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Grass-legume mixtures improve forage yield, quality, stand persistence

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Cattle farming and hay production are interrelated agricultural practices and the major economic contributors to the state of Wyoming.

According to Wyoming 2015 Agricultural Statistics, the cattle industry contributed 62 percent to the Wyoming agriculture economy with a total cash receipt of $937 million. On the other hand, hay contributed 67 percent of the total cash receipts for all crops in Wyoming, with a total cash receipt of $317 million. Among the different forage species, about 54 percent of the 1,060,000 acres planted for hay production was cultivated with grass, and the remaining was with alfalfa.

Grass hay producers in the state apply a significant amount of nitrogen (N) fertilizers to increase productivity. Chemical fertilizers, however, increase production costs and may degrade the soil and environment if the fertilizers are not applied and managed carefully. Natural fertilizers such as legumes can fix free atmospheric N. Grass-legume mixtures could be a good alternative to reduce production costs and increase yield, quality, and stand persistence of forage crops; however, information is lacking on the optimum seeding mass ratios of grass-legume mixtures in Wyoming conditions.

Based on over three years' study in Wyoming's environments, there is clear evidence grass-legume mixtures have beneficial effects on forage productivity, quality, and stand persistence. There are numerous, unquantifiable environmental benefits as well. The 50-50 percent seeding mass ratio of grass-legume mixture performed very well and provided the following outcomes:

- Produced the highest total forage yield during the study period, which was 37 and 42 percent higher than N applied (134 pounds N per acre) monoculture meadow bromegrass and monoculture alfalfa, respectively.
- Provided the higher quality forage than N fertilized (134 pounds N per acre) monoculture grass.

Photo 1. *Quadrat (20 inches × 20 inches) clipping to estimate the forage dry matter yield from the experiment at the James C. Hageman Sustainable Agriculture Research and Extension Center, Lingle, 2013.*

Photo 2. *Harvesting plots using custom-built research harvester at the James C. Hageman Sustainable Agriculture Research and Extension Center, Lingle, 2014.*

- Produced 20 percent more crude protein (CP) yield than monoculture alfalfa.
- Had also constant alfalfa stand persistence throughout the study period.

Table 1. *Treatment details, seeding rates, and three years' total forage dry matter (DM) yield from different seeding mass ratios of grass-legume mixtures at the James C. Hageman Sustainable Agriculture Research and Extension Center, Lingle, 2012-2014.*

Treatments	Seeding rates	DM yield
(ALF-MB-OG*)	*Pounds per acre*	
100-0-0	20-0-0	20,615
75-25-0	15-5-0	23,777
75-0-25	15-0-1.5	23,644
50-50-0	10-10-0	29,260
50-0-50	10-0-3	25,946
25-75-0	5-15-0	23,991
25-0-75	5-0-4.5	23,193
0-100-0	0-20-0	16,182
0-0-100	0-0-6	14,071
0-50-50	0-10-3	19,258
0-100-0 + N#	0-20-0	21,378
0-0-100 + N	0-0-6	17,926
0-50-50 + N	0-10-3	22,741

**ALF = Alfalfa; MB = Meadow bromegrass; OG = Orchardgrass.*

#N = Nitrogen applied at the rate of 134 pounds per acre as urea.

Experimental Evidence

To obtain field-based information, an experiment was conducted from 2011-2014 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle to identify optimum seeding mass ratios of grass and legume for improved forage yields, quality, and stand persistence. The experiment consisted of 13 treatments with different seeding mass ratios of two grasses ('Fleet' meadow bromegrass and 'Paiute' orchardgrass) and one legume ('WL 319 HQ' alfalfa). The recommended seeding rates of alfalfa, meadow bromegrass and orchardgrass at 20, 20, and 6 pounds pure live seed (PLS refers to amount of live seed in bulk seed and is calculated multiplying seed purity percentage by seed germination percentage) per acre, respectively, were used. The treatments were repeated three times to collect precise information. Grass plots received either no N or 134 pounds N per acre as urea (Table 1). Plots were harvested three to four times each year from 2012 to 2014 (Photos 1 and 2). Forage dry matter (DM) yield was recorded and forage nutritive values were determined using near infrared reflectance spectroscopy (NIRS) at each harvest.

