucky bluegrass (*Poa pratensis* L.) cv. 'Newport'.

MATERIALS AND METHODS

This study was conducted adjacent to the experimental plots investigating the long-term effects from non-burning described by Young et al. (1984). Thus, all management practices previously detailed apply to the three species used in this experiment to evaluate less than annual burning treatments. Alternating residue removal treatments were established on 'Manhattan' perennial ryegrass in 1978, and on 'Encota' fine-leaf fescue and 'Newport' Kentucky bluegrass in 1979. The final year of seed harvest was 1983; thus, treatment effects were evaluated over five years on perennial ryegrass and four years on fine-leaf fescue and bluegrass.

Each plot was 2.4 × 11 m and was replicated six times in a randomized block design. Treatments were arranged so that annual burning was compared to plots burned every other year or every third year with mechanical removal of stubble in the non-burning years. Also, flail-chop removal of straw was alternated every other year with burning (Table 1). Burn, close-clip removal of stubble, and flail-chop removal of straw treatments were imposed, using equipment described by Young et al. (1984) following seed harvest. Yield component data and seed yield was also determined, using procedures previously described (Young et al., 1984).

Data were subjected to a randomized block analysis of

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Table 1. Chronological listing of residue removal treatments applied over four or five years.

TREATMENT	1979	1980	1981	1982	[1]
	1978	1979	1980	1981	1982 [2]
1	B[3]	B	B	B	B
2	B	CC	B	CC	B
3	CC	B	CC	B	CC
4	B	CC	CC	B	CC
5	CC	CC	B	CC	CC
6	CC	B	CC	CC	B
7	B	FC	B	FC	B
8	FC	B	FC	B	FC

[1]Fine-leaf fescue and bluegrass
[2]Perennial ryegrass
[3] B = Burn field sanitizer
CC = Close-clipped removal of stubble
FC = Flail-chop removal of straw

variance and least significant difference tests to determine differences among treatment means.

RESULTS AND DESCUSSION

Perennial Ryegrass

The growth pattern during each growing season was characteristic of the residue management treatment last imposed. Burning always resulted in complete removal of straw and stubble, regardless of the previous year's residue removal practice. Non-burned treatments had an increased residue accumulation and a greater population of crop and weed seedlings; however, visual differences between plots close-clipped for two years and those close-clipped only one year were not apparent. Flail-chop treatments always had more stubble and residue surrounding the crown and were less vigorous in appearance.

No significant differences in yield components were observed due to treatment effects. However, annual burning resulted in consistently high seed yield throughout the later years of the study (Table 2).

Seed yield for alternate year burning treatments averaged 93% of continuous burning regardless of treatment (flail-chop or close-clipped) in the year of non-burning. Thus, there was no distinct advantage for choosing the more expensive close-clipping over the flail-chopping if a non-burning option is selected.

Burning every third year, following two years of close-clipping, reduced seed yields to 92% of continuous burning. There was a considerable "year effect" within like treatments for every third year burning and alternating burning with flail-chopping. Thus, weather associated interactions can alter the long-term effect on seed yield, depending on the sequence of residue removal treatments over time.

Fine-leaf Fescue

Plots close-clipped or flail-chopped in the year of non-burning appeared less vigorous due to increased residue on the soil and the presence of old stem structures within the crown. Visual appearance in the 1982-83 crop year gave no indication of previous year's residue removal treatment. Furthermore, changes in stand density following continuous close-clip stubble treatments reported by Young et al. (1984) were not observed when alternated with burning.

The planned plot design for the fourth year of study was destroyed by an accidental open field fire which escaped from an adjacent field before post-harvest residue treatments were applied. Thus, all alternating residue removal treatments were burned in 1982.

The number of fertile tillers per unit area at harvest was determined from a 0.1 m^2 quadrat just prior to seed maturity (Table 3). Plots burned had a significant decrease in tiller number in the third year (1982) and when averaged over the four years studied. Increased tiller number in alternate year treatments may have been the result of increased completion from volunteer seedlings which became established in the later years of the study with non-burning treatments.

Significant increases in seed yield were noted in the third and fourth harvest years (Table 4). In 1983, the two highest

Table 2. Cumulative treatment effects on mean seed yield (kg ha^{-1}) and yield as a percentage of annual burning in the non-yearly burning plots on perennial ryegrass, 1979-83.

