# FERTILIZING ALFALFA FOR OPTIMUM PRODUCTION

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Alfalfa is a high producing crop. Therefore, it only makes sense not to limit its production or longevity by establishing it on unsuitable soil and by the use of unsound fertility practices. It is the aim of this paper to propose practices which will not limit the production of alfalfa, but, also allow it to be done as efficiently as possible with only the necessary inputs.

The beginning of any good fertility program always starts with a good soil sample. For this, there is no substitute.

The next important step in a good fertility program is a proper pH. A pH of 6.5-7.0 gives an optimum range for activity of nitrogen-fixing bacteria and assures optimum availability of plant nutrients in the soil. Having the pH properly adjusted is especially important for stand establishment and for long-term maintenance of the stand. If the pH is below 6.0, there may be toxic amounts of aluminum and manganese that can interfere with alfalfa root growth. If the pH is not at least 6.2 then molybdenum may be limiting. As the pH goes down, the amount of molybdenum available to the plant is reduced. Molybdenum is very important in production of nitrogen by nitrogen-fixing bacteria on the roots of the alfalfa plant. If the pH is below 6.2 at seeding and the recommended lime was not applied 4-6 months before seeding, then apply one pound of sodium molybdate (6.4 oz. of molybdenum) per acre. With established stands at a pH below 6.2, broadcast (30-40 gal./A of spray) the molybdenum in late winter or early spring before new shoots reach 2 inches in height. This is necessary to avoid reaching molybdenum toxicity in the harvest product for the consuming livestock.

All legumes, including alfalfa, are especially responsive to phosphorus, therefore available phosphorus levels in the soil should be built to the high level and maintained there for prolonged high production. Responses to potassium is more dependent on soil type. Responses to potassium have been found consistently on Maury and Tilsit soils, but are not as dependable on soils like Pembroke and Eden. Soil testing will help in this respect.

Seasonal removal of phosphate ($P_2O_5$) and potash ($K_2O$) from the soil by a high yielding crop (5-6 tons hay/ac) is on the order of 75-90 pounds $P_2O_5$ and 250-300 pounds of $K_2O$ per acre. This is why it is so important to maintain a high level of these nutrients in the soil. There are basically two approaches which can be taken to provide these high fertility needs in the soil. One way is to rapidly raise soil test to the high level by a large application of phosphate and potash, then maintaining it there with lower annual topdressing rates made largely to compensate for plant removal.

The other approach would be to fertilize each year on the basis of existing soil test levels. This program would probably make more efficient use of the added fertilizer than the first approach. The U. K. College of Agriculture fertilizer recommendations use the second approach and are as follows:

Table 1. Phosphate and Potash (Higher rates will be necessary to get immediate build-up of soil test levels.)

| | New Seedings | | Established Stands* | |
|---|---|---|---|---|
| | lbs/a | | lbs/a | |
| Soil Test Level | $P_2O_5$ | $K_2O$ | $P_2O_5$ | $K_2O$ |
| High (over 60P, 250K) | 0 | 0 | 0 | 0 |
| Medium (60-30P, 250-165K) | 0-100 | 0-100 | 0-100 | 0-100 |
| Low (less than 30P, 165K) | 100-160 | 100-160 | 60-120 | 160-240 |

*For yield goals over 4 T/A, increase $P_2O_5$ by 30 lbs/a and $K_2O$ by 60 lbs/a.

There is always the question of when to put the fertilizer on and if it should be split.

Research indicates that there may be a small advantage to placing all or part of the fertilizer on in the fall. It is preferred that the fertilizer be applied about one month before the expected freeze-down for winter dormancy. The small increase in production seems to occur whether all the P and K is applied in the fall or only 50% of it. These increases due to time of fertilizer application are small and the overriding factor is that the recommended fertilizer is applied.

The average removal for a ton of alfalfa hay is about 14 lbs/a of $P_2O_5$ and 50 lbs/a of $K_2O$. However, the additions of these "maintenance" amounts of fertilizer may not stabilize the soil test. This is due to the complex nature of soils. Therefore, soil test themselves become the overriding factor in the fertility program.

Table 2 is from work done by Wells, Vaught and Driskill in Warren County. As you can see, the soil tests stabilized at a high level when fertilizer application rates were below the nutrient removal rate. It will depend a lot on the soil. The opposite situation may exist with some soils. Consequently, fertilizing by soil test is more accurate than using maintenance fertilizer based on the amount of hay removed from the field.

Table 2. Effect of applied and removed $P_2O_5$ and $K_2O$ on soil tests before and after 6-years of alfalfa production on a Pembroke soil.

| $P_2O_5$/yr. Applied | $P_2O_5$/yr. Removed | Soil Tests: Before Study March 1970 | Soil Tests: After Study March 1976 | Avg. Hay Yield |
|---|---|---|---|---|
| lbs/ac | | | | T/A/yr. |
| 0 | 64 | 55 | 21 | 5.65 |
| 90 | 82 | 55 | 97 | 6.23 |
| 135 | 82 | 55 | 145 | 5.98 |
| 180 | 85 | 55 | 155 | 6.05 |
| **$K_2O$/yr. Applied** | **$K_2O$/yr. Removed** | **Before Study March 1970** | **After Study March 1976** | **Avg. Hay Yield** |
| lbs/ac | | | | T/A/yr. |
| 0 | 318 | 240 | 145 | 6.07 |
| 100 | 368 | 240 | 195 | 6.33 |
| 150 | 379 | 240 | 260 | 6.48 |
| 200 | 382 | 240 | 363 | 6.13 |

Boron availability is often a limiting nutrient for alfalfa production, and alfalfa should receive 1.5-2.0 pounds of elemental boron (B) per acre per year. There is no universal response to boron in Kentucky but it is cheap insurance.

