Enhancing Alfalfa Production through Improved Potassium Management

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Potassium (K) is essential for maximum yield of alfalfa, but the manner in which K increases performance is unclear. This study showed that the greater forage yield obtained with K fertilization of alfalfa primarily resulted from increased mass/shoot. Soil test maintenance fertilizer requirements were 14 lb P_2O_5 and 60 lb K_2O per ton of dry hay removed.

Additions of K fertilizers have long been associated with increased alfalfa yield and stand longevity. Popular belief is that K addition promotes improved plant persistence through enhanced production of root reserves, especially TNC (total nonstructural carbohydrates). As plant populations decrease, K fertilizer additions are thought to increase shoots/plant, thus sustaining high yields. This study focuses on determining the mechanisms that promote increased yield with addition of K.

In the spring of 1997, a stand of Pioneer Brand 5454 alfalfa was established at the Throckmorton Purdue Agronomy Center near West Lafayette, Indiana. At the onset of this study, soil test K and P concentrations were approximately 90 parts per million (ppm) and 5 ppm, respectively. Following establishment, a randomized complete block design of five K treatments (0, 100, 200, 300, and 400 lb K_2O/A/year) and four P treatments (0, 50, 100, and 150 lb P_2O_5/A/year) in factorial combination was created. Fertilizer application was split, with half of the specified amount applied after the first harvest in May and the remainder applied after the last harvest in September. Forage yield was obtained four times annually, and a sub-sample of shoots was taken to obtain mass/shoot. Shoots/area was calculated by dividing forage yield per area by mass/shoot. Roots were dug in May and December to monitor plant populations over time, as well as to confirm when plant death occurred...either in summer (May to December) or winter (December to May). Shoot and root tissues were digested, concentrations of P and K determined, and total nutrient uptake calculated using forage yield data.

In each of the five years of this study, K additions increased forage yield (**Figure 1**).

Addition of 400 lb K_2O/A (pictured at right) increased yield through greater mass/shoot over the treatment not receiving K fertilizer (pictured at left). Application of K produced taller and thicker shoots, creating a greater shoot mass in alfalfa. Writing on the yellow handles compares height of growth.

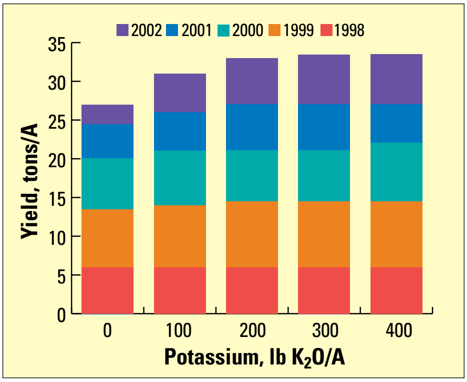


Figure 1. Impact of K addition on yield in each of the five experimental years. Yield was increased with each increment of K.

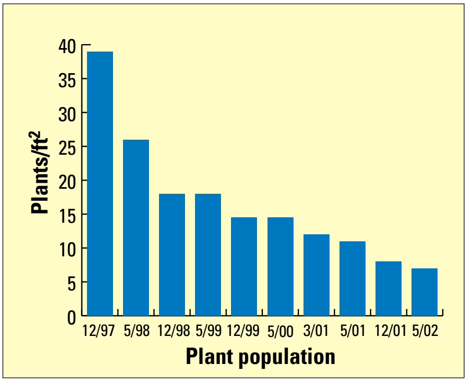


Figure 2. Trends in plant population (plants/ft^2) from December 1997 to May 2002. Data are averaged over P and K fertilization treatments. After the initial decline, plant populations have declined during summer (May to December) but not over winter (December to May).

Application of 400 lb K_2O/A/year improved yield by 600, 480, 560, 440, and 1,760 lb hay/A over the control receiving no K in 1998, 1999, 2000, 2001, and 2002, respectively (see photos). Yield was increased with each additional increment of K.

Analysis of alfalfa yield components (plants/area, shoots/plant, mass/shoot) has led to several unexpected conclusions. Potassium fertilization has yet to affect alfalfa plant populations in any year. Populations have declined since establishment, as expected, but K fertilization has not reduced the rate of plant disappearance (**Figure 2**).

