

DO I NEED FERTILIZER? – ASK THE PLANT!

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ABSTRACT

Growers, PCA's and others involved in producing alfalfa often ask the question, "Do I need fertilizer and if so how much?" Can soil tests or plant tissue tests be used to indicate what fertilizers should be applied? It is the objective of this presentation to give some guidelines as to how plant tissue samples can be taken and used effectively to indicate the kinds and amounts of fertilizers to apply to alfalfa to maintain or improve yields and quality.

Key Words: alfalfa, fertilizers, soil tests, plant sampling, plant tissue tests, monitoring nutrient status, fertility management.

INTRODUCTION

As the title suggests, this presentation will focus on the alfalfa plant to determine what, if any fertilizer nutrients should be applied to increase the growth and yield of one of the most important forage crops in the Western United States. Perhaps the first thing that comes to mind when the comment "ask the plant" is made concerns what the plant or a field of alfalfa looks like. Is it a good green color? Is it slightly yellow or is it very dark green, even bluish dark green suggesting stunted growth? Certainly the visual appearance is the first impression that we use to assess the status of growing plants. Unfortunately, visual symptoms are not specific enough to identify the particular nutrient or nutrients that may be deficient or the symptoms caused by other factors—insect injury, diseases, restricted root growth. The other problem with using visual observation of plant symptoms to diagnose nutrient deficiencies is that significant yield losses may have already occurred by the time the symptoms appear. Always confirm visual diagnosis with chemical analysis in the laboratory or test strips with selected fertilizers. Many times it is discovered after the seeding is made that yes we should have taken a soil test, perhaps it would have helped avoid the problem we are now confronting. Yes, asking the plant can be a very effective tool to diagnose what fertilizer nutrient, seed treatment or soil amendment is necessary to provide the best growing situation for the alfalfa crop.

DISCUSSION

If an alfalfa field shows visual color differences or the grower wishes to set up a monitoring program to assure optimum crop growth, plant sampling and laboratory analysis for nutrient evaluation offers considerable benefit. Taking samples representing the areas of good and poor growth is usually the most desirable when these differences can be observed. For setting up long-term crop monitoring/sampling locations, it is most beneficial to select

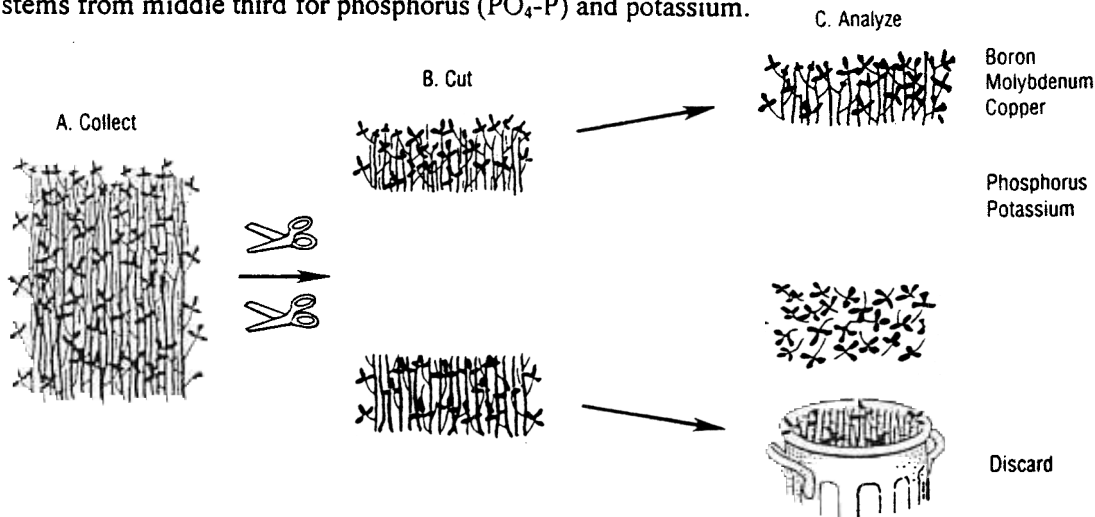
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areas in fields based on crop productivity levels. Nearly every field will have a 2 to 3 fold yield difference between the lowest yielding 10% and the highest yielding 10% of the field. It is suggested that benchmark areas of 50 feet by 50 feet in size be located in the lowest, intermediate and highest yielding parts of the field from which soil and plant tissue samples will be taken. To ensure that you will be able to find each benchmark area again, describe it in relation to measured distances to specific landmarks on the edge of the field. By using this method to collect soil and plant tissue samples, you will be able to compare areas of the field with different production levels, develop appropriate management responses, and track changes over the years.

