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Balanced P and K Applications Crucial to Optimum Alfalfa Yields

Tests conducted at Purdue show the grave consequences of adding P without K.

Summary: *Clearly, nutrient imbalance (adding P without K) has much graver consequences for alfalfa survival than we had anticipated. From an alfalfa persistence point of view, producers are better off not fertilizing than applying P alone, if they suspect soil K levels are inadequate. In our studies, total annual yield increased with application of P and K, but K application did not increase first harvest yield. Yield increases were due to greater mass per shoot, whereas stems per unit area were not related to forage yield. Although P fertilizer increased forage yield significantly, it decreased plant populations by producing fewer but larger individual alfalfa plants. Fertilization with P alone resulted in faster stand thinning than observed in plots provided with both P and K, and those left unfertilized. This rapid stand loss was associated with low concentrations of root reserves including starch, amino acids, and protein in taproots.*

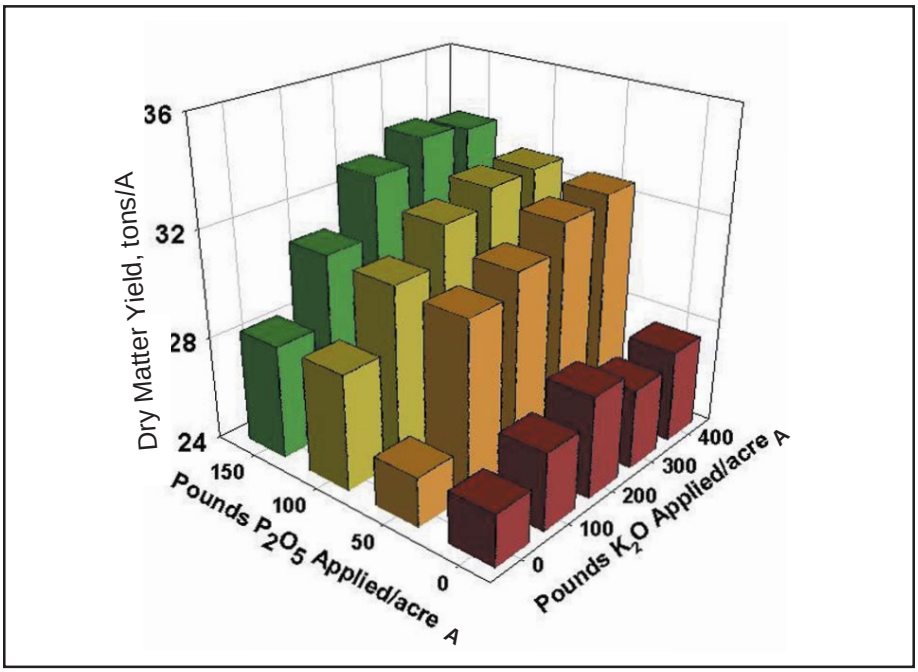

Figure 1. Influence of P and K application on cumulative orage yield of alfalfa, 1998-2002.

High yield and excellent forage quality make alfalfa the forage of choice in many livestock systems, but intensive harvest management and average winter hardiness can undermine maximum yield, persistence, and ultimately profit. Improved fertilizer management represents one approach for increasing alfalfa yield and persistence, but our understanding of how alfalfa responds to P and K application is rudimentary. Our objective in this study was to determine how alfalfa yield components are altered by P and K application.

YIELD

Forage yield increased markedly with P and K application (Figure 1). Highest yields were obtained when at least 200 lbs/A of K_2O and 100 lbs/A of P_2O_5 were provided annually. Additions of K without P did not increase yield, whereas the addition of 100 and 150 lbs/A of P_2O_5 increased yield of no-K plots over control plots (no K or P). However, these yield increases resulted from greater first-cut (May) yields in 1998 to 2000, and have recently been offset by severe stand losses in the no-K, high-P plots in 2002 (Figure 1).

YIELD COMPONENTS

Alfalfa yield is comprised of three yield components: mass/shoot, stems/area, and plants/area that, when multiplied together, determine forage yield. An increase in forage yield should be the result of increase(s) in one or more of these yield components.

Mass/shoot. Greater alfalfa yield obtained with P and K fertilization has primarily resulted from increased mass/shoot (Figure 2). Mass/shoot has consistently been associated with P- and K-induced increases in forage yield each growing season, whereas the other yield components have either decreased

or have not been influenced by P and K addition. Increased mass/shoot can occur as a result of two different mechanisms: rapid initiation of new shoots after defoliation ("bud break"), and faster elongation rate of alfalfa shoots after bud break. Both of these factors increase dramatically with the addition of P and K. Increased levels and enhanced mobilization of stored reserves may be physiological factors contributing to the rapid shoot initiation and growth after harvest.

