FERTILIZING ALFALFA FOR PROFIT

Monroe Rasnake and Steve Isaacs
University of Kentucky

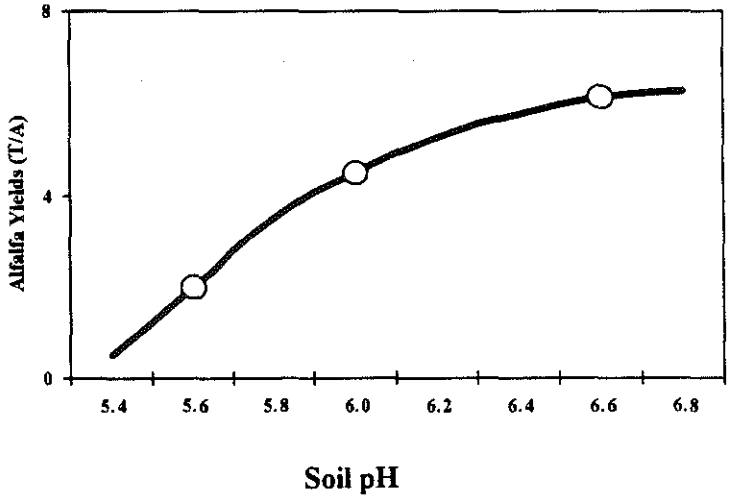
Alfalfa has the potential for producing high yields of high quality forage with good management. A key component of good management is supplying plant nutrients in adequate quantities and proper balance. In Kentucky, this requires fertilizing soils with agricultural limestone, commercial fertilizers and/or animal manures. Good soil fertility is necessary for alfalfa stand establishment, high yields and long stand life.

The establishment cost for alfalfa is high - about $250-300 per acre. Lime and fertilizer account for about $75 of this. While this cost is significant, it is small compared with the loss of a years production and the expense of reseeding. Success depends on establishing a thick, uniform stand of well-nodulated alfalfa plants. The proper pH and good soil phosphorus availability are two primary factors in getting this done.

High yields of alfalfa require large amounts of nutrients. For example, a six-ton yield of alfalfa hay removes 315 lbs nitrogen, 84 lbs phosphate, 302 lbs potash, 147 lbs calcium and 25 lbs of magnesium. The nitrogen needed is normally acquired through nitrogen fixation by bacteria living in nodules on alfalfa roots. Calcium, and usually magnesium, are supplied by lime that is used to increase soil pH to the desired level. Phosphate and potash must be replaced in soil by applying fertilizer, manure or other nutrient sources. This amounts to a cost of about $11.00 per ton of alfalfa.

Actual yield responses to lime and fertilizers usually only occur at low soil fertility levels. An example is shown in the following graph. Yields increased the most (2t/a) from pH 5.6 to pH 6.0. The increase from pH 6.0 to 6.6 was about 1.6 t/a. It is unlikely that yields would increase at pH's above 6.6. The pH on most Kentucky soils can be maintained at 6.6 or above

Figure 1. Alfalfa Response to Liming



using an average of one ton of lime per acre, ie. three tons every three years. This would add about two dollars per ton for a six-ton yield of alfalfa.

The effect of applying phosphorus to alfalfa is illustrated in Tables 1 & 2.

Table 1. Effect of phosphorus fertilizer rate on alfalfa yields.

P_2O_5 (lbs/a)	Alfalfa Yield (T/A)
0	6.4
40	7.5
80	8.0
120	8.3

Table 2. Effect of Phosphorus fertilizer rates on alfalfa.

P_2O_5 (lbs/a) Annually	Alfalfa Yields (T/A)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
0	8.1	7.7	7.4	7.1	9.1	8.2	48
40	9.3	9.3	8.9	8.5	10.6	9.7	56
80	9.3	9.7	9.5	8.8	11.4	10.4	59
120	9.6	10.6	10.0	9.5	12.1	11.4	63

These studies were done in Kansas on high fertility soils. However; with the high yields, there was still a two plus tons per acre yield increase per year with 120 pounds of phosphate fertilizer per year. Actually, this is just about equal to the amount of phosphate removed by the ten tons per acre average yield for the treatment. It is also relatively inexpensive at a cost of just over three dollars per ton of hay produced.