Fertilizing 10 ton/A Alfalfa

In 1981 an experiment was established by Garry Lacefield, Bill Talley and Lloyd Murdock in an attempt to produce 10 ton/A of alfalfa. A concerted attempt was made to optimize all controllable variables. Fertility was one of the variables which was adjusted to determine optimum rates. Table 3 shows the effect of different rates of P and K on yield. The medium rates (210 lb/A $P_2O_5$ and 360 lb/A $K_2O$) were those recommended for 10 T/A alfalfa by AGR 1. These rates are doubled in different combinations to see if it would effect yield.

Table 3. Effect of Fertility and Irrigation on High Yield Alfalfa.

| Fertility $P_2O_5$ | Fertility $K_2O$ | Irrigation | Yield (12% hay) 1982 | 1983 | 1984 | Avg. |
|---|---|---|---|---|---|---|
| ---lb/ac--- | | | ------ tons/ac ------- | | | |
| 0 | 0 | + | 8.3 | 5.5 | 4.9 | 6.2 |
| 210* | 360* | + | 9.5 | 7.7 | 6.7 | 8.0 |
| 210 | 720 | + | 9.9 | 8.0 | 7.1 | 8.3 |
| 420 | 360 | + | 9.7 | 7.8 | 7.1 | 8.2 |
| 420 | 720 | + | 10.1 | 8.3 | 7.4 | 8.6 |
| 0 | 0 | - | 8.2 | 4.1 | 5.4 | 5.9 |
| 210 | 360 | - | 9.8 | 6.6 | 7.6 | 8.0 |
| 210 | 720 | - | 10.1 | 6.7 | 7.6 | 8.1 |
| 420 | 360 | - | 9.7 | 6.4 | 7.4 | 7.8 |
| 420 | 720 | - | 9.9 | 6.8 | 7.8 | 8.2 |

*As recommended by AGR 1 for 10 ton/A alfalfa.

The plots that received no fertilizer produced lower yields than those receiving fertilizer and the yields were much less after the first year. The different levels of added phosphorus and potassium had little effect on yield. This indicates that the lowest rate was sufficient for maximum economic yield. There was a trend in the irrigated plots for the extra fertilizer to increase yields, but it certainly was not an economical trend.

With an average production of about 9 T/A for 1982 and 1983, the expected removal would be 135 and 450 lb/A of $P_2O_5$ and $K_2O$, respectively.

The 210 lb/A rate of $P_2O_5$ is more than is needed for maintenance and is reflected in the soil tests in Table 4. The soil tests climbed rapidly with the rates of $P_2O_5$ added in this experiment. Even when no $P_2O_5$ was added, the P soil tests did not decrease. This could be partially due to a change in soil sampling depth and soil testing laboratories that occurred during the course of the experiment. The rapid rise in P soil test with the 210 lb/A rate of $P_2O_5$, indicated that the $P_2O_5$ recommendations are excessive when fertilizing for very high yield levels. The rates should be lowered to only a maintenance level once the soil tests move into the high range.

Table 4. Effect of Fertility Application and High Alfalfa Yields on Soil Tests.

| Application $P_2O_5$ (lb/A) | | P Soil Test (lb/A) | | |
|---|---|---|---|---|
| 1981 | 1982-83 | 1981* | 1982** | 1983** |
| 0 | 0 | 45 | 54 | 77 |
| 75 | 210 | | 108 | 166 |
| 150 | 420 | | 161 | 200+ |
| $K_2O$ (lb/A) | | K Soil Test (lb/A) | | |
| 0 | 0 | 293 | 165 | 174 |
| 120 | 360 | | 256 | 250 |
| 240 | 720 | | 388 | 475 |

* - 0-7 inch soil sample depth and analyzed in UK lab Lexington.
** - 0-4 inch soil sample depth and analyzed in UK lab Princeton.

The plots that received the recommended rate of $K_2O$ (360 lb/A) maintained their soil test level in the high range even though the added $K_2O$ was below maintenance levels. The soil tests at the highest level of added $K_2O$ was increasing rapidly while the soil tests were dropping at the zero level. Plant analysis indicates that reduced potassium plant uptake was probably responsible for the reduced yields in the unfertilized plots.

The experiment indicates that high alfalfa yields can be achieved under Kentucky conditions and that the present phosphorus and potassium recommendations are adequate for these yield levels. However, the recommendations may need adjustment based on yearly soil tests.

## Nitrogen at Establishment

As a part of the same experiment, different nitrogen levels were added at establishment to determine its effect on alfalfa yields. The results are shown in Table 5. The nitrogen had no positive effect on yield. In fact, there was a trend for it to result in decreased yields. There was an increase in early vigor of the alfalfa seedlings that did receive nitrogen. There was also a large increase in the vigor of grassy weeds, which was probably responsible for the subsequent decrease in alfalfa yield.

Table 5. Effect of nitrogen at establishment on yield of Classic Alfalfa.

| N | Yield (12% hay) | | |
|---|---|---|---|
| | 1982 | 1983 | Avg. |
| lb/ac | -------- tons/ac -------- | | |
| 0 | 9.5 | 7.3 | 8.4 |
| 30 | 9.1 | 7.4 | 8.3 |
| 60 | 9.0 | 6.4 | 7.7 |

## Irrigation

Table 3 shows the effect of irrigation on alfalfa yield production in Kentucky. It is surprising to note that there is little or no effect on the 3 year average comparing irrigated and non-irrigated yields. Even during the driest year in 30 years (1983), the increases due to irrigation were barely economically feasible. Apparently this deep rooted crop can extract much greater amounts of water than most other crops commonly grown in Kentucky.