G. Kruger[1], J. Soroka[2], and H. Loeppky[2]

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Creeping red fescue and meadow bromegrass regrow quickly following seed harvest. Seed guides recommend that stubble and regrowth be removed to stimulate regrowth of fertile tillers for the next seed crop (Smith, 1996). Regrowth management trials were set up at one location for each species over two growing seasons (1995 and 1996) to determine the impact of several management practices on seed yield of grasses. The trial's first year results have been reported previously (Kruger et al., 1995).

The experiment was designed as a split-plot with four rates of nitrogen (0, 30, 60, and 90 kg N/ha) as main plots and five types of post-harvest management as subplots. The post-harvest treatments applied in August, 1994 after the first seed crop included:

1) leaving stubble intact at swathing height (20-25 cm),
2) mowing stubble and regrowth as short as possible with a flail mower and removing clippings by hand raking,
3) spraying stubble and regrowth with Gramoxone (paraquat) at 1.1 kg/ha in 550 l/ha of water and burning after one week,
4) mowing stubble and regrowth as short as possible with a flail mower, removing clippings by hand raking, and tilling with an Aerway implement,
5) mowing stubble and regrowth as short as possible with a flail mower and burning the clippings after one week of drying.

Treatment #3 in 1995 severely thinned the stand. To avoid re-injuring the plants in the second year (1995), no herbicide was sprayed; instead, the regrowth after harvest was mowed and raked as for treatment #2. Post-harvest operations were conducted during the last week of August and first week of September in both years. Nitrogen was applied during the first and third week of October in 1994 and 1995, respectively. Fifty kg P_2O_5/ha was broadcast on both sites during the third week of October in 1995.

The density of tillers in fall (1995) and spring (1996) was counted at the meadow bromegrass site to monitor tiller survival over the winter and to form a baseline for

[1] Saskatchewan Forage Council. Dept. of Crop Science and Plant Ecology. 51 Campus Dr., Saskatoon. SK S7N 5A8 (306)-966-8663 email: kruger@fc.usask.ca
[2] Agriculture and Agri-Food Canada. 107 Science Place. Saskatoon. SK S7N OX2 (306)-956-7200

estimating the percentage of tillers which developed seed heads. Because tillers were too numerous to count in creeping red fescue, bright red twist ties were placed loosely around 25 tillers per plot in spring, 1996. Marked tillers were evaluated after heading to estimate the percentage of tillers which produced seed heads.

Silvertop and productive seed heads were counted in four - 0.25 m^2 quadrats for each plot of both crops in early July, 1996. Samples of 7.6 m^2 were harvested at seed maturity to estimate seed yield in each plot. The samples were hung in the shade to cure for 7-10 days before being dried in a forced air oven at 35°C for 24 hours. The dried samples were threshed in a stationery plot harvester and the seed was cleaned with a Clipper sample sieve before weighing.

Meadow Bromearass

The effect of the fall treatments on regrowth of meadow bromegrass is shown in

Table 1: The (m^2) per meadow bromegrass in fall, 1995.

	Nitrogen Rate (kg/ha)				
					Average
Control	772	705	659	735	718 a (100%)
Clip	601	653	543	635	608 b (85%)
Spray / Burn	619	604	648	625	624 b (87%)
Clip / Aerway	551	640	526	613	582 b (81%)
Clip / Burn	568	662	578	652	615 b (86%)
Average	**622 ab**	**652 a**	**591 b**	**652 a**	

F (fall mgt.) 7.77** *LSD(.05) = 53
F (N rate) = 3.53 Sig. at 0.10 LSD(.10) = 41
F (FM x N) = 1.05 NSF

Many tillers died over the winter (Table 2). Nitrogen did not affect the spring counts, but clipping the regrowth had a large impact. Clipping and raking maintained the highest tiller density followed by the other two clip treatments. The control had the lowest tiller density. Tillers in the control were long and thin, and appeared very weak. Removal of the dense canopy in fall improved the survival of these tillers through the winter.

The survival of fall tillers is an index of winter injury and spring vigour. Tiller numbers decreased over winter for all residue treatments (Table 3). The best survival occurred in the clip/rake and clip/Aerway treatments at 95 and 89%, respectively, while almost half of the tillers died in the control. Nitrogen fertility had no effect on survival.

Table 2: The effect of fall management and nitrogen fertility on the density of tillers (no. per m^2) in the spring for the third seed crop (1996) of meadow bromegrass.