Plant tissue testing is by far the most precise method of determining the nutrient needs of alfalfa. Such tests are the best reflection of what the plant has taken up and are more accurate than soil tests, particularly for sulfur, boron and molybdenum. Plant tissue tests are useful in monitoring the nutritional status and evaluating the effectiveness or current fertilization practices. The best time to take a tissue sample is when the crop is in the 1/10 bloom growth stage or when regrowth measures ¼ to ½ inch in length. Since alfalfa is often cut prior to 1/10 bloom to attain high-quality forage (for example, bud stage), nutrient concentrations should be approximately 10 percent higher than when sampled at 1/10 bloom. Samples can be collected at any cutting, but collection at first cutting is preferred because it is the best time to detect a sulfur deficiency. Collect 40 to 60 stems from at least 30 plants in each of the benchmark areas.

Different plant parts are analyzed for different nutrients (Figure 1). Cut each sample into three sections of equal length. Discard the bottom third; place the top one third in one paper bag and the middle one third in another. Dry the samples in a warm room or oven. After drying, separate leaves from stems in middle one-third sample by rubbing the sample between

Figure 1. Plant tissue sampling and testing: (A) Collect 40 to 60 stems including leaves from at least 30 plants. (B) Cut stems into three sections of equal length. (C) Discard the bottom third. Place the top third in one paper bag and the middle third in another. Dry the samples. Separate leaves from stems in middle third by rubbing between hands. Put leaves in one bag and stems in another bag. Analyze top-third sample for boron, molybdenum, and copper. Analyze leaves from the middle third for sulfur (SO₄-S) and stems from middle third for phosphorus (PO₄-P) and potassium.



your hands. Put leaves and stems into separate bags. Figure 1 lists the analyses that should be performed on the three sample sections. Table 1 gives guidelines for interpreting plant tissue-test results. Entire plant samples or baled hay samples are not recommended because they can only detect extreme nutrient deficiencies.

Table 1. Interpretation of test results for alfalfa plant tissue samples taken at 1/10 bloom.¹

Response Category ²	<u>Midstems</u>		<u>Midstem leaves</u>	<u>Top 1/3 of plant</u>	
	Phosphorus (PO ₄ -P) (ppm)	Potassium (Total K) (%)	Sulfur (SO ₄ -S) (ppm)	Boron (B) (ppm)	Molybdenum (Mo) (ppm)
Deficient	<500	<0.65	<400	<15	
Critical	500 – 800	0.65 – 0.80	400 - 800	15 – 20	0.3-0.9
Adequate	800 – 1500	0.80 – .50	800 – 1200	20 – 40	
High	>1500	>1.50	>1200	>200 ³	5 - 10 ⁴

1. Concentrations should be higher if alfalfa is cut at bud stage (multiply tabular values by 1.10)
2. An economic yield response to fertilizer application is very likely for values below the deficient level, somewhat likely for values in the critical level, and unlikely for values over the adequate level.
3. A concentration over 200 may cause reduced growth and vigor.
4. A concentration over 10 may cause molybdenosis in ruminant animals.

Tissue tests can determine only the single most limiting nutrient affecting plant growth—the concentration of other nutrients may actually increase due to reduced growth. Therefore, correct the most severe deficiency with a fertilizer application first. After it is corrected, take new plant tissue samples to determine if other nutrients are deficient. Also, low concentrations of a nutrient in plants may not always indicate a deficiency in the soil. Remember that plant analysis reflects nutrient uptake by the plant: a problem affecting roots, such as nematodes, can affect nutrient uptake as well.

