

# TESTING ALFALFA FOR PHOSPHORUS AND POTASSIUM NUTRIENT DEFICIENCIES

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**Key Words:** alfalfa, tissue testing, phosphorus, potassium, sulfur, nutrient deficiency

## INTRODUCTION

Molybdenum, phosphorus, sulfur and potassium are all essential for good alfalfa growth and quality. They are commonly deficient elements in alfalfa grown in the Sacramento Valley. Soil tests are not useful in determining sulfur and molybdenum levels and are only good at predicting growth responses from applied P and K when test levels are very low. Plant tissue tests have been very reliable for Mo and S regardless of growth stage, but have not been as reliable in predicting P and K responses with alfalfa sampled from early bud stage to 1/10<sup>th</sup> bloom (3).

The major problem with the P and K tissue analysis is the nutrient dilution that occurs as alfalfa grows and gains dry matter. The current UC standard critical level for tissue testing is to take the sample when the alfalfa reaches the maturity stage of 1/10<sup>th</sup> bloom. When this level was established, the common practice was to harvest at 10% bloom. However, with the market incentive for higher quality, growers rarely let their hay mature beyond the bud stage. The literature suggests that the tissue values be increased by 10% if taken before the 1/10<sup>th</sup> bloom stage (2,3). States other than California use Total P analysis of the top 1/3 of the plant sample or the whole plant. Their threshold standards also call for samples to be taken at 10% bloom.

## PROCEDURES

In 2003-2004, a total of 6 replicated small plot fertilizer trials were established in grower fields that were suspected of having P deficiencies, with soil P levels between 2 and 12 ppm. Phosphorus treatments of 0, 100, 200 and 400 lbs. P<sub>2</sub>O<sub>5</sub> per acre were applied. A total of 12 harvests for yield were taken from these 6 trials. Tissue samples were taken at harvest and analyzed. Even though yields indicated a positive yield response to applied P, many of the PO<sub>4</sub>-P tissue levels of the control plots were above the critical 1000 ppm level. We suspected that the PO<sub>4</sub>-P tissue levels were high because we were sampling about a week or more before the alfalfa reached 10% bloom. This is a common situation because most growers harvest in the bud stage and only on rare situations will they let the alfalfa mature to 10% bloom.

Two of the locations with a positive yield increase to applied P were then chosen for sequential tissue sampling at different growth stages to determine the rate of nutrient dilution in the plant parts sampled as the alfalfa matured. Eleven cutting/ locations were sequentially sampled in

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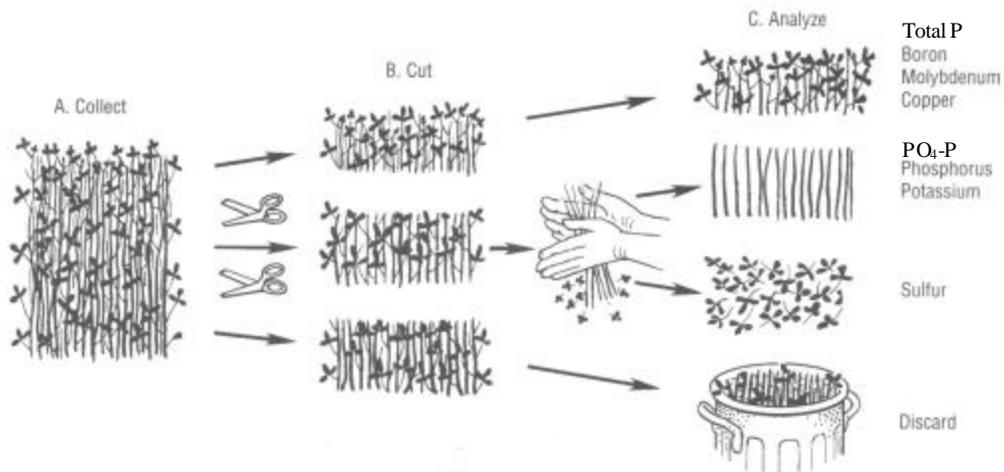
2004 and 2005 starting at the vegetative stage, with three cutting/location final sampling at 10% bloom. Alfalfa growth stage at sampling was determined by 5 methods: 1). Mean Stage Count (1,4), 2). stage of most mature stem, 3). predominant stage, 4). height of tallest stem and 5). canopy height.