	Nitrogen Rate (kg/ha)				
Fall Management	*0 N*	*30 N*	*60 N*	*90 N*	*Average*
Control	367	425	376	*381*	*387* d (100%)
Clip	566	583	571	566	571 a (148%)
Spray / Burn	454	468	417	464	451 c (117%)
Clip / Aerway	508	510	475	546	510 b (132%)
Clip / Burn	516	514	482	550	515 b (133%)
Average	482	500	464	501	

F (fall mgt.) = 17.3***LSD(.05) = 42
F (Nrate) = 0.60 NSF
F (FM x N) = 0.30 NSF

Table 3: The effect of fall management and nitrogen fertility on the survival of tillers (%) for the third seed crop (1996) of meadow bromegrass.

	Nitrogen Rate (kg/ha)				
Fall Management	*0 N*	*30 N*	*60 N*	*90 N*	*Average*
Control	49	61	57	52	55 d
Clip	94	91	106	90	95 a
Spray / Burn	72	78	65	74	72 c
Clip / Aerway	92	81	92	90	89 ab
Clip / Burn	92	79	84	85	85 b
Average	80	78	81	78	

F (fall mgt.) = 43.1***LSD(.05) = 6%
F (N rate) = 0.23 NSF
F (FM x N) = 1.65 NSF

Silvertop limits the seed yield of some grasses by prematurely halting development of the seed head in cereals and grasses. The head emerges from the stem, but turns white when the supply of water and nutrients is cut off. In some species, a maggot chews the stem. In others, insects puncture the stem and the seed head turns white once the plant is exposed to an environmental stress. A fungal disease often appears at the injury. The end result is a conspicuous white seed head with no seed.

Residue management influenced the number of seed bearing heads (*Table 4).* Statistical analysis divided the treatments into three group - the spray treatment, the clip treatments, and the control. Clipped meadow bromegrass which was raked, Aerway-tilled, or burned had equal numbers of seed heads. Numbers of silvertop heads were the same regardless of regrowth management (Table 5). Numbers of silvertop heads increased with nitrogen application at the 10% level of significance, but the percentage of silvertop heads was not significant. Because silvertop heads per unit area were similar among the regrowth management treatments, the percentage of silvertop heads was inversely related to the number of seed bearing heads (Table *6).*

The percentage of spring tillers which produced seed heads was calculated in Table 7. The control and three clip treatments had similar percentages of fertile tillers

Table 4: The effect of fall management and nitrogen fertility on the seed bearing heads (# per m^2) of the third seed crop (1996) of meadow bromegrass.

	Nitrogen Rate (kg/ha)				
Fall Management	*O N*	30 N	60 N	90 N	*Average*
Control	29	53	58	98	59 c
Clip	98	107	112	192	127 b
Spray / Burn	301	304	269	363	309 a
Clip / Aerway	78	116	133	236	141 b
Clip / Burn	106	117	138	161	130 b
Average	122 b	139 b	142 b	210 a	

F (fall mgt.) = 39. 9*** LSD(.0 5) = 42
F (N rate) = 5. 32* LSD(.0 5) = 53
F (FM x N) = 0.56 NSF

Table 5: The effect of fall management and nitrogen fertility on silvertop head (# per m^2) in the third seed crop (1996) of meadow bromegrass.

	Nitrogen Rate (kg/ha)				
Fall Management	*O N*	30 N	60 N	90 N	*Average*
Control	26	44	35	40	36
Clip	24	29	41	37	33
Spray / Burn	27	38	22	36	31
Clip / Aerway	30	32	36	44	36
Clip / Burn	18	31	42	32	31
Average	25 a	35 b	35 b	37 b	

F (fall mgt.) = 0.62 NSF
F (N rate) = 2.82 Sig. at 0.10 only LSD(.1 0) = 9
F (FM x N) = 0.86 NSF
F (N rate linear) = 6.5 8*

Table 6: The effect of fall management and nitrogen fertility on silvertop heads (as a percentage of total number of heads) in the third seed crop (1996) of meadow bromemass.