Grass-legume Effect on Forage Production

Variations were observed among the treatments for the total forage DM yield (Table 1). The 50-50 percent seeding mass ratios of meadow bromegrass-alfalfa provided the highest total forage DM yield followed by the 50-50 percent seeding mass ratios of orchardgrass-alfalfa with no N fertilizer application.

Table 2. *Three years' average crude protein (CP), in vitro dry matter digestibility (IVDMD), acid detergent fiber (ADF), and neutral detergent fiber (NDF) of forage from different seeding mass ratios of grass-legume mixtures at the James C. Hageman Sustainable Agriculture Research and Extension Center, Lingle, 2012-2014.*

Treatments	CP	IVDMD	ADF	NDF
(ALF-MB-OG*)	%			
100-0-0	27.6	83.6	22.0	31.1
75-25-0	24.9	81.1	24.8	37.4
75-0-25	25.6	81.6	23.3	35.6
50-50-0	23.4	79.5	26.1	40.0
50-0-50	24.9	79.7	24.8	37.5
25-75-0	22.1	77.7	27.1	42.2
25-0-75	23.9	78.6	25.5	41.1
0-100-0	15.0	72.8	33.4	53.0
0-0-100	16.9	75.4	31.0	47.6
0-50-50	16.1	73.0	31.8	50.7
0-100-0 + N#	17.3	74.8	31.5	50.3
0-0-100 + N	19.2	76.8	28.7	45.2
0-50-50 + N	18.1	75.8	30.3	49.0

**ALF = Alfalfa; MB = Meadow bromegrass; OG = Orchardgrass.*

#N = Nitrogen applied at the rate of 134 pounds per acre as urea.

Application of N fertilizer increased DM yields of monoculture grasses; however, these yields were lower than all seeding mass ratios of grasses and alfalfa. The 50-50 percent seeding mass ratios of meadow bromegrass and alfalfa produced 37 percent more forage yield than N applied (134 pounds N per acre) monoculture meadow bromegrass (29,260 vs. 21,378 pounds per acre), and 42 percent more than monoculture alfalfa (29,260 vs. 20,615 pounds per acre) over the three-year period. The higher yield from grass-legume mixtures than monoculture of either species was due to more efficient utilization of light, water, and nutrients. It was also due to mutual benefits from legume and grass in mixtures – legumes transferred fixed N to grasses and grasses reduced the hindering effect of soil N on biological N fixation by legumes.

Grass-legume Effect on Forage Nutritive Value

Grass-legume mixtures also affected forage nutritive values such as crude protein (CP), in vitro dry matter digestibility (IVDMD), acid detergent fiber (ADF), and neutral detergent fiber (NDF) contents during study period (Table 2).

In general, the CP and IVDMD of forage increased with increasing proportion of alfalfa in the mixtures. On the other hand, the ADF and NDF content of forage decreased with increasing proportion of alfalfa in the mixtures.

The N fertilizer application increased CP and IVDMD of grasses; however, these values were lesser compared to grass-legume seeding ratios containing at least 50 percent legume. Mixing legume with grass at least by 50 percent by seeding ratio also reduced ADF and NDF contents of forage compared to N fertilized monoculture grass. The total CP yield in three years from 50-50 percent seeding ratios of alfalfa and meadow bromegrass was 20 percent higher than monoculture alfalfa (6,847 vs. 5,689 pounds per acre).

Grass-legume Effect on Stand Persistence

Stand persistence of alfalfa in the mixtures was also determined during the three-years of study period. The proportion of alfalfa DM production was measured at each harvest in each year from all mixtures and analyzed for their changing pattern over the study period (data not shown). Among different treatments, the

