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Effects of the Application of Balanced Phosphorus and Potassium Fertilizers on Alfalfa Yield and Yield Components

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Background

Alfalfa (*Medicago sativa L.*) stands normally provide the highest yield in their first two or three production years, and then start to decline thereafter, where sometimes re-establishing the stand becomes necessary. As re-establishing a stand is costly, it may be more profitable to improve management practices that will keep stands high yielding for more years. Towards that end, several research projects have been conducted in the low desert of Arizona. An on-farm study at Buckeye, Arizona indicated that application of phosphorus (P) fertilizer at 104 lb P_2O_5 per acre significantly increased (8.7%) hay yield (Ottman et al 2015). Other research has revealed that various phosphorus fertilizer sources had equal effect on alfalfa forage at equivalent rates of application (Burayu et al 2016) & (Brouder et al. 2005).

Individually, P fertilization at a rate of 100 and 125 lb P_2O_5 per acre significantly increased (8%) alfalfa yield when compared with alfalfa not receiving P, while application of potassium (K) fertilization at a rate of 100 K_2O slightly increased (4%) yield of alfalfa (Mostafa and Burayu 2020) & (Lissbrant et al. 2010). Some research even suggests K fertilization in highly K concentrated soils (Barbarick, 1985). More so, optimizing P and K fertilization significantly increased alfalfa yield (Burayu and Mostafa 2021), but the changes in yield components as influenced by P and K fertility level have not been evaluated in the low deserts of Arizona. The yield components of alfalfa are the indicators of alfalfa yield.

What are the Indicators of Alfalfa Yield? (Berg et al. 2007)

1. **Live plants per area.** The indicator most often used is live plants per square foot. For a highly productive stand a minimum of 4-6 plants should occupy each square foot. Usually, correlation between plants per square foot and yield is rather low since individual alfalfa plants respond to decreasing stand density by producing more stems. If plant density drops below 5 plants per square foot, replacing the alfalfa stand should be strongly considered.
2. **Stems (shoots) per plant.** The density of stems rather than plants is a better indicator of the adequacy of a stand because some plants may have few stems and not contribute much to yield. The stems should be counted when about 6 to 10 inches tall. An increase in stems per plant compensates for fewer plants and will often maintain yield.
3. **Number of stems (shoots) per square foot.** In many cases this can be a better indicator of a productive field since it reflects the health and vigor of the plants. Usually, fields with 55 or more stems per square foot produce maximum yields. Some yield reduction expected when stems become at the range of 40-50 stems /ft^2. Once stem numbers fall below 40 per square foot alfalfa fields, and thus profitability, begins to drop and replacing the stand should be given strong consideration.
4. **Mass per shoot (shoot weight).** Mass per shoot is also a good indicator of yield as yield is a function of shoots number and mass per shoot (Yield = plants/area X Shoots/plant X mass/shoot).
5. **Uniformity of the stand.** Factors to consider include the uniformity of the stand and the weed situation. Is weed competition affecting the number of stems per square foot or will it reduce forage quality and reduce future yields? Are there areas within the field where the population is below the desired number? Stands may need replacement if plants are not uniformly distributed or if many bare spots exist. Weeds may become a problem in a thinning alfalfa stand and may be difficult to control. Reduction in forage quality may occur in sparse stands due to thicker stems.

6. **Plant height.** Plant height should be considered when determining the optimum harvest maturity. Optimum plant height for cutting alfalfa in Arizona is 28 inches

7. **Node, Internode length and trifoliate:** A stem is a major organ consisting of a series of internodes connected by nodes. The sum of the lengths of elongated internodes accounts for a large fraction of plant height which in turn affects yield. Internode elongation is influenced by various factors such as growth duration, photoperiod, temperature, stress inducing environments, and external inputs.

