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Fertilizer Use on Dryland Perennial Forages

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Introduction

Enhancing forage production per unit area of dryland hay and pastureland is becoming increasingly important for Montana forage producers as the economic value of forage increases and more land is diverted to non-agricultural uses. Forage production per unit area can be increased with fertilizer use, selection of suitable species or varieties and optimizing harvest (haying and grazing) strategies. For most situations, species and variety decisions have been made and remain in place for at least 10 years. Fertilizer use and harvest management decisions are made continuously over the life of the forage stand.

Phosphorus (P) is typically the first limiting essential element in much of Montana for both broadleaf and grass crop species. As organic matter nitrogen (N) is depleted, N becomes the most limiting element. Alfalfa mines significant amounts of potassium (K) from the soil (60 lbs K_2O/ton of alfalfa). However, K is generally quite plentiful in most Montana soils. Traditionally, Montana soils are thought to have few sulfur (S) deficiency problems. However, S can be leached from the root zone in porous soils resulting in crop deficiencies. Sulfur applications have been observed to increase alfalfa yields in central and northwest Montana. Fertilizer use history and soil type affect soil fertility. Previous fertilizer use and manure applications can contribute to a build up in the soil of nutrients such as phosphorus. Localized production information is important to Ag producers in determining their risks and potential benefits from investing in additional production inputs. This study was conducted to gather information on the potential forage yield responses to the application of the four primary fertilizer elements (N, P, K and S) to established dryland alfalfa and alfalfa-grass stands.

Methodology

The plow layer of established stands of alfalfa and alfalfa-grass were sampled and analyzed to find suitable trial sites. Field trials were established near Belt, Geyser, Moccasin, and Moore, Montana, on sites with marginal to low levels of soil P (< 17 ppm) in the soil plow layer (0-6" depth). The Belt, Geyser and Moore sites were about 20-35 percent grass. The Moccasin site was 100% alfalfa. A nutrient elimination method was used to determine the effect of N, P, K, and S fertilizer on forage yields. The control treatment consisted of a composite application of N+P+K+S at rates of 50+100+50+25 lbs/a, respectively. To determine the yield response to an element, that element was removed from the fertilizer blend. A decrease in forage yield when an element is removed from the blend indicates a positive yield response to that fertilizer element in the control blend. Fertilizer treatments were broadcast applied in a randomized complete block experimental design. The sources of each element were N- urea (46-0-0), P – triple super phosphate (0-45-0), K- potassium chloride (0-0-60), and S - pearled or "dissolving" S (0-0-0-90). A single fertilizer application was made and the effects on forage yields were determined for the following three growing season. The Belt site was abandoned after two years due to variable results caused by the variability in the underlying soil.

Results and Discussion

Plow layer soil nitrogen (NO_3-N) levels of the potential study sites ranged from 0.4 ppm to 32.1 ppm (see Table 1). P levels ranged from a very low 5.4 ppm to high of 45.0 ppm. Potassium levels ranged from 174 ppm to 856 ppm. Sulfur levels, SO_4-S, (14 sites only) ranged from 3.1 ppm to 39 ppm and soil pH levels ranged from 5.6 to 8.0. The ranges are shown to demonstrate why very different nutrient responses may be seen within within a relatively small region. Soil analysis of the selected fertilizer study sites are presented in Table 2. The selected sites were within 4-10 miles of the Snowy and Little Belt Mountain foothills on the Judith Basin side.

The complete fertilizer treatment (50+100+50+25 lbs NPKS/a) produced three year total yields of 5.1, 9.2, and 7.4 tons dry matter per acre at Geyser, Moore and Moccasin, respectively. The no fertilizer applied treatment reduced forage yields by 41%, 20% and 26% at the same three locations. Results at the Belt Site were variable due to soil variability, and are not included.

The application of N fertilizer did not have an impact on forage production in any of the trials (Figure 1). The alfalfa was apparently generating a sufficient amount of N for the grass present at the Geyser and Moore sites. The application of N did appear to cause a decrease in forage protein content at all three sites (Figure 2). No explanation was determined for the trend for lower protein with the application of N, although high available nitrogen levels can inhibit bacteria from fixing N in alfalfa nodules, possibly reducing N available to both grasses and alfalfa after the N fertilizer was depleted.

Forage yields were reduced the most, 41%, at the Geyser location when phosphorus was eliminated from the fertilizer blend. The dry matter yields at Moore and Moccasin were reduced only 12% and 10%, respectively, when the P fertilizer was withheld. A significant response was expected at Geyser because the soil P level was 6.2 ppm. The generally cooler growing season temperatures at the Geyser site may have contributed to the size of the yield response to P fertilizer there.

The K fertilizer did not influence forage yields at any of the sites and had a varied impact on crude protein. The K fertilizer tended to enhance protein content at Geyser, reduce protein content at Moore and had no effect on protein at Moccasin. It was hypothesized the Geyser site would show a response to K because it has the coolest growing season temperatures. Soil tests showed K levels were adequate at all three sites.

The Moccasin site showed a yield response to the application of sulfur. Removing S from the fertilizer blend reduced forage protein content at all three locations. It was a surprise that these trials indicated a S deficiency since current studies are finding pearled S (0-0-0-90) is relatively unavailable in the first two growing seasons after application (data not shown).