**Canopy Height Measurement**

Analyses for  $\text{PO}_4\text{-P}$  and K were done on the mid-stem portion of the samples. Total P analysis was done on the top 1/3 portion and  $\text{SO}_4\text{-S}$  was done on the mid-stem leaves.

Tissue sampling procedure:



## RESULTS

Sampling the first cutting was problematic because of the erratic spring growth that occurs in the non-dormant growing areas such as the Sacramento Valley. In order to get an accurate estimation of the stage of growth at sampling, all of the plants sampled must be generally at the same stage of maturity. This occurs in the more dormant growing areas such as the Intermountain areas, but does not occur at the lower elevations. If the herbicide paraquat is used for winter weed control in the non-dormant areas, there is a specific start of spring re-growth and the samples taken near harvest are much more uniform in their stage of development.

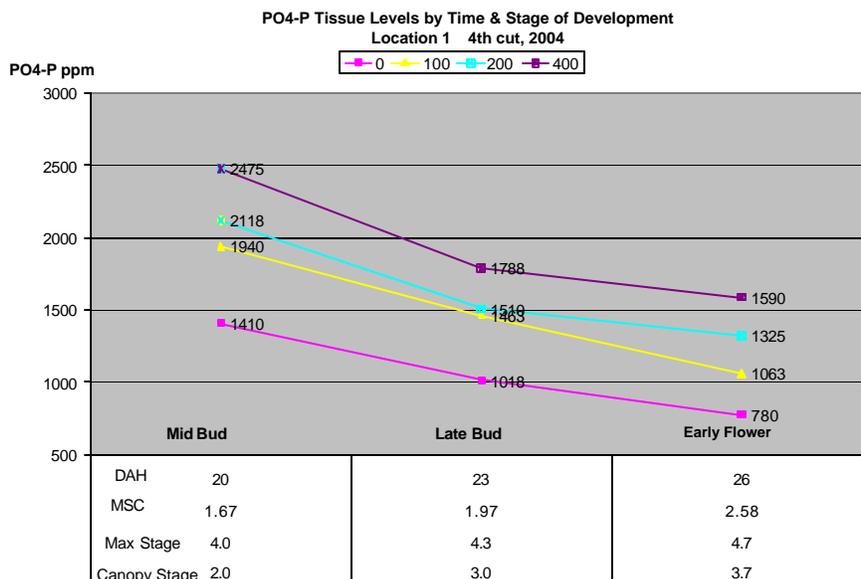


**Non-dormant growing area  
(Sacramento Valley)**  
Spring growth very erratic in height and stage of development.

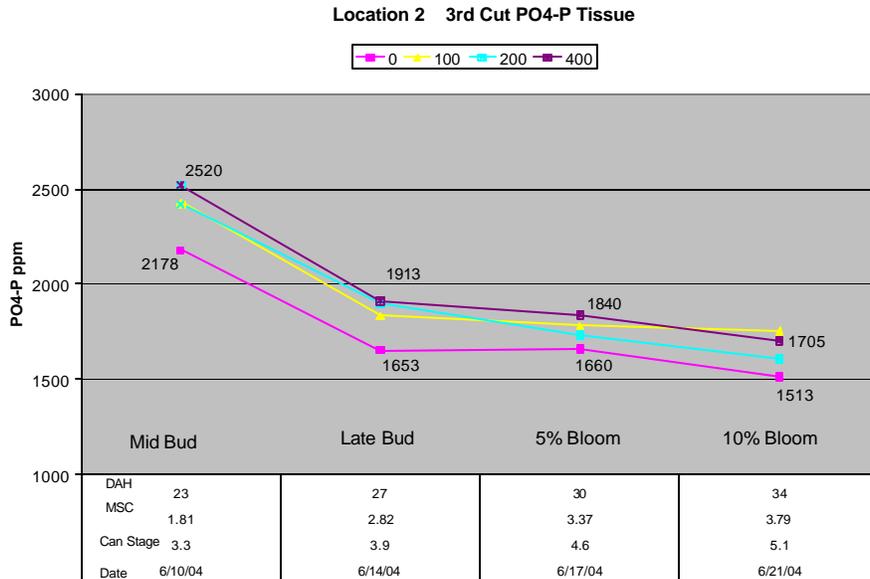


**Dormant growing area  
(Intermountain area)**  
Spring growth starts all at one time, very uniform height and stage of development

