MONTANA

Extending Phosphorus Fertilizer Benefits in Established Alfalfa

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Much of the soil on which alfalfa is planted in the semi-arid and arid regions of the world has relatively high concentrations of calcium carbonate ($CaCO_3$). Concentrations frequently range from a few percent (by weight) to as much as 8 to 10 percent or more. These concentrations are often synonymous with soil pH values greater than 8.0, fine textured soils, and $CaCO_3$-rich irrigation water. The fixation capacity of these soils significantly reduces the effectiveness of limited amounts of P fertilizer incorporated into the soil during seedbed preparation, thereby necessitating frequent annual applications.

In order to better understand the fixation process and the role of P incorporation into existing alfalfa stands, we conducted a 3-year study in southeast Montana. The objective of our investigation was to determine the residual effect or duration of the response of 3 to 5 year old stands of alfalfa to various rates and methods of P application. This study was initiated in September 1991, and continued through October 1994, at three field locations.

Effectiveness of phosphorus (P) fertilizer applications for alfalfa depends on several factors, including initial soil test P level, pH, and soil texture, method and rate of P application, health and vigor of the crop, and subsequent moisture conditions. Numerous studies have reported the effectiveness of surface broadcast applications of P to established alfalfa can be significantly limited on calcareous soils. Phosphorus, when applied to these soils, readily combines with free calcium (Ca) to form insoluble products.

Treatments

Phosphorus was applied in October 1991 (fall treatments) and in March 1992 (spring treatments). We then compared yields over the next three growing seasons. The methods of P application included subsurface banding (knifing at a 3 to 4 in. depth) on 16 in. centers using a modified double-disk drill with fertilizer banding capabilities, surface broadcast application, and surface banding on 8 in. centers. A single rate of 300 lb of P_2O_5/A was used for all P treatments. Control treatments were a single knifing operation without any P fertilizer addition and a check treatment (no P, no stand disturbance). All treatments were replicated three times. Plots were harvested up to three times a year depending on the availability of irrigation water. Fields were harvested for hay (and data collected) when irrigation water was available to produce reasonable growth. When water was not available, usually toward mid- to late-season, the fields were managed as pasture (no data collected). Hay was harvested nine times over 3 years at the Griffin Ranch, two times over 2 years at the Jurica Ranch and four times over 3 years at the Gay Ranch. Soil characteristics are presented in **Table 1**.

Results

Table 2 contains a summary of the yield response (tons/A/harvest) to P over a 3-year period. We concluded that at all three sites, response to P additions was significant relative to the check treatment. Disturbing the soil by knifing the alfalfa stand without addition of P caused a slight decrease in yield at the Gay site and increases at the other two sites. Addition of P during the knifing operation more than compensated for yield reductions due to knifing at the Gay site. Differences between time of application (fall vs. spring) and among methods of application were generally small and inconsistent across sites. This may be due in part to the relatively high rate of P fertilizer used. Under the conditions of this research, surface application appears to be most economical due to the lower cost of application compared to knifing P into the soil.

TABLE 1. Soil characteristics at 3 study sites.

Location and soil depth, inches	pH	Available P, ppm[1]	Free lime, %	Soil texture
Griffin Ranch				
0-3	8.3	9.2	2.4	Coarse-loamy, mixed, fine sandy loam
3-6	8.3	3.0		
6-12	8.4	2.4		
Jurica Ranch				
0-3	8.3	11.5	3.6	Fine-loamy, mixed loam
3-6	8.3	3.2		
6-12	8.5	5.6		
Gay Ranch				
0-3	8.1	2.9	6.1	Fine, montmorillonitic silty clay
3-6	8.4	2.1		
6-12	8.4	1.0		

Available P was determined by Olsen's bicarbonate test.
Percent free lime determined for 0-6 inch depth. [1]ppm = parts per million

TABLE 2. Summary of alfalfa yields following three different methods of P application at 300 lb/A of P_2O_5.

Treatment	Griffin Ranch	Jurica Ranch	Gay Ranch	Average
	Avg. yield per harvest, t/A (12% moisture)			
Check	2.17	1.24	1.73	1.93
Fall application				
Knife (no P)	2.30	1.43	1.63	2.00
Knife	2.50	1.65	1.76	2.19
Surface band	2.49	1.57	1.95	2.23
Topdress	2.40	1.69	1.89	2.17
Spring application				
Knife (no P)	2.21	1.53	1.65	1.97
Knife	2.42	1.58	1.85	2.15
Surface band	2.36	1.50	2.05	2.16
Topdress	2.38	1.59	1.89	2.14
LSD (0.05)	0.12	0.09	0.09	0.09

Over the 3-year period, the total yield response across P treatments to 300 lb/A of P_2O_5 was 2.1, 0.7 and 0.9 tons/A for the Griffin, Jurica and Gay sites, respectively, on total yields up to 22.5, 3.3 and 8.2 tons/A (data not shown). These are relatively small responses that reflect lack of available water for hay production at the latter two sites. The yield increase necessary to pay the cost of the P fertilizer is about 0.8 tons/A (@$90/ton of hay and 25 cents/lb of P_2O_5). This does not factor in the cost of application or the additional pasture that may have been produced. Although responses at the Jurica and Gay Ranches are at about the breakeven point, hay responses in the third year were similar to the first 2 years, suggesting that there is sufficient residual P for continued yield responses in future years. BC

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