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Late-season Applied N Can Increase Alfalfa Yields

Increased yields due to applied N found in last or second to last harvest.

Summary: *Total alfalfa dry matter yield (sum of five harvests) increased by 1,151 lbs/A or 0.57T/A from a total annual nitrogen (N) application of 100 lbs/A (20 lbs/A following each cutting). Our study suggests that low N rates can be applied to alfalfa following each cutting without increasing the risk of subsurface NO_3-N accumulation. In our work, increased yields due to applied N were found in either the last or second to last harvest. We speculate that the potential benefits of applying low N rates in alfalfa will take place in later harvests and in arid, irrigated systems with fertigation, high yield potential, and good water management.*

Nutrient-use efficiency (NUE) has been investigated in alfalfa production systems for many of the essential macro- and microelements. However, except for investigating nitrogen (N) needs for stand establishment, these studies have not examined in-season applied N following each harvest on established stands.

Other studies have found that fertilizer N applied to legumes was not beneficial. Applied N tends to cause N-fixing bacteria to cease fixation and may then replace, rather that supplement, the N that normally would be fixed. Alternative work concluded that Rhizobium symbiosis cannot produce sufficient reduced N for optimum alfalfa growth during stand establishment, because N fertilization increased both yield and N percentage in the first two regrowth cycles while having no benefit in later stages. Another comprehensive review reported that fertilizer N applied at planting can increase yields when soils are low in N or organic matter.

Application of 89 lbs/A of N after first cutting in the spring has increased alfalfa yields. This same work also found that fertilizer N recovery was greatest in the first two cuttings in an arid environment using supplemental irrigation. Applying N at seeding has increased first but not second cutting yields, and increased weed growth.

Onetime N applications up to 200 lbs/A of N did not increase soil profile NO_3-N in alfalfa; therefore, alfalfa was considered to have a value in a rotation for reducing profile NO_3-N, which can accumulate in continuous corn. Studies have shown that deep-rooted forage crops such as alfalfa can remove NO3-N and water to a depth of approximately 8 feet. Considerable NO_3-N leaching can occur, especially if legume plowdown is followed by a fallow period, when N mineralization increases with increased soil moisture storage in fallow systems.

The rationale for this work is that favorable growing conditions immediately following harvest may create a growth potential and N requirement by plants in excess of the N-supplying capacity of Rhizobium melilot.

The objectives of this experiment were 1) to evaluate over five years the effect of applying low rates of N (10-40 lbs N/A), following each cutting, on alfalfa dry matter production and forage N removed, and 2) to characterize soil profile inorganic N accumulation following long-term N applications in a perennial legume production system.

Field analyses

A significant quadratic response to applied N was detected in the single-degree-of-freedom nonorthogonal contrast in the first year of the study. Across the five years included in this study, an average annual yield increase of 1,803 lbs/A was observed when comparing the 20 lbs/A N treatment to the check where no N was applied (Figure 1). In general, the 40 lbs/A of N rate per cutting tended to result in somewhat lower yields and N removed when compared to the 10 and 20 lbs N/A rates per cutting.

Total yield and N removed were greater in the third year of the study than in the other four years. Demand for N was therefore expected to be greater during that year. Timely but not excessive rainfall and lack of excessively high temperatures from July to August presumably contributed to increased yields and significant N response.

In the final year of the study, a significant depression in alfalfa yield was found from applied N. Although soil pH declined significantly from year one to year five, and pH decreased with increasing rates of applied N, soil pH remained above the 6.0 that is considered suitable for alfalfa production. Soil test P and K declined during the five-year period, were not affected by treatment, and remained above 85 and 100 percent sufficiency at the end of the experiment, respectively.

Differences in total N removed by year were generally small. Treatment differences for alfalfa protein were very similar to results reported for total N removed. When evaluated across the five-year period, as would interest

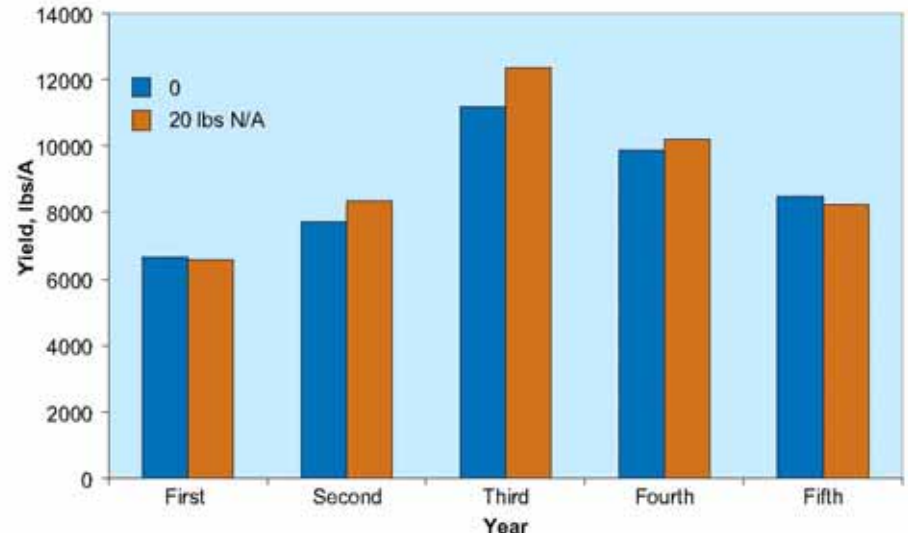

Figure 1. Analysis of variance by treatment means on total alfalfa dry matter yield, five-year study, Lahoma, OK.