Treatment					1979		1980		1981		1982		1983		Mean	
78/	79/	80/	81/	82/	Seed Yield	% of burn	Seed Yield	% of burn	Seed Yield	% of burn	Seed Yield	% of burn	Seed Yield	% of burn	Seed Yield	% of burn
B[1]	B	B	B	B	738	100	531	100	1119	100	505	100	320	100	628	100
B	CC	B	CC	B	738	100	514	97	1042	93	482	96	318	99	598	95
CC	B	CC	B	CC	731	99	525	99	578	52	553	110	327	102	575	92
B	CC	CC	B	CC	738	100	514	97	852	76	568	112	277	86	601	96
CC	CC	B	CC	CC	731	99	441	83	715	64	471	93	381	119	635	101
CC	B	CC	CC	B	731	99	525	99	578	52	468	93	322	100	499	80
B	FC	B	FC	B	738	100	502	94	896	80	537	106	307	96	638	102
FC	B	FC	B	FC	697	94	538	101	558	50	543	108	330	103	533	85
LSD	.05				NS	-	NS	-	363	-	69	-	NS	-	95	-

[1] B = Burn field sanitizer
CC = Close-clipped removal of stubble
FC = Flail-chop removal of straw

Table 3. Fertile tillers in the non-yearly burning plots on fine-leaf fescue, 1980-83.

Treatment				Tillers (0.1 m^{-2})				
79/	80/	81/	82/	80	81	82	83	Mean
B[1]	B	B	B	316	165	179	136	192
B	CC	B	B	316	165	287	180	249
CC	B	CC	B	297	195	217	153	212
B	CC	CC	B	316	165	202	166	208
CC	CC	B	B	297	179	240	161	221
B	FC	B	B	316	181	233	207	228
FC	B	FC	B	260	217	198	173	212
LSD	.05			NS	NS	52	NS	27

[1] B = Burn field sanitizer
CC = Close-clipped removal of stubble
FC = Flail-chop removal of straw

yield treatments were two consecutive years of burning after either a close-clip or flail-chop treatment in the first of a three-year sequence. It is not clear why the continuously burned treatment yielded significantly less than the two treatments mentioned above. However, cumulative effects of the four year study suggest that any combination of the alternate year treatments discussed in this report have not resulted in a reduction of seed yield.

Bluegrass

Plant height differences due to etiolated growth on plots close-clipped or flail-chopped are consistent with those described by Young et al. (1984). However, in addition, those plots receiving a close-clip stubble removal treatment for two years prior to a burn treatment appeared to have a high proportion of burnout, i.e., the loss of plants from exposure to excessive or prolonged heat during field burning. Thus, following two years of close-clipping, a significant thatch layer developed which ignited during burning in the third year with sufficient heat to kill a portion of the stand. When close-clipping was followed by burning in an alternate year sequence, no increase in burnout was observed. Similarly, plots flail-chopped alternately with burning showed no greater burnout.

Table 5. Fertile tillers in the non-yearly burning plots on bluegrass, 1980-83.

Treatment				Tillers (0.1 m^{-2})				
79/	80/	81/	82/	80	81	82	83	Mean
B[1]	B	B	B	404	322	341	306	336
B	CC	B	CC	404	252	384	188	301
CC	B	CC	B	396	308	290	298	351
B	CC	CC	B	404	252	352	270	326
CC	CC	B	CC	396	280	382	235	320
CC	B	CC	CC	396	308	290	180	269
B	FC	B	FC	404	240	410	186	316
FC	B	FC	B	271	281	174	265	248
LSD	.05			44	41	81	61	32

[1] B = Burn field sanitizer
CC = Close-clipped removal of stubble
FC = Flail-chop removal of straw

Burned treatments had more fertile tillers than mechanical straw or stubble removal treatments across four years (Table 5). All plots burned in 1982 had significantly more fertile tillers than plots with non-thermal residue removal treatments. Plots close-clipped for two consecutive years had the smallest number of fertile tillers in 1983; however, plots alternately burned and flail-chopped had the lowest number of fertile tillers averaged over four years. Some yield component compensation for low fertile tiller number via an increased number of spikelets per panicle and florets per spikelet was observed in 1981 (Table 6).

Cumulative seed yield data are shown in Table 7. In the fourth year of the study, when previous residue management is considered, burning every other year in alternation with close-clipping resulted in 91% of the yield associated with annual burning. Close clipping for two consecutive years before alternating to burning reduced seed yield to 87% of continuous burning. Furthermore, alternate burning every other year with flail-chopping resulted in 86% of the yield where annual burning was used. Thus, close-clipping alternated with burning has an advantage over the flail-chopper in an alternate year system of residue management (91% vs. 86% of annual burning).