Materials and Methods

Our hypothesis is that balanced P and K fertilization will increase one or more alfalfa yield components, and those component responses may change yields. A Coolidge sandy loam soil (72% sand) from alfalfa grown area around Phoenix, AZ was collected and filled into a three feet long white plastic pipe commonly known as polyvinyl chloride (PVC) duct pipe and installed near Maricopa County Cooperative Extension Office. Many of the irrigated crops including alfalfa in Central Arizona around Phoenix and Buckeye are grown on Coolidge soil series (USDA Soil Conservation Service in Cooperation with The University of Arizona Agricultural Experimentation Station, 1972). Treatments included factorial combinations of three P rates (0, 100, 125 lb. P_2O_5 $a^{-}1$) and three K rates (0, 100, 300 lb. K_2O $a^{-}1$) arranged in a randomized complete block design with three replications. Monoammonium Phosphate (MAP, 11-52-0) as a source of P and Potassium Chloride (KCL, 0-60-0) as a source of K were used. A non-dormant PGI 908-S variety with fall dormancy rating = 9.0 alfalfa crop was used. Drip irrigation was provided at equivalent irrigation amount of 74 inches per season. Plots were maintained at non-stress level.

Results

Application of P and K affected alfalfa growth and performance significantly compared to alfalfa receiving no P or combination of P and K (Figure 1). Stems per plant, stems per square foot, mass/stem, maximum height, and internode length significantly affected alfalfa forage yield (Figure 2). In the present findings, we found 11 shoots (stems) per plant, 55 shoots/ft^2, 0.55gm/shoot, and 29 inches maximum plant height gave the highest forage yield.

Figure 1. Application of P and K affected alfalfa growth and performance. Images collected about 12 weeks after planting (top) and 3 weeks after the first cutting (below).

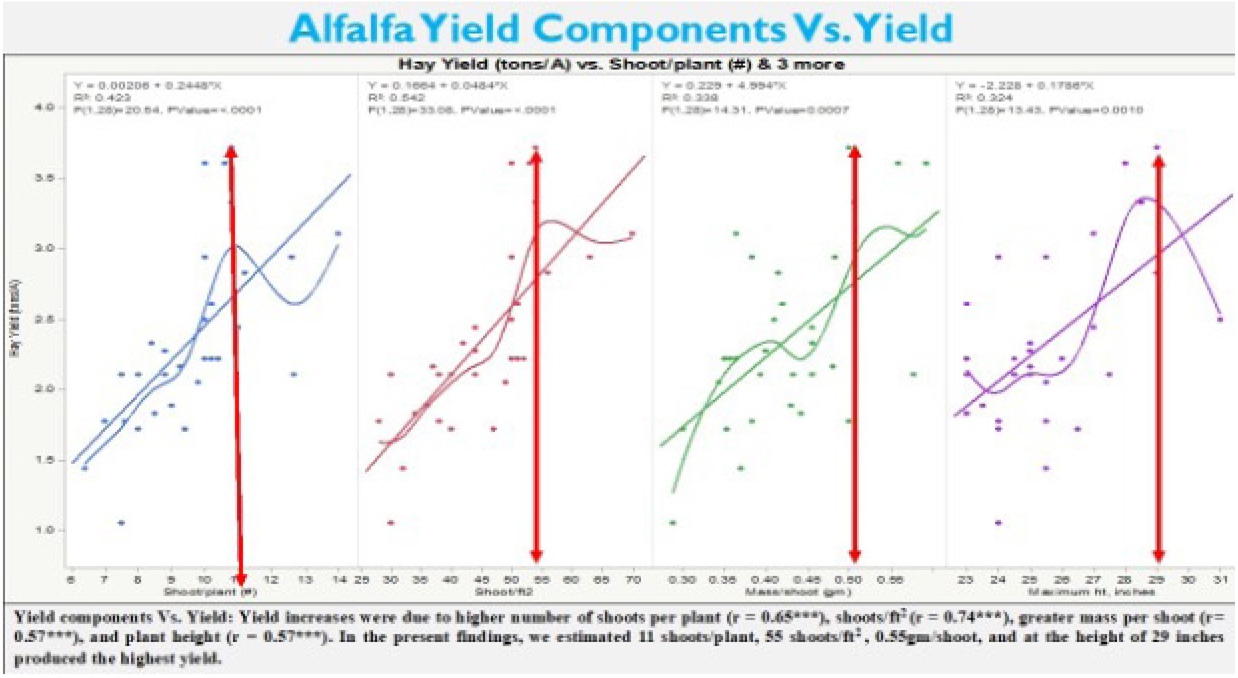

Figure 2. Yield (Ton/A) comparing to yield components, including number of shoots/plant, Number of shoots.m², mass (gm)/shoot, and maximum height (inches) of alfalfa.