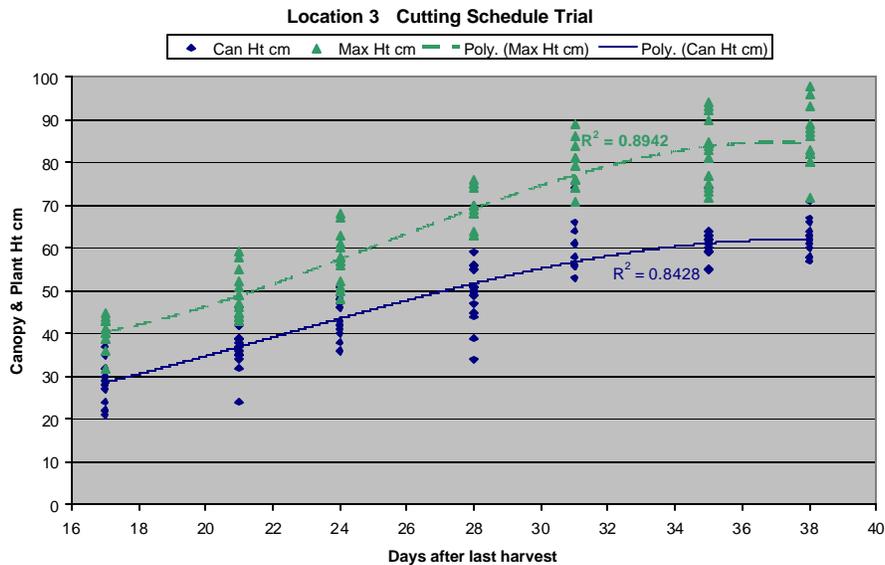
Data from the 11 cutting/ locations indicate that the rate of P and K decline is much steeper than expected from the previous research. The surprising result was the PO<sub>4</sub>-P levels declined at a rate greater than 100 ppm PO<sub>4</sub>-P per day from mid-bud stage to early flowering! Potassium levels declined in a similar manner to PO<sub>4</sub>-P. This shows that harvesting a few days early can significantly affect the P and K tissue levels.



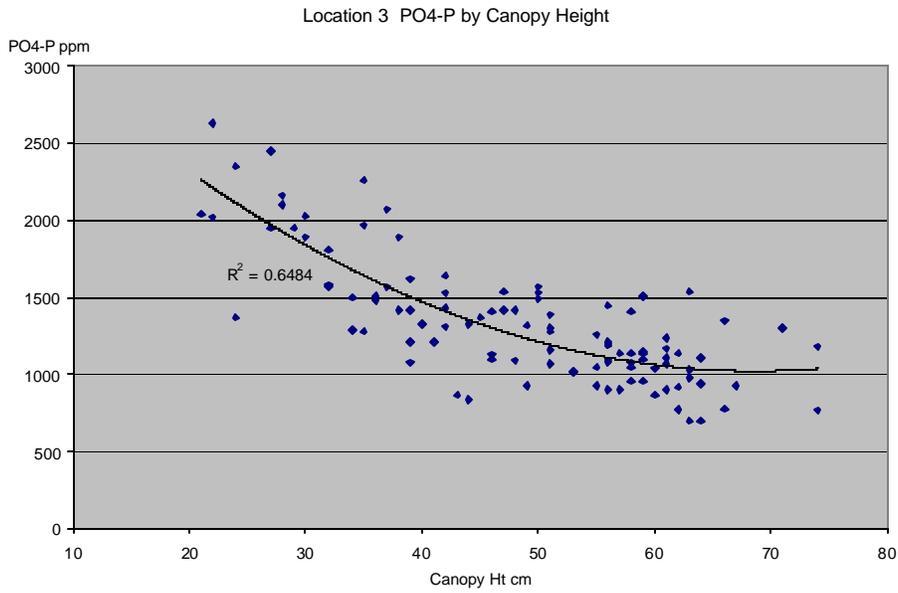
From one of the cutting/locations that was allowed to actually reach 10% bloom (shown below), the rate of decline is steep prior to sometime around late bud stage, then it levels off to a more gradual decline similar to what was expected from earlier research.