Also, to our surprise, plant death occurred primarily during the summer instead of winter. From December 1998 to May 1999, December 1999 to May 2000, and December 2001 to May 2002, plant losses over winter were 2, 0, and 2 plants/ft^2, respectively. However, injury incurred during winter may weaken plants that ultimately die during summer. Prior to the first harvest, injured plants may not be physiologically prepared for defoliation and subsequent regrowth. Competition from neighboring plants following defoliation may finally kill these weak, slow-growing plants.

Shoots/plant has often been thought of as the yield component that compensates for plant death and stand thinning. It is believed that as stands age and plant populations decrease, increased shoots/plant sustain forage yield once generated by more plants. Through the first four years of the experiment (1998 to 2001), number of shoots/plant was not affected by K fertilization, nor was number of shoots/plant associated with forage yield. In 2002, addition of K increased shoots/ft^2 in each harvest, but increased shoots/ft^2 did not necessarily result in higher forage yield (**Figure 3**). At each harvest, the highest forage yield was not necessarily found in plots with the greatest numbers, and application of the highest K rates did not result in the greatest number of shoots.

Productivity potential of established stands has often been evaluated using 40 shoots/ft^2 as the threshold of acceptance. Alfalfa stands with less than 40 shoots/ft^2 are generally viewed as being shoot-limited, and stand replacement is recommended. In our experiment, forage yields over 1.6 tons dry matter/A/harvest have consistently been obtained in plots containing fewer than 40 shoots/ft^2, whereas plots containing 50 or more shoots/ft^2 have not produced yields over 1.4 tons dry matter/A/harvest. This suggests that shoots/ft^2 is not a good indicator of the productivity potential of an alfalfa stand.

The greater forage yield obtained with K fertilization of alfalfa has primarily resulted from increased mass/shoot. Throughout the first five years, only increases in mass/shoot

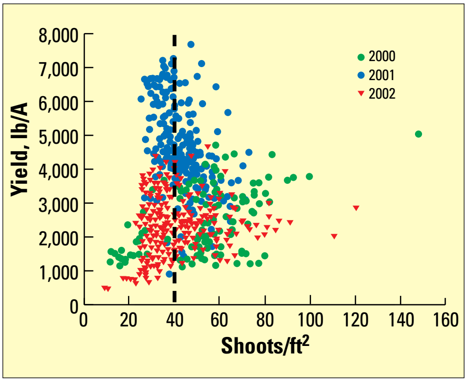


Figure 3. Yield as influenced by shoots/ft² in 2000, 2001, and 2002. The dashed line indicates 40 shoots/ft². Increased shoots did not necessarily increase yield.

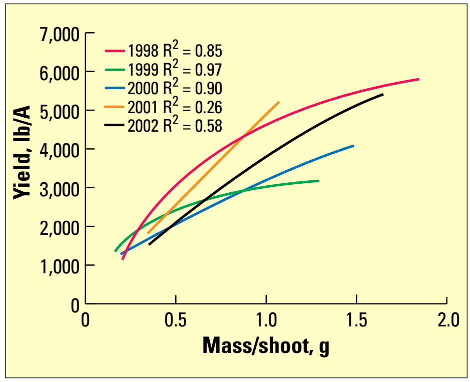


Figure 4. Alfalfa yield as influenced by mass/shoot in 1998 through 2002. Increases in yield have been primarily through enhanced mass/shoot. Each line represents 320 data points taken from harvests each year.

have consistently been associated with increased forage yield (**Figure 4**). Increased mass/shoot is produced through two different mechanisms. First, rapid shoot initiation after defoliation permits shoot growth to resume quickly following harvest, thus increasing mass/shoot. Initiation of regrowth after defoliation is substantially greater when alfalfa is supplied K. Secondly, elongation rate of shoots is increased with increased K fertility, which leads to greater mass/shoot.

Despite the occurrence of acute K deficiency symptoms and greatly reduced forage yields in fall, K fertilization has not enhanced forage yields in May of any year (**Figures 5a, 5b** and photo on next page). The reason is unclear. One working hypothesis is that K released from the interlayers of clay minerals during late fall through early spring may provide sufficient K to meet the nutritional needs of alfalfa at first harvest, but not in subsequent harvests.