	Nitrogen Rate (kg/ha)				
Fall Management	*O N*	30 N	60 N	90 N	*Average*
Control	49.7	44.5	39.4	28.4	40.5 a
Clip	22.6	20.8	26.8	16.7	21.7 b
Spray / Burn	8.9	11.1	8.5	10.0	9.6 c
Clip / Aerway	27.4	21.5	22.9	14.9	21.7 b
Clip / Burn	16.5	22.0	23.9	17.4	20.0 b
Average	25.0	24.0	24.3	17.5	

F (fall mgt.) = 27.5 ***LSD(.0 5) = 6.0%
F (N rate) = 1.62 NSF
F (FM x N) = 1.11 NSF

ranging from one-quarter to one-third of the tillers present in spring. In contrast, thr ee-quarters of the tillers in the spray treatment produced seed heads.

The seed yields mirrored the number of seed heads with the highest yield obtained for the spray treatment (Table 8). The statistical grouping of treatments followed the same pattern as the number of seed bearing heads. The lowest yielding treatment in the second crop had the best seed yield for the third crop. This recovery brought the two year seed yield for the spray/burn treatment within 200 kg/ha of the

seed yield for the three clip treatments (Table 9). The relatively ineffective burn of the clippings did not reduce the seed yield of meadow bromegrass.

Table 7 The effect of fall management and nitrogen fertility on total seed head density as a percentage of tillers counted in spring in the third seed crop of meadow bromegrass.

	Nitrogen Rate (kg/ha)				
Fall Management	*O N*	**30 N**	**60 N**	**90 N**	*Average*
Control	15.3	22.9	25.8	36.5	25.1 b
Clip	21.4	23.2	27.3	40.3	28.1 b
Spray / Burn	75.3	71.4	71.7	85.6	76.0 a
Clip / Aerway	20.9	29.0	36.5	48.8	33.8 b
Clip / Burn	25.7	29.4	38.8	35.0	32.2 b
Average	31.7 b	35.2 b	40.0 ab	49.2 a	

F (fall mgt.)= 43.7***LSD(.05) = 9.0%
F (N rate) = 5.23* LSD(.05) = 10.6%
F (FM x N) = 0.49 NSF

Table 8 The effect of fall management and nitrogen fertility on the seed yield (kg/ha) in the third seed crop (1996) of meadow bromegrass.

	Nitrogen Rate (kg/ha)				
Fall Management	*O N*	*30 N*	*60 N*	*90 N*	*Average*
Control	26	54	52	104	59 c
Clip	234	280	204	458	294 b
Spray / Burn	548	780	586	680	648 a
Clip / Aerway	166	366	275	520	332 b
Clip / Burn	232	378	366	439	354 b
Average	214 a	372 b	297 ab	440 b	

F (fall mgt.) = 40.2***LSD(.05) = 94
F (N rate) = 5.38* LSD(.05) = 120
F (FM x N) = 0.97 NSF

Table 9: The effect of fall management and nitrogen fertility on total seed yield (kg/ha) harvested from the second and third seed crops (1995 and 1996) of meadow bromegrass.

	Nitrogen Rate (kg/ha)				
Fall Management	*O N*	*30 N*	*60 N*	*90 N*	*Average*
Control	444	524	547	581	524 c
Clip	983	1178	1013	1521	1174 a
Spray / Burn	960	1030	1032	991	1003 b
Clip / Aerway	1123	1304	1077	1329	1208 a
Clip / Burn	844	1298	1293	1259	1174 a
Average	871 b	1067 a	*993* ab	1136 a	

F (fall mgt.)= 25.6***LSD(.05) = 161
F (N rate) = 3.70 Sig. at 0.10 only LSD(.10) = 153
F (FM x N) = 1.28 NSF
F (N rate linear)= 7.49*

Creeping red fescue

Creeping red fescue is seldom harvested for seed for three consecutive years without rejuvenation. Tiller counts could not be completed on creeping red fescue to assess tiller survival from fall to spring. The harsh winter of 1995-96 and snow molds which appeared during spring thaw left patches of dead tillers in spring. The percent of

the plot area with brown tillers was estimated with "0" equal to total kill of tillers and "10" representing no brown tillers. The fall tilled treatment was rated lower than the other four treatments (Table 10). This result differs from the meadow bromegrass site where the Aerway treatment did not affect the survival of tillers.

Table 10: The effect of fall management and nitrogen fertility on winter injury observed in spring, 1996 in the third seed crop of creeping red fescue.