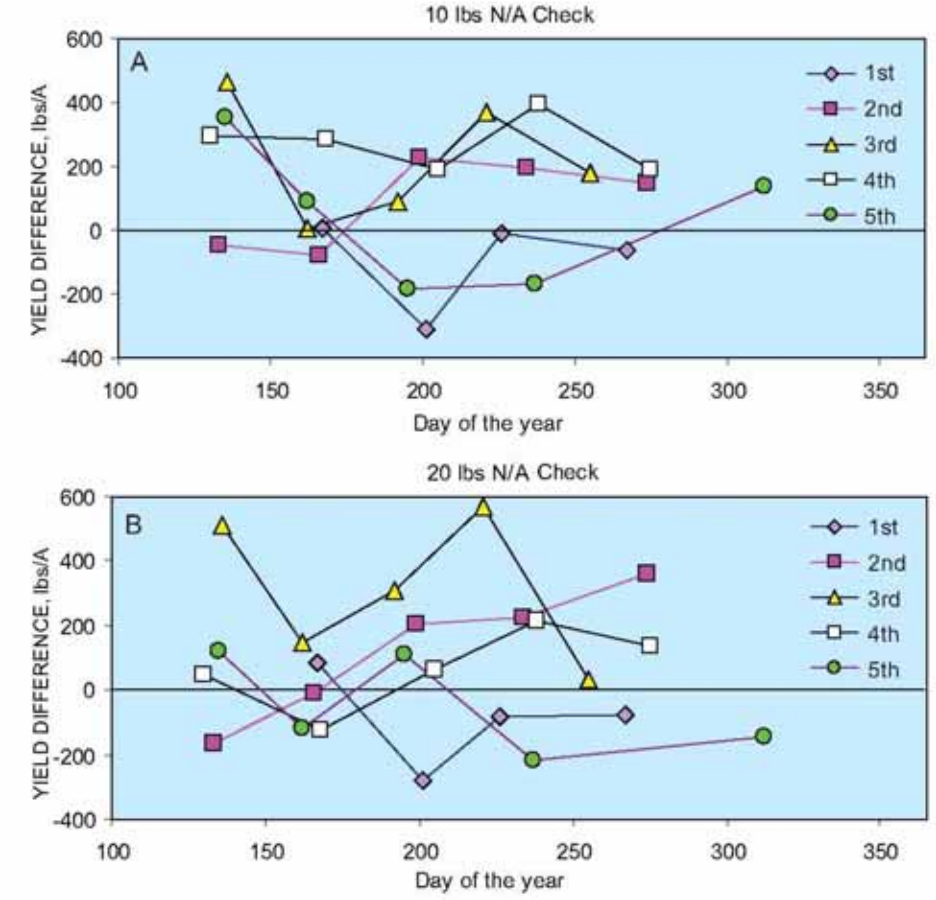

Figure 2. By-harvest alfalfa dry matter yield differences for treatments receiving (A) 10 or (B) 20 lbs/A of N following each harvest compared with the check (no N application) for 24 harvests, five-year study, Lahoma, OK.

alfalfa producers, no significant treatment differences in either yield or N removed were apparent. All estimated NUE registered less than 18.6 percent. The application of dolomitic limestone did not produce a significant response in yield or N removal. Similarly, the initial soil pH was relatively high (7.2) at this site, although no significant response was found either by harvest or across years.

Bottom line

Significant yield increases as a result of applying N immediately following harvest were detected on only three of 24 harvest dates (Figure 2). For these three dates, yield increases (percentage of check yield) ranged from 17 to 26 percent. These increases all took place in either the last or second to last harvest.

For growing periods encompassing the three dates where we observed significant increases in yield, rainfall received since the previous cutting ranged between 2.2 and 3.6 inches and was generally evenly distributed across the 30- to 40-day growing periods. For some of the growing periods much higher than normal rainfall (greater than 7.9 inches) was received during relatively short periods of time. Although single-harvest yield increases in excess of 0.18 T/A (360 lbs/A) were observed on several dates, treatment variability was high, thus reducing the number of significant responses.

Using a price of $100/T for alfalfa, current N prices of $0.45 per lb of N and an increase of around 0.18 T/A, low rates of N (20 lbs/A) applied prior to late cuttings could produce a positive return on investment ($18 of hay value for $9 of applied N). However, applying N as low as 10 lbs/A after every cutting over the 5 years of the study resulted in net losses even at N prices 40 percent (28 cents/lb of N) less than current levels.

Excluding the first year of the study, forage N tended to decline from the second to the fifth harvest. Studies have attributed this to a seasonal decline in N2 fixing capacity of the alfalfa plants. The three significant yield increases as a result of applying N took place in either the last or second to last harvest.

Conclusions

For this five-year study, total fertilizer N applied and forage N removed was similar in plots with and without added N, and no increase in soil profile inorganic N accumulation was observed. The soil-plant system was apparently able to compensate for the surplus N. If increased subsoil inorganic N accumulation was an indicator of increased risk for NO_3-N leaching, applied N in this non-irrigated alfalfa experiment cannot be considered to increase leaching risk. Because no increase in soil profile inorganic accumulation was observed in this study, biological nitrogen fixation probably was lower in plots receiving additional N, especially since total N removed was similar for fertilized and unfertilized plots. Increased total N in the surface (0-6 inch) horizon was evident at the 40 lbs/A N rate; however no differences in total N were noted at depths greater than 6 inches. Decreased biological N fixation as a result of adding N is yet another buffering mechanism in a legume production system, and this helps explain why no observed increase in soil profile inorganic accumulation was found.

This work suggests that low N rates can be applied to alfalfa following each cutting without increasing the risk of NO_3-N accumulation. In our work, increased yields due to applied N were found in either the last or second to last harvest. We speculate that the potential benefits of applying low N rates in alfalfa will take place in later harvests and in arid irrigated systems with high yield potential, where fertigation and good water management are possible.

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