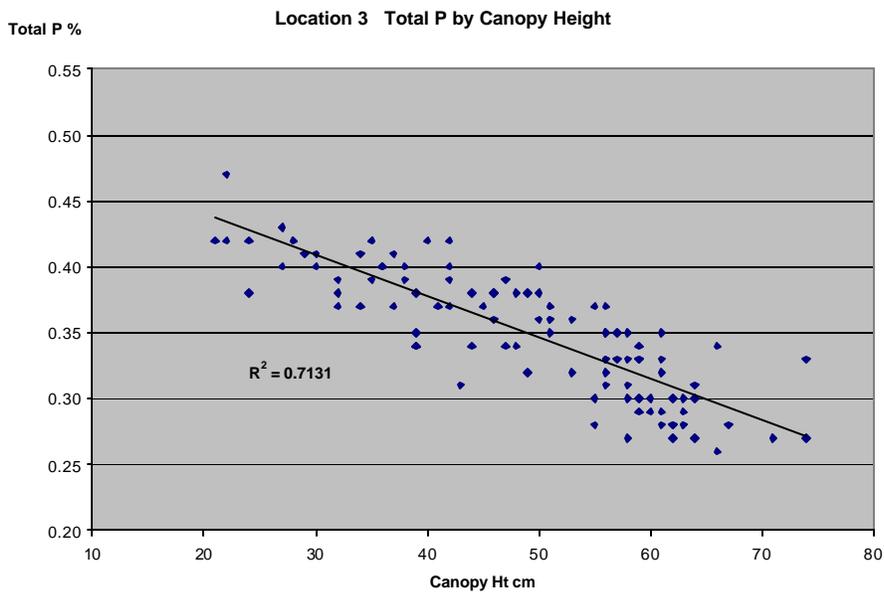
Of the 5 methods used to describe the maturity of alfalfa at sampling, the canopy height method provided the best correlation with the decline in PO<sub>4</sub>-P and K concentrations. Plant canopy height also seems to be a good measurement of total alfalfa biomass accumulation.



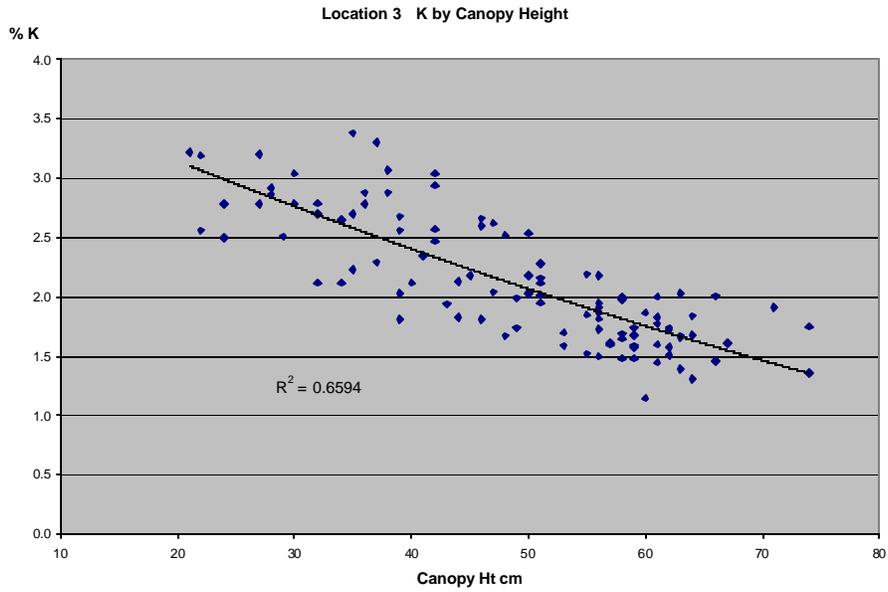
When PO<sub>4</sub>-P is compared to canopy height, the decline in concentration is steep until approximately 45 centimeters, and then it flattens out similar to the Location 2-- 3<sup>rd</sup> cut results in a previous graph.