Field Trial Results to Illustrate Plant Tissue Analysis-Alfalfa Yield Relationships

The first trial to be discussed was conducted in the Intermountain Region where both phosphorus and potassium were limiting the yield potential. The experiment was established with several rates of applied phosphorus and potassium alone and in combination. Fertilizer treatments were applied on the soil surface in June after the first harvest and only slight yield increases were measured by the third cutting in early September. Figure 2A illustrates the dramatic yield increase to applied phosphorus the first cutting of the following year, but little or no yield increase to applied potassium (Figure 2B). Figure 2A also shows that as phosphorus fertilizer rates were increased, yields increased as did midstem phosphorus levels but potassium levels in the plant tissue were decreased slightly. Likewise, phosphorus tissue levels and yields stayed the same or increased slightly as midstem potassium levels increased when rates of

Figure 2. Alfalfa yield, midstem $\text{PO}_4\text{-P}$ and midstem K response to applied phosphorus (A) and applied potassium (B).
 (Shasta County, Daniel B. Marcum and Roland D. Meyer)

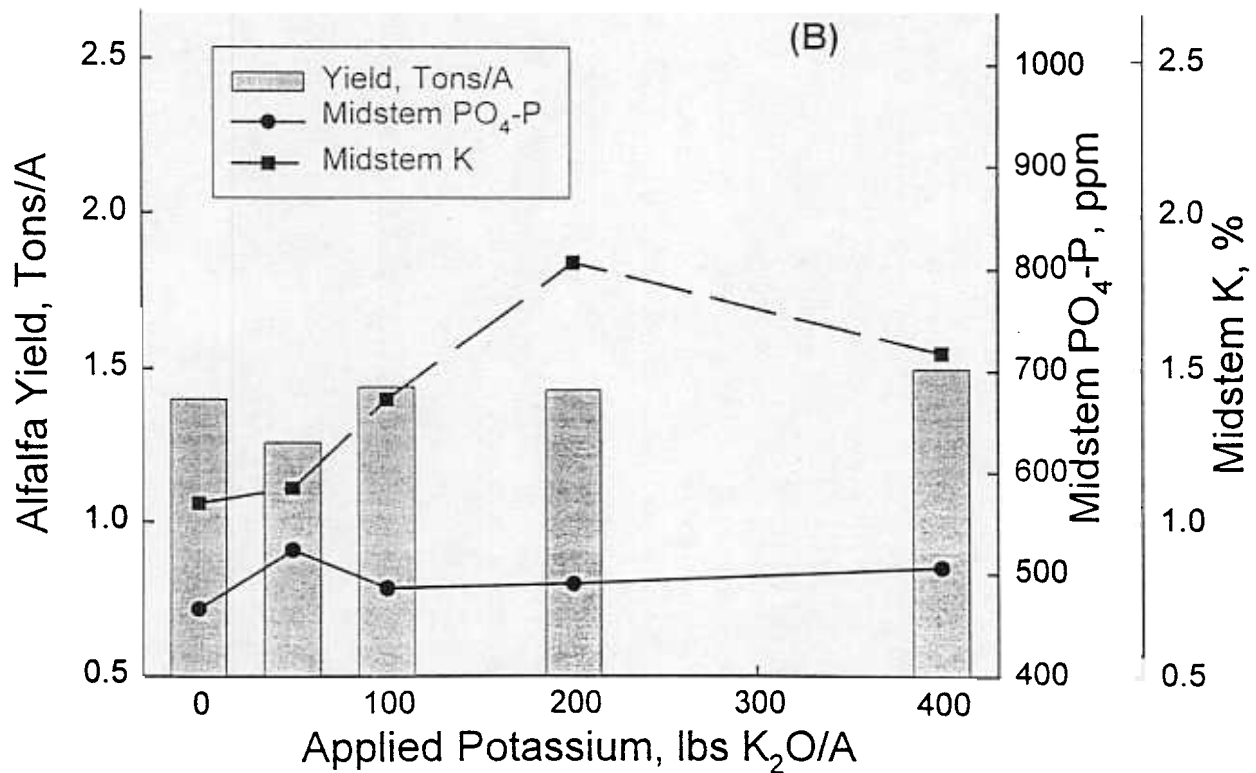
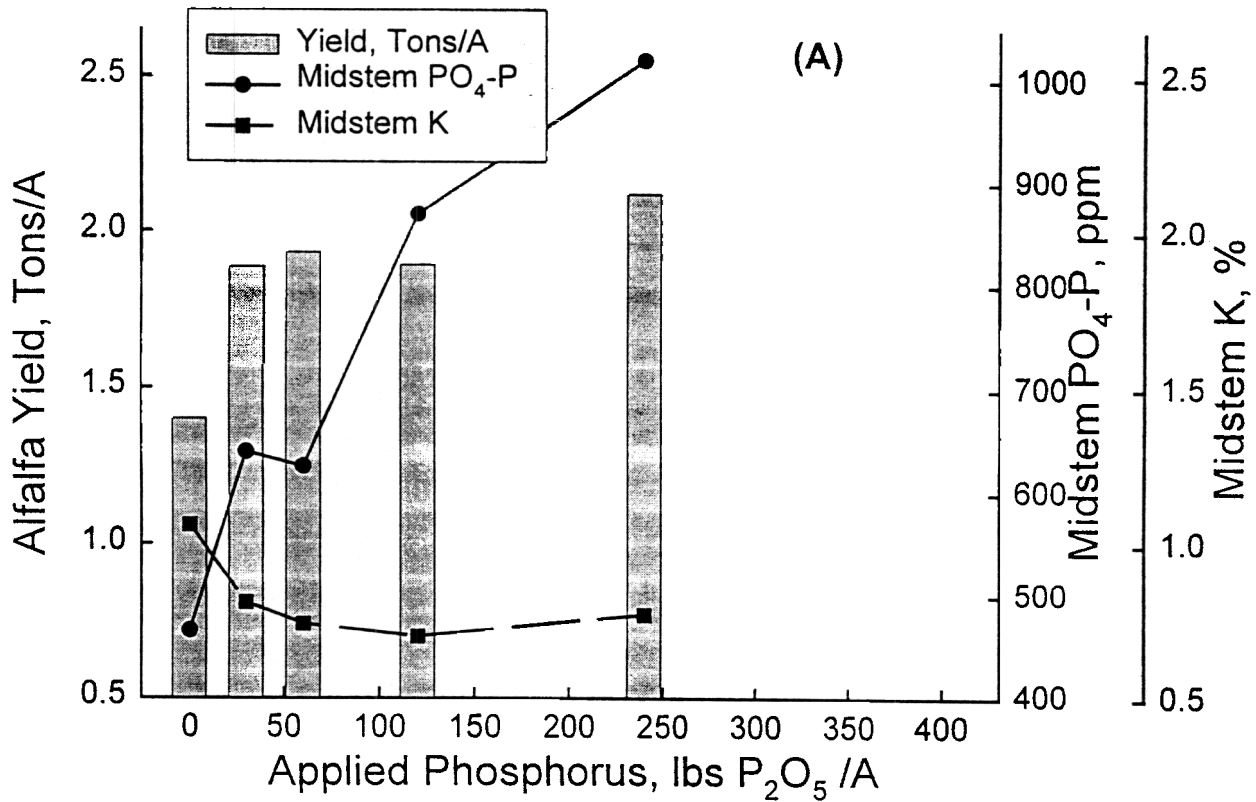
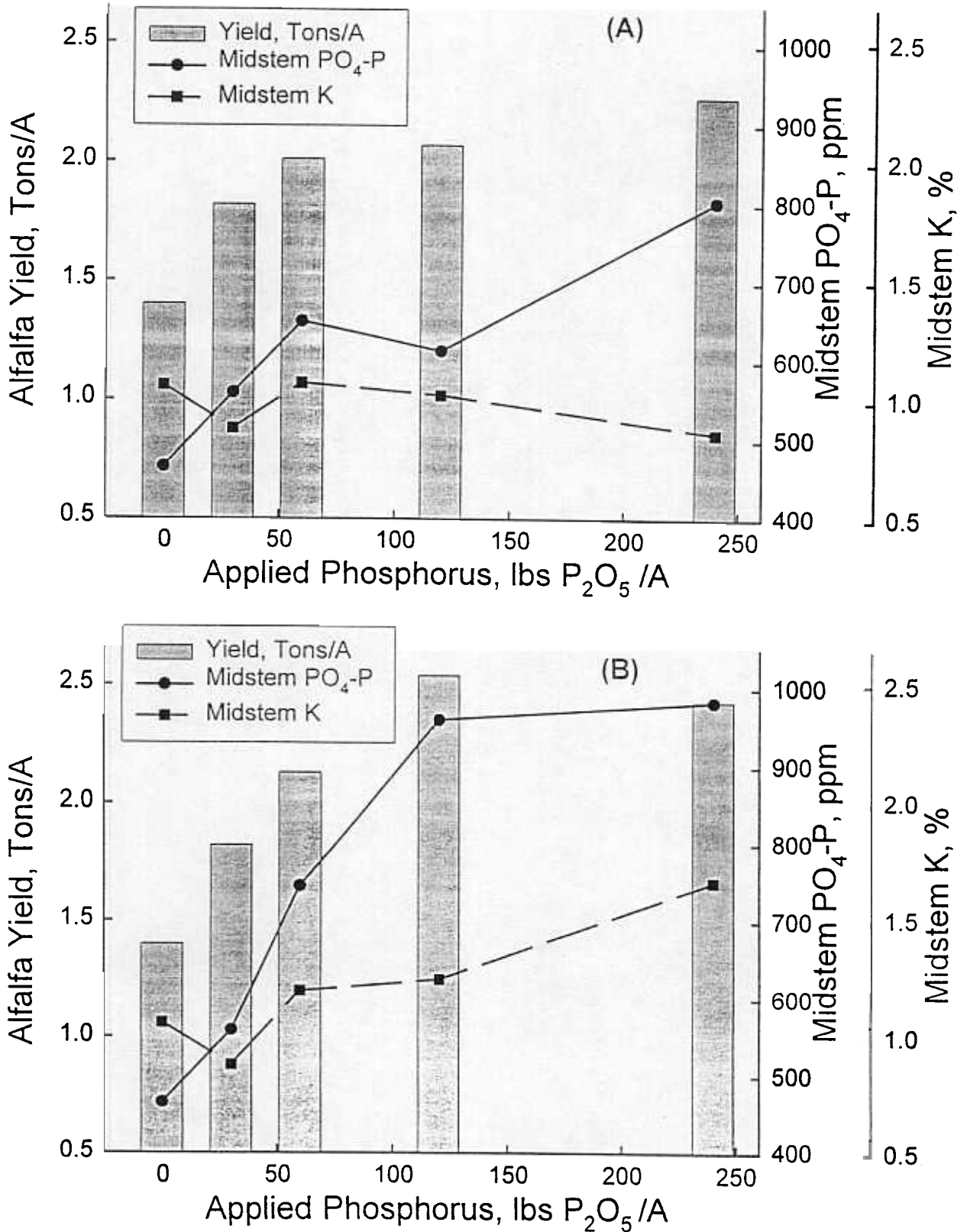


