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Improvement of Regar Meadow Bromegrass Seed Yield by Residue Removal and Nitrogen Fertilization[1]

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ABSTRACT

Seed yields of 'Regar' meadow bromegrass (*Bromus biebersteinii* Roem and Schult) are high the first year of production and decline rapidly in subsequent years. This study was conducted to evaluate the effects of timing of nitrogen (N) fertilization and residue removal on Regar seed yield. Experiments were conducted at Bozeman and Kalispell, Montana. Treatments consisted of four N application dates during the seeding year, four N applications to the established stands, and four dates of residue removal from established stands. Seeding year fall N fertilization increased first year seed yield at Kalispell, but not at Bozeman. The most economical stand life of Regar at each location was two years. Fall N application and fall residue removal increased first and second year seed yield at Kalispell and second year seed yield at Bozeman. Third and fourth year seed yield at Kalispell and third year yield at Bozeman was improved with N applied after harvest. However, these yields were low compared to first and second year seed yield.

Additional index words: grass seed production, N-fertilization, simulated grazing.

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INTRODUCTION

'Regar' meadow bromegrass (*Bromus biebersteinii* Roem and Schult.) has become popular in northern U.S. and Canada because of its stand longevity, rapid regrowth, high forage yield, and weakly rhizomatous characteristics. This cultivar was selected from Turkish accession PI-172390 and was released in 1959 by the USDA Plant Introduction Station, Agricultural Research Service. Regar has consistently equalled or exceeded forage yields of 'Manchar' smooth bromegrass (*B. inermis* L.), in its area of adaptation (Cooper et al., 1978; Foster et al., 1966). Yield advantages have been attributed to reduced sodboundness of Regar (Foster et al., 1966).

The supply of Regar seed has been short due to demand and production problems. Regar seed yield is normally high the first production year and declines dramatically during the second and third production years (Cooper et al., 1978). In Idaho, first year dryland seed yield decreased from 336 kg ha^{-1} to 112 kg ha^{-1} by the third production year (Foster et al., 1966). Under dryland conditions in Montana, seed yield declined from 572 kg ha^{-1} to 265 kg ha^{-1} by the third production year, a 54% reduction (Cooper et al., 1978). When stands were irrigated every two weeks during the growing season, seed yield declined from 470 kg ha^{-1} to 18 kg ha^{-1} by the third production year, a 96% reduction. Reductions in seed yield are generally more pronounced with rhizomatous sod-forming grasses than with bunchgrasses (Canode and Law, 1975).

Fall grazing or clipping of grass seed crops has increased seed yield. Knowles et al. (1969) showed that burning or removal of all residue increased smooth bromegrass seed yield by 30% over the untreated control, with no significant difference between the two methods. However, Canode and Law (1978) showed that mechanical removal of smooth bromegrass straw and stubble resulted in a 24% reduction in seed yield compared to burning. Clipping and removal of both straw and stubble resulted in higher seed yield than removal of straw alone. Post harvest residual removal is essential in maintaining high seed yields of Kentucky bluegrass (*Poa pratensis* L.) (Canode, 1972, 1980; Canode and Law, 1975, 1977; Pumphrey, 1965). Thatch accumulation was the primary factor causing reduced seed yield.

Application of nitrogen (N) has increased seed yield and slowed the decline in seed production due to stand age for many species. Knowles et al. (1969) found that the greatest increase in smooth bromegrass seed yield was obtained with low rates of N. They showed that fall application of N result in higher smooth bromegrass seed yield than spring application, and mid-September application resulted in higher yield than mid-August or mid-October application.

The objective of this research was to determine the effects of N timing and residue removal on seed yields of Regar meadow bromegrass.

MATERIALS AND METHODS

These experiments were conducted at the Arthur Post Field Research Laboratory near Bozeman, Montana and at the Northwestern Agricultural Research Center near Kalispell, Montana. Bozeman soil is mainly Amsterdam silt loam, classified in the fine-silty mixed family of Typic Haploborolls. The 15-year precipitation average at Bozeman is 4.27 dm. Kalispell soil is mainly Flathead very fine sandy loam, classified in the coarse-loamy mixed family of Pachic Haploxerolls. The 37-year precipitation average at Kalispell is 4.93 dm.

Regar was seeded at 66 pure live seeds m^{-1}/in rows 6.1 m long in May, 1980 at each location. Each plot consisted of four rows spaced 61 cm apart. Plots were irrigated during the growing season, immediately after harvest and in the fall. Prior to seeding, 336 kg $P_2O_5 ha^{-1}$ were incorporated into the seedbed. Weeds were controlled by hand.

Thirteen N fertilization and residue removal treatments (Table 1) were applied during the establishment year and to established stands for 4 years at Kalispell and 3 years at Bozeman. The N fertilization rate during the seeding year and for established stands was 84 kg ha^{-1} supplied as ammonium nitrate. Residue removal was accomplished by cutting residue to approximately 50 mm with a flail forage harvester.

Seed was hand harvested from 4.8 m of the center two rows of each plot. Harvested seed was threshed and cleaned to a minimum purity of 90% using a resilient taped thresher. After cleaning seed was weighed and yields calculated.

