Alfalfa Yield Response to Method and Rate of Applied Phosphorus

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Alfalfa is an important forage legume crop in Oklahoma. It is preferred over other forage legumes due to its high yield potential, protein content, and palatability. The nitrogen (N) fixing capability of alfalfa decreases the need for N fertilizer, but places a higher demand on the soil for P and potassium (K). Phosphorus and K make up 0.2 to 0.5 percent and 1.0 to 2.0 percent of alfalfa forage, respectively. This implies that a field that produces 5 tons/A of alfalfa removes 20 to 50 lb P/A and 100 to 200 lb K/A annually from the soil which must be replenished from fertilization or soil mineral weathering. Typically, producers supply P annually to meet the needs of the crop and recharge depleted P pools. This research was conducted to evaluate the effect of high rates and banding of fertilizer P on alfalfa yield.

Alfalfa response to a high rate of phosphorus (P) application was studied in a high yield environment.

An experiment was initiated in 1992 with treatments designed so that a total of 600 lb P_2O_5/A was applied over a six-year period. Fertilizer P was applied as diammonium phosphate (DAP, 18-46-0) broadcast (incorporated at planting) annually (100 lb P_2O_5/A/yr), biennially (200 lb P_2O_5/A/2-yr), and as a single fertilizer event (600 lb P_2O_5/A first year only); ammonium polyphosphate (APP, 10-34-0) knifed 6 inches below the surface on 20 inch spacing biennially (200 lb P_2O_5/A/2-yr) and as a single event (600 lb P_2O_5/A first year only). Two additional treatments were added to evaluate the effect of 500 lb K_2O/A/yr and 50 lb sulfur (S)/A/yr, each applied in conjunction with 200 lb P_2O_5/A/2-yr broadcast. The K treatment was included to identify when blanket applications should be made in order to eliminate or minimize available K as a yield limiting variable. Accordingly, the entire test site received blanket applications of 500 lb K_2O/A at establishment and in years three and five. Forage was

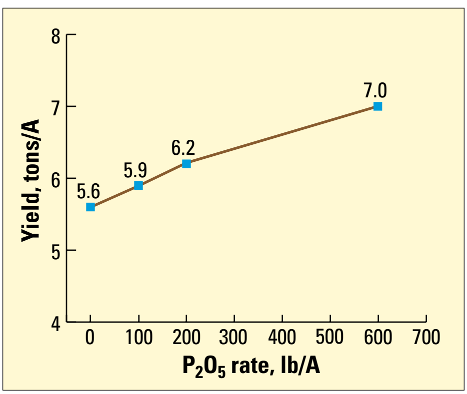

Figure 1. Alfalfa yield response in year one (1993) to DAP fertilization.

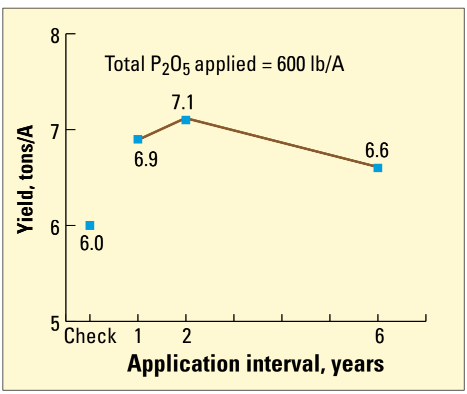

Figure 2. Alfalfa yield response in year six (1998) to DAP fertilization.

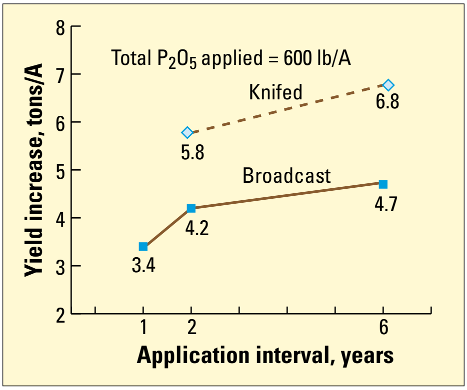

Figure 3. Total alfalfa yield increases from P fertilization (treatment minus check) after six years.

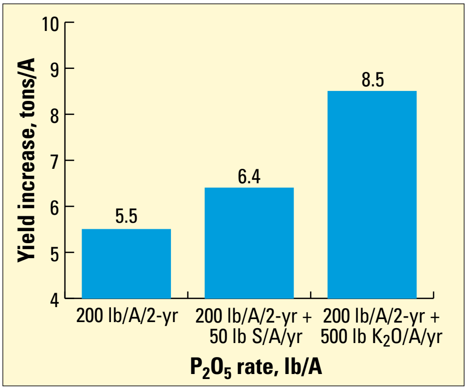

Figure 4. Total alfalfa yield increases (treatment minus check) from P, K, and S fertilization after six years.

usually harvested five times during the growing season (four times in 1997 and 1998) when 10 percent of the crop was flowering.