	Nitrogen Rate (kg/ha)				
Fall Management	*O N*	30 N	60 N	90 N	*Average*
Control	8.6	9.9	9.9	10.0	9.6 a
Clip	9.6	9.6	9.5	9.8	9.6 a
Spray / Burn	9.8	9.8	9.9	9.9	9.8 a
Clip / Aerway	8.5	9.6	8.8	9.5	9.1 b
Clip / Burn	9.9	9.5	9.3	9.5	9.5 a
Average	**9.3**	**9.7**	**9.5**	**9.7**	

F (fall mgt.) = 2.45 Sig. at 0.10 only LSD(.10) = 0.40
F (N rate) = 0.41 NSF
F (FM x N) = 0.26 NSF

The number of panicles per unit area was counted in early July. The trends for seed bearing heads (Table 11) were similar to those observed with meadow bromegrass even though the level of silvertop was much higher in creeping red fescue than in meadow bromegrass. The highest density of heads was found in the spray/burn treatment. The three clip treatments had equal numbers of seed heads, but the control produced only 15% of the seed heads counted in the spray/burn treatment. Compared to the second seed crop (1995), the average density of panicles in the trial was only 17% of last year's levels.

Table 11: The effect of fall management and nitrogen fertility on the seed bearing heads (# per m^2) of the third seed crop (1996) of creeping red fescue.

	Nitrogen Rate (kg/ha)				
Fall Management	*O N*	*30 N*	*60 N*	*90 N*	*Average*
Control	23	26	53	40	35 c
Clip	120	91	89	76	94 b
Spray / Burn	305	224	357	291	294 a
Clip / Aerway	167	66	85	72	97 b
Clip / Burn	101	a3	132	90	102 b
Average	143	98	143	114	

F (fall mgt.) = 33.6*** LSD(.05) = 48
F (N rate) = 0.66 NSF
F (FM x N) = 0.79 NSF

The number of silvertop heads followed the same pattern as the number of seed heads. In other words, the level of infection was proportional to the number of seed heads in creeping red fescue (Table *12).* This contrasts with meadow bromegrass where

the number of silvertop heads was constant throughout the plots regardless of the number of seed heads. This difference in silvertop for sites separated by only ten miles indicates that the causal agent for silvertop differs among species or locations. As a percentage of total number of heads in the plot area, the level of incidence of silvertop was the same for the different methods of regrowth management (Table 13).

The number of silvertop heads increased with the rate of nitrogen application (Table 12). Silvertop heads as a percentage of the total number of heads, however, also increased with the rate of nitrogen application (Table 13). This trend contrasts with the effect in meadow bromegrass where the number of silvertop heads increased, but the percentage of silver-top heads declined as the rate of nitrogen application increased (Table 5 and 6).

Table 12: The effect of fall management and nitrogen fertility on the incidence of silvertop heads (# per m^2) in the third seed crop (1996) of creeping red fescue.

	Nitrogen Rate (kg/ha)				
Fall Management	*0 N*	*30 N*	*60 N*	*90 N*	*Average*
Control	8	16	31	16	18 c
Clip	25	25	43	73	42 b
Spray / Burn	55	114	145	188	125 a
Clip / Aerway	16	30	50	82	44 b
Clip / Burn	24	32	78	75	52 b
Average	25 c	43 bc	69 ab	87 a	

F (fall mgt.) = 36.3 LSD(.05) = 19
F (N rate) = 8.61 LSD(0.05) = 30
F (FM x N)= 2.28*

Table 14 summarizes the percentage of tillers marked in spring which developed seed heads later in the growing season. There was no influence of nitrogen fertility on the proportion of reproductive tillers. There was also no significant difference between

Table 13: The effect of fall management and nitrogen fertility on the incidence of silvertop heads (as a percentage of the total number of heads) in the third seed crop (1996) of creeping red fescue.

	Nitrogen Rate (kg/ha)				
Fall Management	*0 N*	*30 N*	*60 N*	*90 N*	*Average*
Control	25	38	38	36	34
Clip	18	35	33	49	34
Spray / Burn	16	34	30	41	30
Clip / Aerway	9	41	32	54	34
Clip / Burn	16	39	39	44	35
Average	17 b	37 a	34 a	45 a	

F (fall mgt.) = 0.58 NSF
F (N rate) = 6.96 LSD(.05) = 14%
F (FM x N) = 1.31 NSF

the control and the clipping residue management treatments. The percentage of reproductive tillers was much higher, however, for the spray/burn treatment. The

Table 14: The effect of fall management and nitrogen fertility on the proportion of seed heads formed from 25 tillers marked in spring, 1996 in the third seed crop of creeping red fescue.