Data were analyzed as a randomized complete block design having four blocks. Means were separated with LSD when the F-test was significant at P = 0.05.

RESULTS AND DISCUSSION

Seed yield was greatest in first seed production year at each location; mean first year seed yield was 1,056 and 1,343 kg ha^{-1} at Kalispell and Bozeman, respectively. Second year mean seed yield at Kalispell (257 kg ha^{-1}) was greatly reduced as compared to Bozeman (852 kg ha^{-1}). Third and fourth year mean seed yield at Kalispell and third year at Bozeman were low.

Seeding year fall application of N increased first year seed yield (examples, treatments 2 vs 4) at Kalispell (Table 1), but not at Bozeman (Table 2). Lack of N response at Bozeman could be due to an adequate supply of N available for Regar seed production. The Bozeman

Table 1. Effects of N Application and Residue Removal on Seed Yields of Regar Meadow Bromegrass at Kalispell, MT.

Treatment number	NSY[a]	NES	RR	Seed yield ($kg\ ha^{-1}$) 1st	2nd	3rd	4th	4-yr total yield
1	0[b]	0	F	543	69	8	18	638
2	0	F	F	635	415	81	95	1226
3	F	0	F	1326	51	4	13	1394
4	F	F	F	1357	460	40	59	1916
5	0	0	0	919	395	31	67	1412
6	F	F	0	1287	269	2	8	1566
7	0	F	0	1193	229	36	57	1515
8	F	0	0	538	56	7	10	611
9	F	AH	F	1348	246	160	284	2038
10	2 wks	F	F	1343	355	60	121	1879
11	2 wks	S	F	1315	458	28	9	1810
12	F	F	AH	562	282	52	35	931
13	F	F	AH + F	1363	56	68	52	1539
Mean				1056	257	44	64	1421
LSD (0.05)				181	93	40	58	226

[a] NSY - Nitrogen application during seeding year, NES - nitrogen application to established stand, RR = residue removal.
[b] 0 = none, F = fall, 2 wks = 2 weeks after seedling emergence, S = spring, AH = after harvest.

study followed alfalfa forage trials. Nitrogen was not applied to established stands until after harvest and in the fall following first year seed production. The spring application (treatment 11) was made in the spring of the first seed production year; therefore, this treatment had 84 kg ha^{-1} of N applied two weeks after seedling emergence and 84 kg ha^{-1} the next spring. The additional N did not increase first year seed yield at Bozeman over treatments receiving N during the fall of the seeding year (treatments 3, 4, 6, 8, 9, 12 and 13, Table 1) at Kalispell. This treatment did increase seed yield when compared to treatments which received seeding year N, but did not receive fall residue removal (treatments 8 and 12).

Second year seed production was highest when N was applied to established stands in the fall (treatments 3 and 4) at each location. However, spring applied N also produced high second year seed yield (Tables 1 and 2). Third and fourth year seed production at Kalispell and third year seed production at Bozeman was improved with N applied after harvest (treatment 9). However, in some cases fall N application also produced similar results at Bozeman.

Highest total seed yield at each location was obtained when N fertilization was combined with fall residue removal, except for treatment 6 at Bozeman (Table 2). After harvest or after harvest plus fall residue removal were not as effective as fall residue removal for total seed production at each location (treatments 4 vs 12 and 4 vs 13, Tables 1 and 2).

Highest total seed yields at Kalispell were obtained when N was applied during the seeding year, either two weeks after harvest or in the fall; combined with N applied each year to the established stand, either after harvest or in the fall; and when crop residue was removed in the fall after the plants were dormant (treatments 4, 9, 10, and 13, Table 2). The cultural practices response at Bozeman are more difficult to categorize, but it appears that the responses are similar to those at Kalispell except for treatments 6 and 11.

The effects of combining cultural practices can be seen by evaluating the interactions between various cultural practices. Significant interactions were found between fall residue removal and N application to established stands at each location (Figures 1 and 2). Second year seed yield was increased by combining fall residue removal and applying N to established stands. A significant interaction between N application during the seeding year and N application to established stands indicates that N application in the fall of the seeding year and/or fall N application to established stands were equally ef-

Table 2. Effects of N Application and Residue Removal on Seed Yields of Regar Meadow Bromegrass at Bozeman, MT.

Treatment number	NSY[a]	NES	RR	Seed yield (kg ha^{-1}) 1st	2nd	3rd	3-yr total yield
1	0[b]	0	F	1446	547	12	2005
2	0	F	F	1271	985	104	2360
3	F	0	F	1399	884	22	2305
4	F	F	F	1316	1090	125	2531
5	0	0	0	1117	850	34	2001
6	F	F	0	1420	1020	128	2568
7	0	F	0	1344	775	63	2182
8	F	0	0	1168	630	7	1805
9	F	AH	F	1416	695	82	2193
10	2 wks	F	F	1418	990	138	2546
11	2 wks	S	F	1262	1122	102	2486
12	F	F	AH	1467	592	56	2115
13	F	F	AH + F	1413	889	7	2309
Mean				1343	852	68	2263
LSD (0.05)				161	172	62	198

[a] NSY = Nitrogen application during seeding year, NES = nitrogen application to established stand, RR = residue removal.
[b] 0 = none, F = fall, 2 wks = 2 weeks after seedling emergence, S = spring, AH = after harvest.