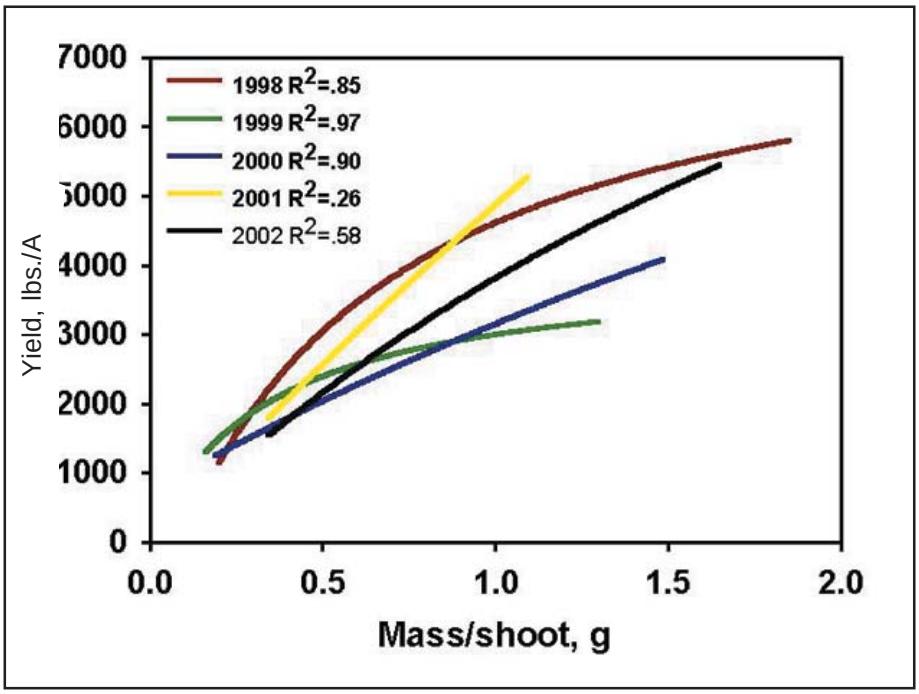

Figure 2. Influence of mass/shoot on forage yield of alfalfa,1998-2002.

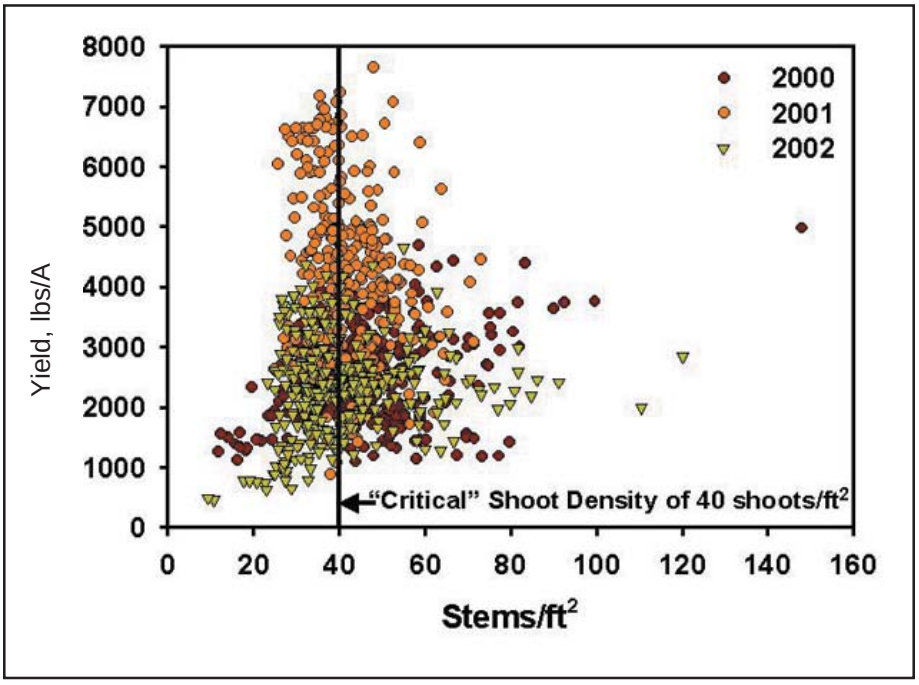

Figure 3. Influence of stems/area on forage yield of alfalfa, 2000-2002.