Summary

Judith Basin lands seeded to dryland alfalfa and alfalfa-grass vary widely in soil organic matter, pH, electrical conductivity, and concentrations of N, P, K, and S. Healthy alfalfa provided sufficient N for the alfalfa-grass mix stands as expected. However, N fixation can be limited by poor seed inoculation or low pH (acid) soils. Phosphorus was the most deficient element. The broadcast P was available to the alfalfa plants and produced statistically significant yield responses when soil P was low. Potassium was not limiting in the study areas and only the Moccasin site exhibited S deficiency. Other on-going studies suggest the pearled form of S is not readily available and thus it is surprising this study showed yield increases with pearled S.

The use of soil testing and plant tissue analysis is encouraged before making fertilizer applications. Fertilizer use guidelines for Montana are available for the use of N, P, and K on alfalfa and grass forages in MT EB 104 (Lichtardt and Jacobsen, 1992). Graham (MT AgResearch Spr. 1984) found plant tissue analysis, including P, to be more reliable than soil analysis for predicting a plant response to fertilizer use.

Fertilizer Facts:

- Forage yields of established dryland alfalfa and alfalfa-grass stands on P deficient soils can be increased with broadcast applications of triple super phosphate fertilizer.
- Healthy dryland alfalfa provides sufficient N for alfalfa-grass stands where the alfalfa is a large enough component of the mixture.

- A single surface application of a high rate of P fertilizer has a multiple year effect on forage yield.

- Increasing perennial forage yields with fertilizer use will not automatically increase forage protein content.

- Sulfur deficiencies can lower the protein content of alfalfa and alfalfa-grass forage.

Table 1. Summary of soil sample results for potential central Montana sites to conduct fertilizer studies on dryland alfalfa and alfalfa grass.

	O.M.	pH	EC	NO_3-N	Olsen P	K	SO_4-S
	%	2:1	mmhos/cm	ppm	ppm	ppm	ppm
High Value	8.9	8.3	1.16	32.1	45	856	17
Low Value	2.2	5.6	0.07	0.4	5.4	174	3.2
Mean	4.0	7.4	0.24	4.0	18.3	376	7.02
Observations	27	27	27	27	27	27	14

Table 2. Soil nutrient analysis of dryland alfalfa and alfalfa-grass fertilizer study sites (0-6" depth).

Study Site	O.M.	pH	EC	NO_3-N	Olsen P	K	SO_4-S
	%	2:1	mmhos/cm	ppm	ppm	ppm	ppm
Geyser	5.47	7.3	0.18	5.47	6.2	277	3.83
Moccasin	3.43	7.7	0.09	4.8	15.8	289	3.43
Moore	4.05	7.2	0.17	19.6	18.7	494	3.21

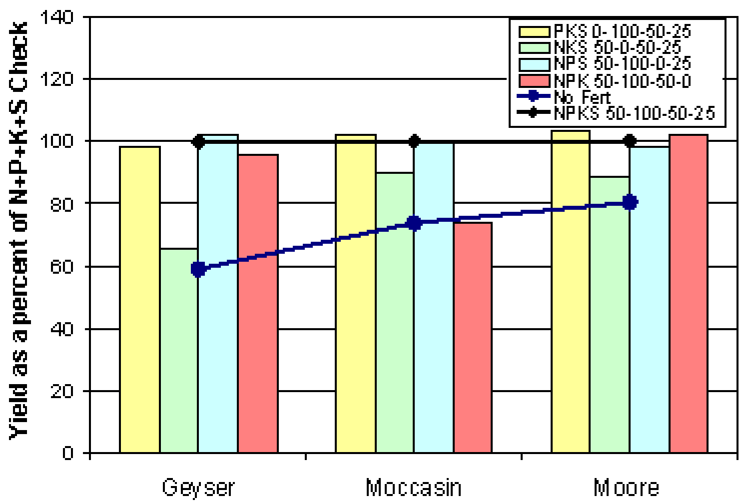

Figure 1. Dryland alfalfa-grass dry matter yield response to N-50lbs, P-100 lbs, K-50 lbs and S-25 lbs/a and yield without each of the fertilizer elements (1994-1996).

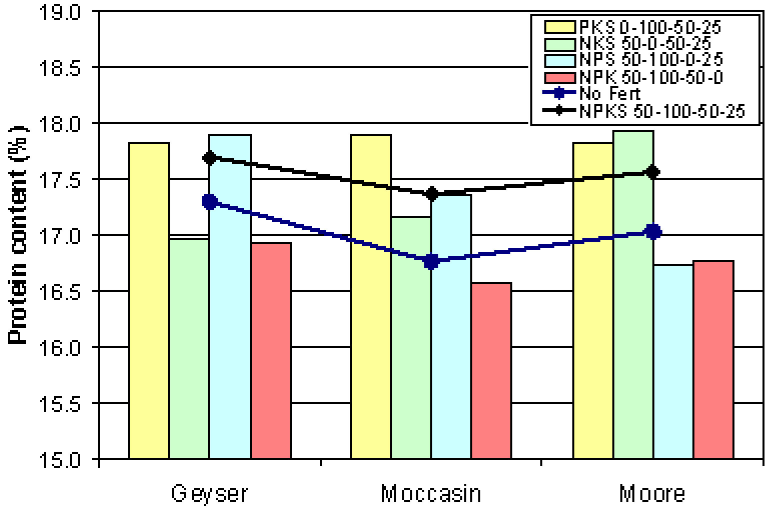

Figure 2. Dryland alfalfa and alfalfa-grass protein content response to broadcast N-50 lbs, P-100 lbs, K-50 lbs and S-25 lbs/a (1994-96).

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