Phosphorus Fertilization of Alfalfa in 2006 to 2008
Dwain W. Meyer and Robert Nudell (posted December 2008)

Productivity of alfalfa may be limited by a nutrient deficiency. Potassium is the nutrient that is most often needed in alfalfa, but in North Dakota, many soils test quite high (300 to 700 lb/acre) in potassium and does not need to be applied to obtain high yields of alfalfa. Phosphorus is typically the most limiting nutrient for alfalfa productivity in North Dakota. The objective of this experiment was to determine the yield loss associated with lack of phosphorus fertilization on a soil testing 2 ppm (4 lb/acre) phosphorus.

Phosphorus treatments (given in Table 1) were applied in the fall of 2005 as ammonium phosphate (11-52-0) to an old stand (4 years) of alfalfa at Buffalo, ND. The plots were laid in the field utilizing a randomized complete-block design with four replicates. Forage was harvested with a flail harvestor at the late bud stage in the first harvest and nearly 80% bloom in the next two harvests since the height of the forage was only 10 to 17 inches. The harvest plot was 38 inches wide by 25 feet. Dry matter samples were taken on each plot and dried at 120°F until dry.

Forage yields for the three harvests and the season in the first year of fertilization are presented in Table 1. Forage yield increased with increasing phosphorus rate up to 60 lb P/acre for the season. Adding sulfur or a foliar micronutrient (Max-In) fertilizer did not affect productivity. Forage yields in 2006 were reduced by inadequate rainfall, almost no rainfall during June and July. Had more normal rainfall occurred, the forage yields would have been much higher, forage yields in 2005 averaged nearly 6 tons/acre on this same site. Therefore, the full potential for phosphorus fertilization was not reached in 2006.

Table 1. Phosphorus fertilization of alfalfa at Buffalo, ND, in 2006, a very dry year during June and July.

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<th>7-10</th>
<th>8-16</th>
<th>Total</th>
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† Treatment included 30 lb/acre S as Zinc sulfate plus Max-In, a micronutrient mixture
§ Treatment included 30 lb/acre S as Zinc sulfate

Forage yield with phosphorus fertility is presented in Table 2 for 2007, the second year of fertilization. Forage yield increased with increasing phosphorus up to 80 lb/acre. Non fertilized plots yielded only 2.23 tons/acre with no fourth harvest while all fertilized plots were harvest four times. Rainfall was adequate in 2007 unlike 2006; therefore, the potential yield advantage from phosphorus fertilization was shown this year. Sulfur fertilization did not affect the forage productivity in 2007 like 2006.
Table 2. Forage yield of alfalfa with phosphorus fertility at Buffalo, ND, in 2007.

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<th>total tons dry matter/acre</th>
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†Treatment included 30 lb/acre S as Zinc sulfate.

Forage quality of alfalfa with varying phosphorus fertilization is presented in Table 3. Forage quality was unaffected by phosphorus fertilization in the first and third harvests. Neutral-detergent fiber, acid-detergent fiber, and acid-detergent lignin were lower and relative feed value and in vitro dry matter digestibility were higher in the non fertilized than phosphorus-fertilized plots in the second harvest probably due to the considerably lower yield. Yet, the lower yield of non-fertilized plots did not increase the forage quality in the first and third harvests. Forage quality of the 40 lb/acre treatment was lower than that of other phosphorus treatments in the fourth harvest.

Forage yield in the third year of phosphorus fertilization of alfalfa is presented in Table 4. Forage yields increased with each level of phosphorus fertilization as in previous years. Forage yields in 2008 were very similar to 2006, again due to limited June and July rainfall. Forage yield in 2008 doubled for 40 lb P/acre. If alfalfa hay sells for $80/ton, the increased forage yield in 2008 generated an additional gross return of $171.20/acre. Assuming that 11-52-0 sells for $650/ton, 40 lb P/acre costs $59/acre or a profit of $112/acre.

Forage yields over the three years of phosphorus fertilization increased with each level of added phosphorus (Table 4). Mean forage yield/year averaged over the three years of this experiment showed the typical law of diminishing returns (Figure 1). Averaged over the years, forage yield was increased 2.23 tons/acre or $119/acre profit. Therefore, phosphorus fertilization was very economical on this low-testing soil even in this high fertilizer cost environment.

![Figure 1. Total forage yield for 3 years with phosphorus fertilization at Buffalo, ND, 2006-2008.](image)
Table 3. Forage quality of alfalfa with phosphorus fertilization at Buffalo, ND, in 2007.

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<th>Phosphorus treatment</th>
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† CP=crude protein; NDF=neutral detergent fiber; ADF=acid-detergent fiber; ADL=acid-detergent lignin; IVDMD=in vitro dry matter digestibility; HEMI=hemicelluloses (NDF-ADF); CELL=cellulose (ADF-ADL); RFV=relative feed value
Table 4. Forage yield of alfalfa with phosphorus fertility at Buffalo, ND, in 2008, the third year of fertilization.

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<th>Phosphorus treatment</th>
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<td>-</td>
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† Treatment includes 30 lb/acre of sulfur as zinc sulfate.