At the other extreme is the zero phosphorus treatment in which phosphorus is being "mined" from the soil. Over the six-year study, from 576 to 720 pounds of phosphate per acre were removed from the soil. Eventually, this will need to be replaced in order to maintain good production. The overall result is a loss of over two tons of hay per acre per year and the need for a large investment in fertilizer in the future.

One of the most definitive studies done on the response of alfalfa to phosphate and potash fertilization in Kentucky was done by Vaught, et.al. on a deep limestone soil in Warren County. The phosphate yield responses are shown in Table 3. Over the six years of this study, there were no significant yield increases to phosphate fertilization. However, large amounts of phosphate were removed in the alfalfa hay - from 385 pounds/a for the unfertilized plots to 508

pounds/a for the high phosphate treated plots. This resulted in the decrease in soil test phosphorus in the unfertilized plots from 55 pounds P per acre at the start to 21 pounds P per acre after six years. Again, this indicates that eventually phosphorus will have to be added to maintain productivity of the soil.

Table 3. Effects of Phosphate rates on alfalfa hay yields (T/A).

Phosphate (lbs P_2O_5/A/Yr)	Year						
	1	2	3	4	5	6	Total
0	5.5	6.7	5.0	6.5	6.1	5.1	34.2
90	5.7	7.2	5.6	7.4	6.7	4.9	37.5
135	5.8	6.7	5.4	6.6	6.6	4.8	31.7
180	5.8	7.2	5.3	6.3	6.3	4.6	36.5

The 90 lbs P_2O_5 per acre treatment came close to showing a significant yield increase. It also more than replaced the phosphorus removed in the alfalfa hay (540 lbs/a added vs. 495 lbs/a removed) and resulted in an increase in soil test phosphorus from 55 lbs/a to 97 lbs/a. The cost of phosphate fertilizer for this treatment at today's prices amounted to about four dollars per ton of alfalfa hay.

Potassium fertilizer rates were also compared in this study (Table 4). As with the phosphate results, there were very few significant yield increases due to the addition of potash fertilizer on this soil. Potash removal in the hay crop ranged from a total of 1900 pounds where no fertilizer potash was added to almost 2300 lbs/a with the 200 lbs/a potash treatment. All the potash removed in the unfertilized plots came from "mining" the soil and resulted in a decrease in soil test K from 240 lbs/a at the start to 145 lbs/a after six years. The 150 lbs potash/a

Table 4. Effect of Potash rates on alfalfa hay yields (T/A).

Potash (lbs K_2O/A/Yr)	Year						
	1	2	3	4	5	6	Total
0	6.1	7.2	5.3	6.7	6.4	4.8	36.5
100	5.8	7.5	5.8	7.0	6.9	5.2	38.2
150	5.6	7.5	5.6	7.6	6.9	5.9	39.1
200	5.9	7.3	5.2	6.7	6.8	5.1	37.0

rate was needed to maintain soil test K levels. This rate of potassium fertilization added $3.23/T to the cost of producing alfalfa hay at today's prices. If it had been necessary to replace all the potash removed in the hay, the cost would have

been $8.73 per ton. In this case, the soil was able to supply $34.32 worth of potash per acre per year.

A study conducted in Wisconsin (Smith, 1975) on a low soil test K soil (K = 127 lbs/a) did show alfalfa hay yield increases when potash was added (Table 5).

Table 5. Effect of Potassium topdressing on alfalfa yields (3-yr. average T/A).