Stems/area. Through the first five years of this study, increased stems/area has not been positively associated with forage yield (Figure 3). We observed nearly a 10-fold range in forage yield at stem densities of 27 to 45 stems/ft^2. Traditionally, 40 stems/ft^2 has been used as an indicator of the agronomic viability of an alfalfa stand, with stands possessing fewer than 40 stems/ft^2 being considered non-viable. While we observed a reduction in yield with fewer than 25 stems/ft^2, high stem counts (>60 shoots/ft^2) did not automatically result in high forage yield. Intermediate values of 27 to 55 stems/ft^2 were generally associated with the highest forage yields in this study, but because of low mass/shoot in unfertilized plots, these shoot densities were also associated with low yield in many plots. Our data indicate that using a cutoff for stand viability of 40 shoots/ft^2 is not appropriate for assessing the productivity potential of an alfalfa stand.

Plants/area declined rapidly after initial establishment of the alfalfa stand (Figure 4). Since establishment of our stand in 1997, plant population has declined with time and in December 2002 there were approximately 6 plants/ft^2 averaged over all treatments. Contrary to popular belief, extensive plant losses have occurred during summer and not during winter. Competition for light, water, and nutrients in summer, as well as defoliation every 30 days may have increased the frequency of plant death and thinned stands prematurely. In addition, injury during the previous winter may have weakened the plants that subsequently die during the summer. Work has begun in an adjacent set of larger plots that will permit us to determine when alfalfa plants die in the summer and to explore the physiological basis for their demise.

P AND K BALANCE

During the 2002 summer we noticed a severe stand decline in plots where P had been applied without K. This was on the poorest fertility soils located at the study site. To our surprise, these stand losses were even greater than what we observed in plots where no P and K had been applied. To understand this stand decline we set up a group of plots where we provided P without K, so we could consider them as a single treatment. We compared them with plots that had been provided with 200 lbs/A/yr of K_2O, this time combined with the same P rates of 50, 100, and 150 lbs/A of P_2O_5/yr. The K rate was selected for comparison because it provided good yields (Figure 1) without being excessive, and because several of the 200 lbs/A of K_2O plots were immediately adjacent to the no-K plus P plots that had suffered extensive stand loss.

Although extensive stand loss occurred in all plots between May and December of 2002, losses were especially acute in the no-K plus P plots.

Clearly, then, nutrient imbalance (adding P without K) has much graver consequences for alfalfa survival than we had anticipated. From an alfalfa persistence point of view, producers are better off not fertilizing than applying P alone if they suspect soil K levels are inadequate. Obviously, the best choice is to soil test and apply P and K as required to meet yield goals of the alfalfa stand.

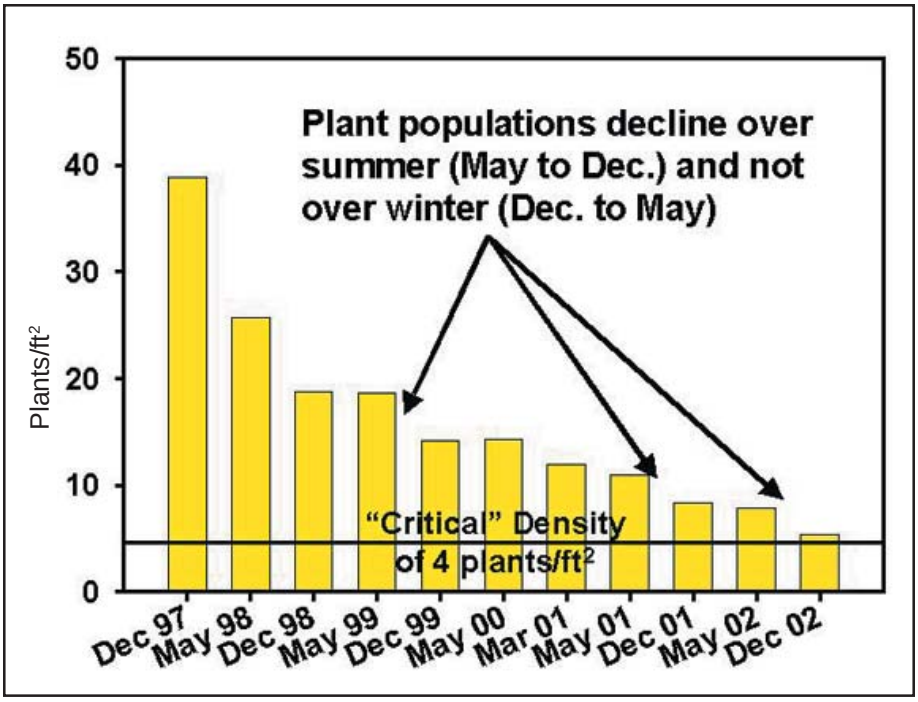

Figure 4. Changes in plants/area. Data are averaged over all fertility treatments, 1997-2002.

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