Alfalfa response to DAP fertilizer the first year showed a linear increase in yield with increasing P across the range of rates in the study (**Figure 1**). In 1998, the final year of the trial, yield response to the initial 600 lb P_2O_5/A treatment had decreased while plots that had received annual and biennial P fertilization still showed marked increases in yields above the check (**Figure 2**). Despite the drop in yield response late in the experiment to the 600 lb P_2O_5/A/6-yr, this treatment still yielded the highest of all DAP broadcast treatments over the six years of the experiment (**Figure 3**). Additionally, subsurface banding of APP stabilized alfalfa yields over the length of the trial, resulting in the highest yield over the six years of all P-only treatments (**Figure 3**).

These responses support the theory that banding of P increases availability by placing the nutrient in closer proximity to plant roots and minimizing soil-fertilizer reactions, maintaining availability for a longer period of time. Supplying a large amount (600 lb/A) of incorporated P at alfalfa establishment in a high yielding environment (e.g. irrigated) provides maximum response because plant density is high. As the stand ages and plant density decreases, availability of fertilizer P is lessened by reactions with soil, removal by crop uptake the first two years, and poorer extraction by a less dense root system. Smaller rates applied more frequently are better able to

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TABLE 1. Initial soil test of the entire experimental area.

NO_3-N	P	K	pH
....	lb/A	....	
27.2	30.2	326	6.6

NO_3-N – 2M KCl extractant; P, K – Mehlich III; pH – 1:1 soil-water

TABLE 2. Soil test of selected treatments after six years.

Treatment	NO_3-N	P	K	pH
	....	lb/A	....	
Check	7.0	15.5	717	7.2
100 lb P_2O_5/A/yr	4.6	77.4	679	6.9
200 lb P_2O_5/A/2-yr	5.5	77.6	738	6.9
600 lb P_2O_5/A/6-yr	6.2	41	708	7.0
200 lb P_2O_5/A/2-yr (knifed)	5.8	78.3	693	6.8
600 lb P_2O_5/A/6-yr (knifed)	5.8	25.6	679	7.0
200 lb P_2O_5/A/2-yr + 500 lb K_2O/A/yr	5.6	59.8	1,135	6.5
200 lb P_2O_5/A/2-yr + 50 lb S/A/yr	5.3	69.3	648	7.1

NO_3-N – 2M KCl extractant; P, K – Mehlich III; pH – 1:1 soil-water plains. Loads and yields of nutrients and pesticides in runoff were minute in relation to nutrients and pesticides applied to cotton, sorghum, and corn crops. Nitrogen and P in runoff are comprised primarily of particulate organic N and particulate P from crop residues, whereas N and P applied to crops are NH_3 and NO_3-N and soluble orthophosphate.

Croplands serve as a sink for both N and P deposition in rainfall. Over five times more N in the form of NH_3 and NO_3 was deposited in rainfall than exited the watershed, primarily as particulate organic N and NO_3 in runoff. Twice as much P was deposited in rainfall than exited the watershed in runoff.

Changes in tillage practices, crop rotations, row spacings (e.g., ultra-narrow row plantings), plant populations, and amount of crop residue left in the soil have different implications for water quality in runoff since loads and yields of particulate organic N and particulate P may vary with cultural practices. However, results from this study and a companion study for southern Nueces and northern Kleberg counties indicate that with current production practices, crop agriculture poses little risk to the coastal environment in this area. BC

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sustain a P-rich environment that supports higher yields in the sixth year.

Potassium fertilizer also resulted in increased yields over the length of the experiment. The 200 lb P_2O_5/A/2-yr rate in conjunction with 500 lb K_2O/A/yr rate yielded the highest of all treatments over the six years (**Figure 4**). This response was somewhat surprising since the initial soil test of 326 lb/A was near the calibrated adequate level (K>350 lb/A), and the comparison treatment received 1,500 lb K_2O over the six-year period. Apparently, alfalfa responds to higher levels of available soil K in a high yielding environment. This statistically significant response of about 3 tons/A (value about $240) was from an input of an additional 1,500 lb K_2O (cost about $165) and would merit economic consideration. It is possible that lower annual rates (e.g. 250 to 300 lb K_2O/A) might have also supported this maximum yield and that the yield difference would have been even larger compared to a no-K treatment, not included in our study. Sulfur fertilization only slightly affected yield over the six years of the trial period.

Initial soil test levels are reported in **Table 1**. Final P soil test levels in the 600 lb P_2O_5/A initial treatment plots (both broadcast and injected) were significantly lower than treatments receiving annual and biennial P applications (**Table 2**). Soil test-P was significantly lower in the unfertilized check than for all other treatments. As expected, the treatment receiving 500 lb K_2O/A/yr had the highest K soil test value, while other plots which received only the initial and two subsequent 500 lb K_2O/A blanket treatments still had higher than what is commonly considered adequate levels of K in the soil (**Table 2**).

The response of alfalfa to high dose P fertilization has important economic implications. If a producer is able to maximize yields over a six-year period by supplying the fertilizer as a single event, additional profit may be realized because the implement and labor costs are decreased due to fewer fertilizer applications. It is important to note these yield responses of alfalfa to P and K fertilization may be unique to high yielding environments (e.g. irrigated areas). BC

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