Potash (lbs/a)*	3 cuts	4 cuts
0	3.0	2.9
56	3.6	3.5
112	3.8	3.7
224	4.0	4.0
448	4.3	4.2
672	4.5	4.3
896	4.4	4.2
1120	4.3	4.2

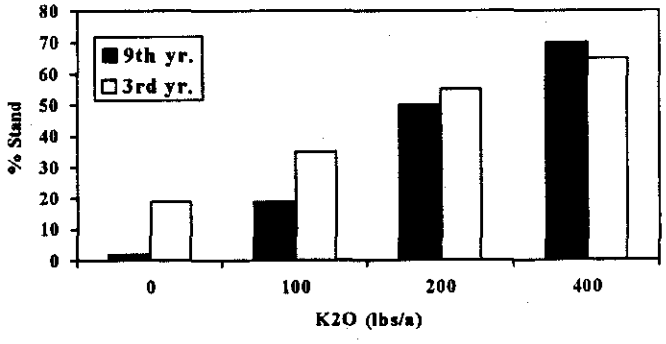
*applied twice

Maximum yields were obtained with the 672 lbs/ac rate of potash topdressing. With this treatment, a total of 1344 pounds of potash was applied per acre. Alfalfa hay removed about 675 pounds, or roughly half the potash applied. As a result, soil test potassium levels would be expected to increase. At the 224 pound rate of potassium topdressing; a total of 448 pounds were added and 600 pounds were removed in the hay. In this study, about 200 pounds of potash per acre per year was needed to just replace that removed in the hay. This would result in a cost of almost seven dollars per ton of hay for potash topdressing.

It is interesting to compare the costs of production for the maximum yields at the 672 lbs/ac rate with those at the 224 lb/ac rate of potash. The cost of potash at the high rate was $62.72 per acre compared with $20.91 per acre at the lower rate. The extra half ton of alfalfa produced cost $41.81 in potash fertilizer alone. This would certainly not be economical in the long run.

Good fertility is also necessary for long stand life of alfalfa. The data in figure 2 shows the effect of potash fertilizer rates on alfalfa stand life. After three years, less than a 20 percent stand remained where no potash fertilizer was applied. At least 200

Figure 2. Effect of Potash Fertilization on Persistence of Alfalfa



pounds of potash per acre per year was needed to maintain a 50 percent stand or better. Almost a 70 percent stand remained after nine years when 400 pounds of potash per acre was applied annually. A six ton annual yield of alfalfa hay would remove at least 75 percent of the added potash (300 pounds/a/yr) with the remainder adding to the soils potash level. At this rate, potash topdressing would add $7.50 per ton to the cost of producing alfalfa hay.

Good fertility is required for alfalfa in order to establish the stand; produce high yields and maintain the stand. All of these are necessary for making a profit with alfalfa.

REFERENCES

Armstrong, D.L., ed. 1999. Yield and Economic Responses to Phosphorus. Better Crops With Plant Food. V-83, pp 8-10.

Lanyon, L.E. and W.K. Griffith. 1988. Nutrition and Fertilizer Use. Alfalfa and Alfalfa Improvement, A.A. Hansen, D.K. Barnes and R.R. Hill, Jr., eds. ASA Monograph No. 29.

Nelson, W.L. 1980. Potassium for Agriculture. Potash & Phosphate Institute. 216 pp.

Sheaffer, C.C., M.P. Russelle, O.B. Hesterman and R.E. Stucker. 1986. Alfalfa Responses to Potassium, Irrigation and Harvest Management. Agron. J. 78:464-468.

Smith, D. 1975. Effect of Potassium Topdressing a Low Fertility Silt Loam Soil on Alfalfa Herbage Yields and Composition and on Soil K Values. Agron. J. 67:60-64.

Vaught, H.C., K.L. Wells and K.L. Driskill. 1977. Alfalfa Response to Varying Rates of Phosphorus and Potassium Fertilization on Deep, Red, Limestone Derived Soils of the Pennyroyal Area in Kentucky. UK College of Agriculture. Agronomy Notes. V-10, No. 6.

Wells, K.L. and W. Thom. 1994. Estimating Nutrient Content and Uptake by Kentucky Crops. UK College of Agriculture. Soil Science News & Views. V-15, No. 4.