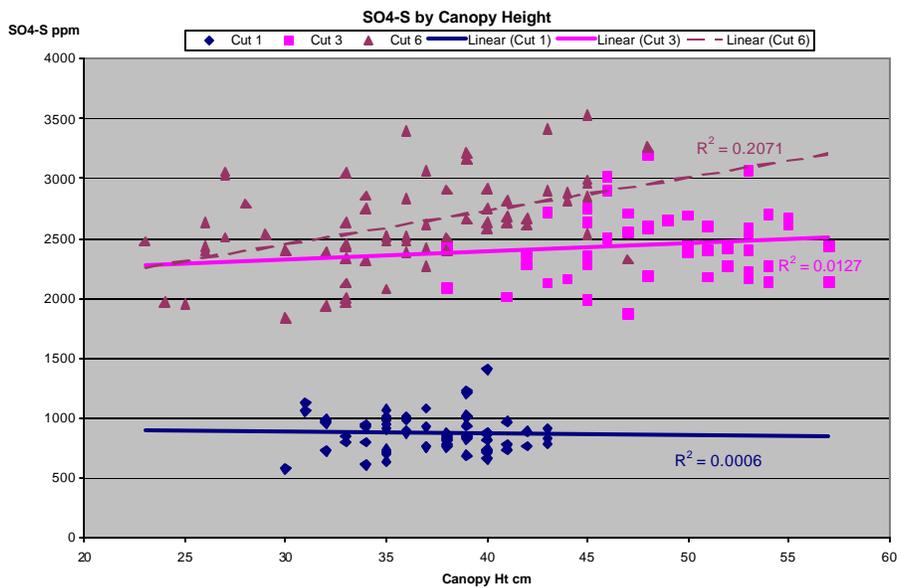
Total P taken from the top 1/3 portion of the plant sample did not experience the flattening decline that is shown for PO<sub>4</sub>-P taken from the mid-stem portion of the sample.



Potassium decline is similar to total P even though K is analyzed from the same mid-stem portion that PO<sub>4</sub>-P is taken.



An increase in canopy height had no effect on SO<sub>4</sub>-S concentration for any one cutting. However, the first cutting (cold and wet soil conditions) results indicate a 1500 ppm reduction from the levels taken at later (warm soil temperature) cuttings.



## CONCLUSIONS

In non-dormant areas, the first cutting is **not** the best cutting to tissue test for P or K because of uneven spring growth. This may be mediated by an application of paraquat that allows for more even re-growth. If a determination for sulfur is important, then the first cutting will give a more accurate level for cold and wet soil conditions that limit sulfur uptake.

Canopy height is a good measure of plant biomass. As plant biomass increases:

- $\text{PO}_4\text{-P}$  declined as time and or canopy height increased, first in a sharp decline approximately 100+ ppm per day, than the decline decreased to a flatter rate of decline.
- Total P and K declined in a similar (linear) manner as biomass increased
- $\text{SO}_4\text{-S}$  levels were static, levels depend on cutting (cold & wet vs. hot & dry)

Critical levels for  $\text{PO}_4\text{-P}$  should be adjusted upward from the 800 ppm concentration when samples are taken earlier than the 10% bloom stage. These results suggest that the critical levels should be adjusted by canopy height measurement or by a less precise method being by stage of development. Tentative critical levels by growth stage are:

10% bloom		800 ppm	
Early flower	Stage 5 (1 node w/ 1 open flower)	1000 ppm	(+/- 100 ppm)
Late-bud	Stage 4 (3 or more nodes w/buds, no flowers)	1500 ppm	(+/- 200 ppm)
Mid-bud	Stage 3+ (1-2 nodes w/visible buds, no flowers)	2000 ppm	(+/- 200 ppm)

## LITERATURE CITED

1. Kalu, B.A., and G.W. Fick. 1981. Quantifying morphological development of alfalfa for studies of herbage quality. *Crop Sci.* 21:267–271.
2. Martin, W.E. and R.L. Luckhart, 1971, How to Predict Fertilizer Needs of Alfalfa, In: *Proceedings California Alfalfa Symposium.*
3. Meyer, R. D., D. B. Marcum and J. L. Schmierer, 1998, Do I Need Fertilizer? -Ask the Plant, Published In: *Proceedings 28th California/Nevada Alfalfa Symposium, December 3-4, 1998, Reno Hilton, Reno, NV.*
4. Mueller, S.C. and Fick, G.W. 1989. Alfalfa: quality, maturity, and mean stage of development. *Information Bulletin 217, Media Services, Cornell Cooperative Extension. Ithica, NY. 14pp.*