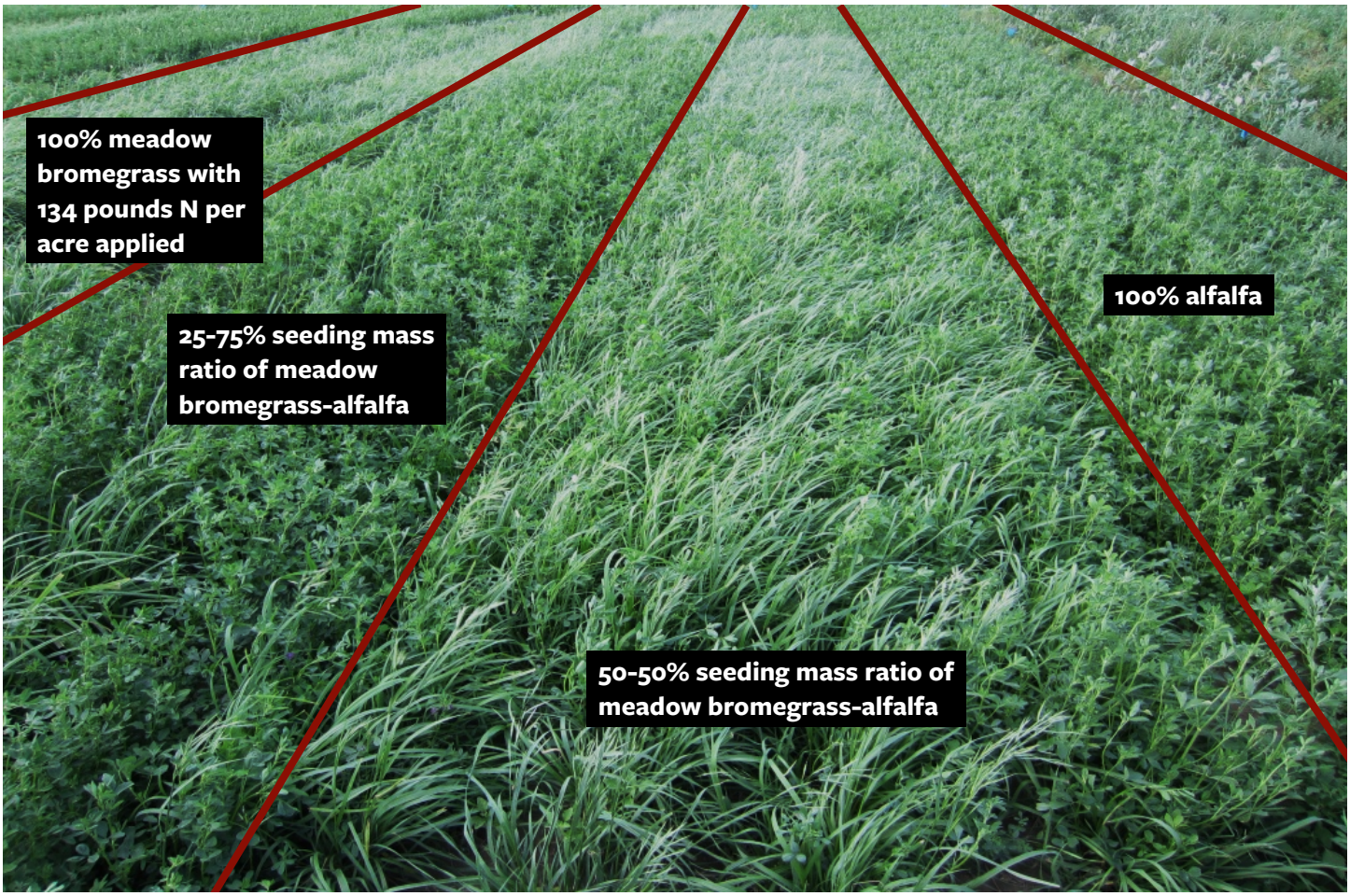

Photo 3. *Plots with different seeding mass ratios of meadow bromegrass-alfalfa at the James C. Hageman Sustainable Agriculture Research and Extension Center, Lingle, 2014.*

highest yielding 50-50 percent grass-legume seeding ratio of alfalfa-meadow bromegrass had constant alfalfa biomass proportion clearly indicating the persistent alfalfa stand during the study period (Photo 3).

Summary

Overall, there is positive impact of legumes on the mixed stands. At least 25 percent legume in the mixed stand can produce higher forage yield and quality than monoculture alfalfa and N fertilized grasses. The 50-50 percent would be an optimum seeding proportion of meadow bromegrass and alfalfa under Wyoming conditions for improved forage yield, forage quality, and stand persistence.

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