Table 4. Cumulative treatment effects on mean seed yield (kg ha^{-1}) and annual burning in the burning plots on fine-leaf fescue, 1980-83.

Treatment				1980		1981		1982		1983		Mean	
79/	80/	81/	82/	Seed Yield	% of burn	Seed Yield	% of burn	Seed Yield	% of burn	Seed Yield	% of burn	Seed Yield	% of burn
B[1]	B	B	B	367	100	189	100	270	100	473	100	333	100
B	CC	B	B	367	100	167	88	253	94	601	127	349	105
CC	B	CC	B	381	104	163	86	261	96	503	107	327	98
B	CC	CC	B	367	100	167	88	326	120	523	111	351	106
CC	CC	B	B	381	104	175	92	259	96	500	106	328	99
B	FC	B	B	367	100	163	86	276	102	622	131	343	103
FC	B	FC	B	384	104	170	90	256	95	458	97	317	95
LSD	.05			NS	-	NS	-	37	-	125	-	NS	-

[1] B = Burn field sanitizer
CC = Close-clipped removal of stubble
FC = Flail-chop removal of straw

However, the cumulative effect on seed yield of any combination of the alternate-year treatments in this study has not reduced seed yield averaged over four years. Declining trends did appear in the fourth year of study, suggesting that the close-clip removal technique should not be used as an alternative to burning for more than two years.

Table 6. Components of Seed Yield for Treatments in the Non-yearly Burning Plots on Bluegrass, 1981.

Treatment		Total Panicles 0.1 m^{-2}	Spikelets Per Panicle	Floret Per Spikelets
B[1]	B	321.7	67.7	2.87
B	CC	251.3	71.2	2.86
CC	C	307.3	74.1	2.97
CC	CC	279.9	82.9	3.08
B	FC	240.2	96.4	2.94
FC	B	280.6	75.5	2.85
LSD .05		41.4	9.9	0.16

[1] B = Burn field sanitizer
CC = Close-clipped removal of stubble
FC = Flail-chop removal of straw

SUMMARY

In perennial ryegrass seed production, close-clipping or flail-chopping of post harvest residue alternating with burning, produced a seed yield 93% of annual burning when averaged over five years. When close-clipped for two consecutive years prior to burning, seed yield was reduced to 92% of annual burning. Furthermore, an increase in weed seed content was associated with all treatments receiving less than annual burning treatment.

In fine-leaf fescue, the alternate year treatments studied through four years have not resulted in a reduction in seed yield. There is no evidence that close-clipping results in a significant advantage over flail-chop residue removal.

Bluegrass seed yield declined slightly in the fourth year, although no effect on seed yield averaged over four years was observed. Thus, deleterious effects on bluegrass may reduce production below that of annual burning after three years. These effects were more obvious where flail-chop residue removal was used for residue removal when plots were not burned.

Although yield reduction with the close-clip equipment is less than with other non-burn treatments, the expense of the operation may limit its adoption in commercial fields. The close-clip technique offers an alternative post-harvest method for field located near highways or cities where burning is prohibited or strictly controlled.

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Table 7. Treatment effects on mean seed yield (kg ha^{-1}) and yield as a percentage of annual burning in the non-yearly burning plots on bluegrass, 1980-83.

Treatment				1980		1981		1982		1983		Mean	
79/	80/	81/	82/	Seed Yield	% of burn	Seed Yield	% of burn	Seed Yield	% of burn	Seed Yield	% of burn	Seed Yield	% of burn
B[1]	B	B	B	748	100	828	100	352	100	988	100	732	100
B	CC	B	CC	748	100	707	85	384	109	864	87	660	90
CC	B	CC	B	789	106	893	108	447	127	952	96	787	108
B	CC	CC	B	748	100	707	85	435	124	924	93	704	96
CC	CC	B	CC	789	106	746	90	447	127	927	94	719	98
CC	B	CC	CC	789	106	893	108	448	127	727	74	708	97
B	FC	B	FC	748	100	853	103	411	117	741	75	701	96
FC	B	FC	B	839	112	767	93	341	97	948	96	724	99
LSD	.05			NS	-	111	-	191	-	NS	-	NS	-

[1] B = Burn field sanitizer
CC = Close-clipped removal of stubble
FC = Flail-chop removal of straw