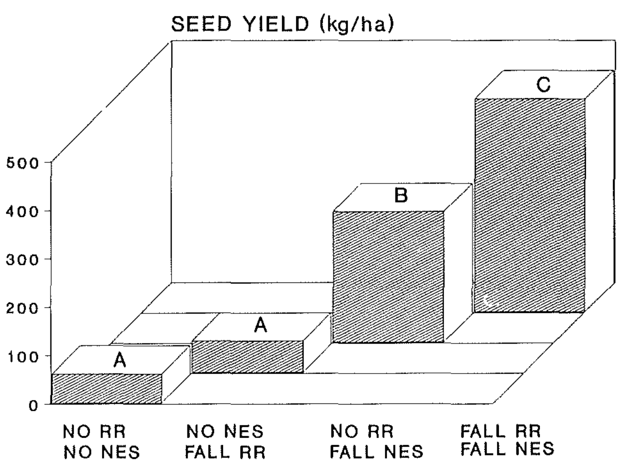

Figure 1. **Second year seed yield of fall residue removal and fall N application to established stands on Regar meadow bromegrass. (Kalispell). RR = residue removal from established stands, NES = nitrogen application to established stands. Means followed by the same letter are not significantly different at the 5% probability level.**

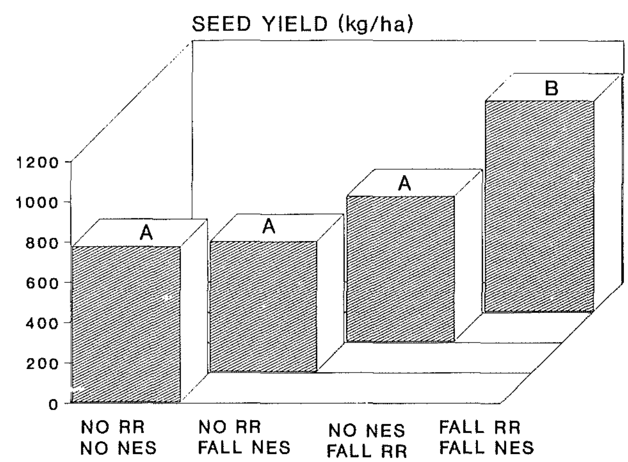

Figure 2. **Second year seed yield of fall residue removal and fall N application to established stands on Regar meadow bromegrass (Bozeman). RR = residue removal from established stands, NES = nitrogen application to established stands. Means followed by the same letter are not significantly different at the 5% probability level.**

fective in increasing second year seed yield at Bozeman (Figure 3).

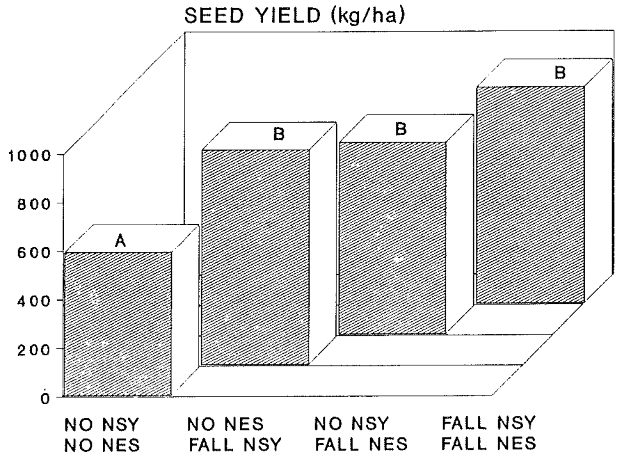

Figure 3. Second year seed yield of N applications during the establishment year and to established stands on Regar meadow bromegrass (Bozeman). NSY = nitrogen seeding year, NES = nitrogen established stand. Means followed by the same letter are not significantly different at the 5% probability level.

The most economical stand life of Regar at each location was two years. Fall N application in addition to fall residue removal, increased first and second year seed yields at Kalispell and second year seed yield at Bozeman.

Green and Evans (1956) reported that grazing between October and April significantly increased the production of fertile tillers in orchardgrass. Studies by Lambert (1963) showed that N application to established stands of timothy resulted in significant increases in number of florets and seed weight per head and per unit area. Therefore, it appears that a higher number of reproductive tillers may be produced in response to fall residue removal from established Regar stands, but seed yields may not be increased without fall N application due to fewer numbers of florets per panicle or reduced seed weight per head. Although the number of florets and seed weight per head may be increased by fall N application to established Regar stands, seed yield may not be increased without residue removal due to the production of fewer reproductive tillers. Regar seed yield increases resulting from fall residue removal in conjunction with N application may be due to increased numbers of florets per panicle, increased seed weight per head and increased fertile tiller numbers.

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