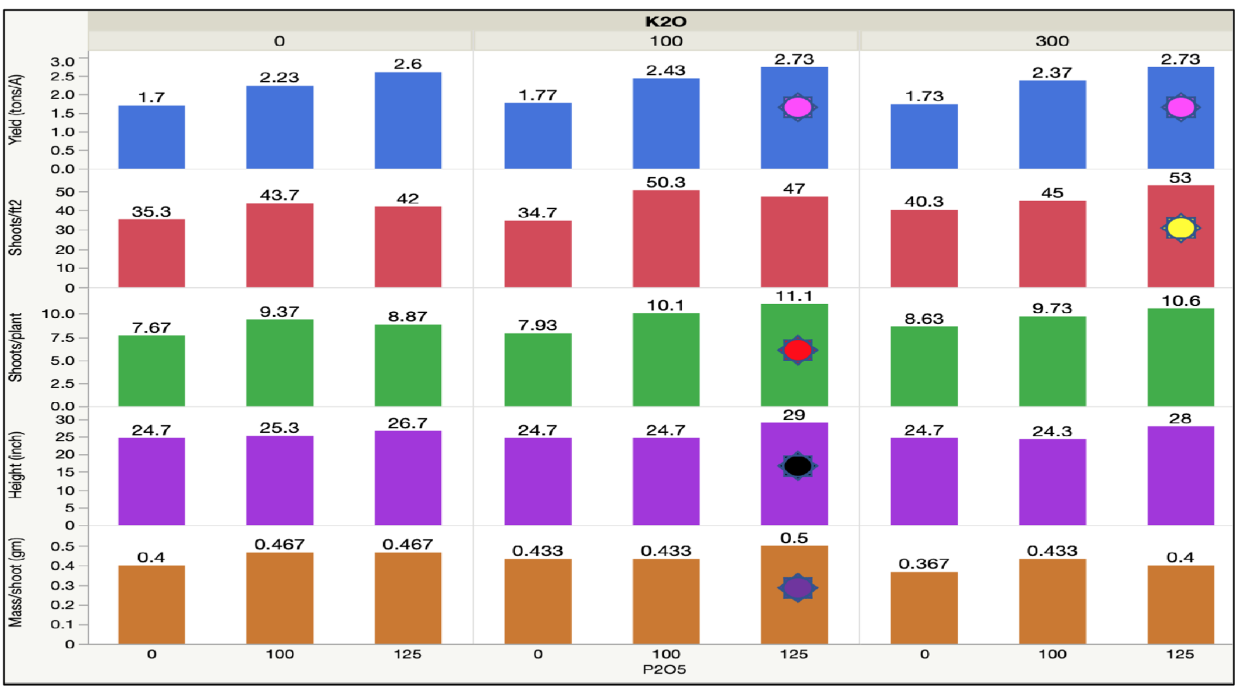

Figure 3. Combination of P and K affected yield (Ton/A) comparing to yield components, including number of shoots/plant, Number of shoots.m², mass (gm)/shoot, and maximum height (inches) of alfalfa.

The highest forage yield was obtained with 125 lb P_2O_5 combined with 100 lb K_2O per acre. However, increasing K_2O from 100 to 300 lb per acre had no yield advantage. The impact of K was more remarkable on shoot per square foot than any of the yield components of alfalfa (Figure 3).

Marking on the pars represent significant differences among treatments.

Conclusions

To answer the question should I maintain my alfalfa field? Evaluate your established or newly seeded stands when plants are about 6 to 10 inches tall. To determine needs, remember 4 to 6 plants and 40-55 stems per square foot established stands.

Application of 125 lb acre-1 P_2O_5 combined with 100 lb acre-1 K_2O appeared adequate to maximize yield as compared to higher P or K fertilizers alone or plots not receiving P and K. More research is needed to refine P and K fertilizer recommendations to evaluate the cost-benefit advantage for irrigated alfalfa hay production in the low deserts of Arizona.

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