Lack of yield response to K fertilization in Harvest 1 of 2000 indicates that spring-applied K fertilizer is not necessary and could contribute to K luxury consumption. Luxury consumption occurs when plants take up nutrients such as K (and N) in amounts that exceed their required needs. Spring K applications and the associated luxury consumption would decrease fertilizer efficiency and possibly deprive subsequent harvests of need-

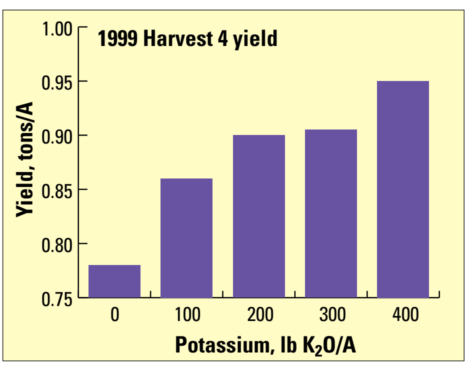


Figure 5a. 1999 Harvest 4 yield. As increased increments of K were provided to alfalfa, yield was dramatically enhanced. LSD = 0.123.

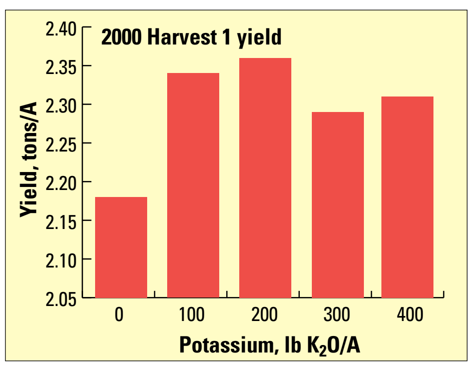
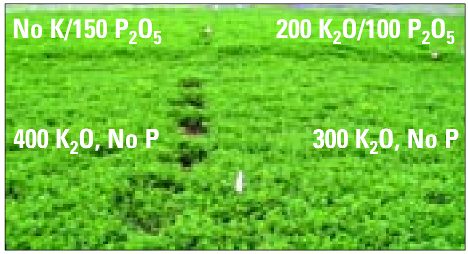


Figure 5b. 2000 Harvest 1 yield. Application of K did not correlate with enhanced yield for the first harvest. LSD = 0.429.

ed K. Applying half the specified amount of K to meet the specific yield goals after the first harvest, and the remainder after the last harvest in the fall, will increase K fertilizer use efficiency.

Seasonal changes in alfalfa response to K application and soil K status also have implications for timing of soil sampling and interpretation of soil test values. Soil samples taken in spring may provide inflated estimates of soil test K concentrations. This could alter fertility management decisions by reducing K applications and subsequently placing the crop at risk of K-deficiency later in the growing season. Also, when comparing soil tests results obtained over a series of years, time of soil sampling must be considered. The most valid comparisons are those tests where the soil sampling is done the same month of each year. This practice would avoid season-induced changes in soil test K values that could be misleading, and provide a clearer indication of how management practices are influencing soil test K concentrations.

By using information on yield and K removal, we can arrive at the following fertilizer recommendations for alfalfa when soil test



Yield increases in May were primarily due to addition of P, whereas additional K supplied without P failed to promote greater alfalfa yield.

P and K are in the maintenance range: 14 lb P_2O_5/ton of dry hay removed/A and 60 lb K_2O/ton of hay removed/A (based on 0% hay moisture). By following these application guidelines, producers can replenish the amount of P and K removed from the soil. To increase soil test P and K levels, greater P or K applications would be required.

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Management of No-Till Flax...

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was determined for each site-year, we observed treatment differences in three of the 12 trials. In two of those years the treatments where N and P were placed in a Sb position gave the highest seed yields. When all sites are included, the trend was for better seed yields when N and P were placed in Sb position, although the differences were small in absolute terms (**Table 1**). The absence of a flax response to P fertilizer, when the crop takes up more than twice the P per unit of yield than spring wheat, is difficult to explain. It appears that the flax crop is capable of using residual soil P to meet growth and development requirements.

Based on the results of this study, we conclude that no-till flax growers have many N and P management options available. The current trend of adding all the crop's fertilizer requirements during the seeding operation, a one-pass seeding and fertilizing no-till system, may in some cases actually improve seed yields with no apparent negative effects on flax nutrient uptake or seed yield. Limited response of flax to fertilizer P applied at seeding supports the recommendation that maintaining soil P in the medium to optimum range provides the best means of ensuring adequate P supply for high yielding flax production.

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