	Nitrogen Rate (kg/ha)				
Fall Management	*O N*	*30 N*	*60 N*	*90 N*	*Average*
Control	ɔ	1	19	2	7 b
Clip	15	9	8	11	11 b
Spray / Burn	41	22	21	30	29 a
Clip / Aerway	13	13	14	10	12 b
Clip / Burn	14	3	10	11	10 b
Average	18	10	14	13	

F (fall mgt.) = 8.41*** LSD(.05) = 9.0%
F (N rate) = 0.93 NSF
F (FM x N) = 0.95 NSF

difference in percentage of reproductive tillers explains all of the difference in seed yield among the regrowth management treatments (Table 15).

Table 15: The effect of fall management and nitrogen fertility on the seed yield (kg/ha) in the third seed crop (1996) of creeping red fescue.

	Nitrogen Rate (kg/ha)				
Fall Management	*O N*	*30 N*	*60 N*	*90 N*	*Average*
Control	7	10	22	13	13 c
Clip	38	17	68	61	46 bc
Spray / Burn	99	205	305	326	234 a
Clip / Aerway	64	51	89	96	75 b
Clip / Burn	52	23	106	69	63 b
Average	52 b	61 b	118 a	113 a	

F (fall mgt.) = 29.1*** LSD(.05) = 45
F (N rate) = 5.79* LSD(.05) = 45
F (FM x N) = 1.79 Sig. at 0.10 only

The seed yield harvested from the trial is summarized in Table 15. The control produced the least seed, but the clip/rake treatment was not significantly different for the third seed crop (1996). The three clipping treatments were also not significantly different from each other. The best seed yield from the third seed crop was from the spray/rake treatment, but, over the two harvest seasons, the yield for this treatment was the lowest (Table 16). Over two harvest seasons, the clip/rake and clip/Aerway treatments were equal. The control and clip/burn treatments were also considered equal.

If the nitrogen response for grass seed is linear, the seed yield response per unit N can be estimated. For creeping red fescue, the two-year average response was 1.25 kg seed per kg N based on averages for the second and third seed crops of 1.74 and 0.76 kg seed per kg N respectively. For meadow bromegrass, the two-year average response was 1.84 kg seed per kg N based on averages for the second and third seed crops of 1.09 and2.59 kg seed per kg N respectively. ‘According to this data, the seed yield of meadow bromegrass was more responsive to nitrogen than creeping red fescue was. The estimate

Table 16: The effect of fall management. and nitrogen fertility on total seed yield (kg/ha) harvested from the second and third seed crops (1995 and 1996) of creeping red fescue.

	Nitrogen Rate (kg/ha)				
Fall Management	*O N*	*30 N*	*60 N*	*90 N*	*Average*
Control	532	436	705	593	566 b
Clip	557	533	942	856	722 a
Spray / Burn	174	259	354	520	327 c
Clip / Aerway	650	696	782	904	758 a
Clip / Burn	495	592	607	684	594 b
Average	482 b	503 b	678 a	711 a	

F (fall mgt.) = 15.9*** LSD(.05) = 121
F (N rate) = 3.59 Sig. at 0.10 only LSD(.10) = 161
F (FM x N) = 0.92 NSF
F (N rate linear) = 9.63*

for meadow bromegrass is likely low because of decomposition of alfalfa *roots* during the second seed crop. This assumption is supported by the increase in seed yield response per unit N from the second to the third year even though the vigour of a grass seed crop decreases as the stand ages.

Conclusion

The regrowth and nitrogen management of grass seed crops have a major impact on the second and third year seed production. Excellent seed yields achieved in one year reduce the seed yield potential of the succeeding crop. Clipping and removal of the season-long basal leaf growth increases yields in the second year. Minimum tillage with an Aerway implement did not increase seed yields significantly compared to the clipped and raked treatment. Burning the clippings was equal to removal by raking in meadow bromegrass, but less successful in creeping red fescue. Burning in late August or early September is too late for adequate regrowth of the red fescue tillers. Nitrogen application to grass seed fields is essential as the seed stand ages. Previous cropping history and the importance of available nitrogen beneath the normal rooting depth of crops are important factors in evaluating nitrogen fertilization requirements.

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