Figure 3. Alfalfa yield, midstem $\text{PO}_4\text{-P}$ and midstem K response to applied phosphorus with low rates of potassium (A) and high rates of potassium (B). (Shasta County, Daniel B. Marcum and Roland D. Meyer).



applied potassium fertilizer were increased (Figure 2B). Figure 3A shows that when phosphorus was combined with low rates of potassium (0, 50, 100 and 200 lbs K₂O/A), yields and midstem phosphorus levels increased but potassium tissue concentrations remained nearly the same. It required higher rates of applied potassium (50, 100, 200 and 400 lbs K₂O/A) along with the phosphorus to increase yield, midstem phosphorus and midstem potassium (Figure 3B).

Many growers have asked the question, "when I need phosphorus, what rate and how often should I apply it?" To develop an answer to this question an experiment was initiated on a site known to be phosphorus deficient based on plant tissue samples. Table 2 gives the rates and times when phosphorus was applied on the soil surface in the winter of each year. Alfalfa yield responses to the different treatments are given in Table 3. Note the large yield response during the first year (three cuttings in 1989) after the application of phosphorus in the winter of 1988. The 50 lbs P₂O₅/A treatment resulted in a 2.47 tons/A increase in alfalfa yield with the 400 lbs P₂O₅/A treatment giving a 5.71 tons/A increase. It can be observed that by the third year (1991) the single 200 lbs P₂O₅/A application (treatment #4) did not record as high a yield as either the three annual 50 lbs P₂O₅/A applications (treatment #2) or the two applications of 100 lbs P₂O₅/A (treatment #3). Nearly the same result occurred for treatments 5,6 and 7. During the fourth year, both of the treatments receiving annual phosphorus applications (#2 & 5) recorded higher yields than either the single application (treatments #4 & 7) or the two-every other year treatments (#3 & 6).

Table 2. Rates and times of phosphorus application on the soil surface to an established stand of alfalfa. (Lassen County, Jerry L. Schmierer and Roland D. Meyer)

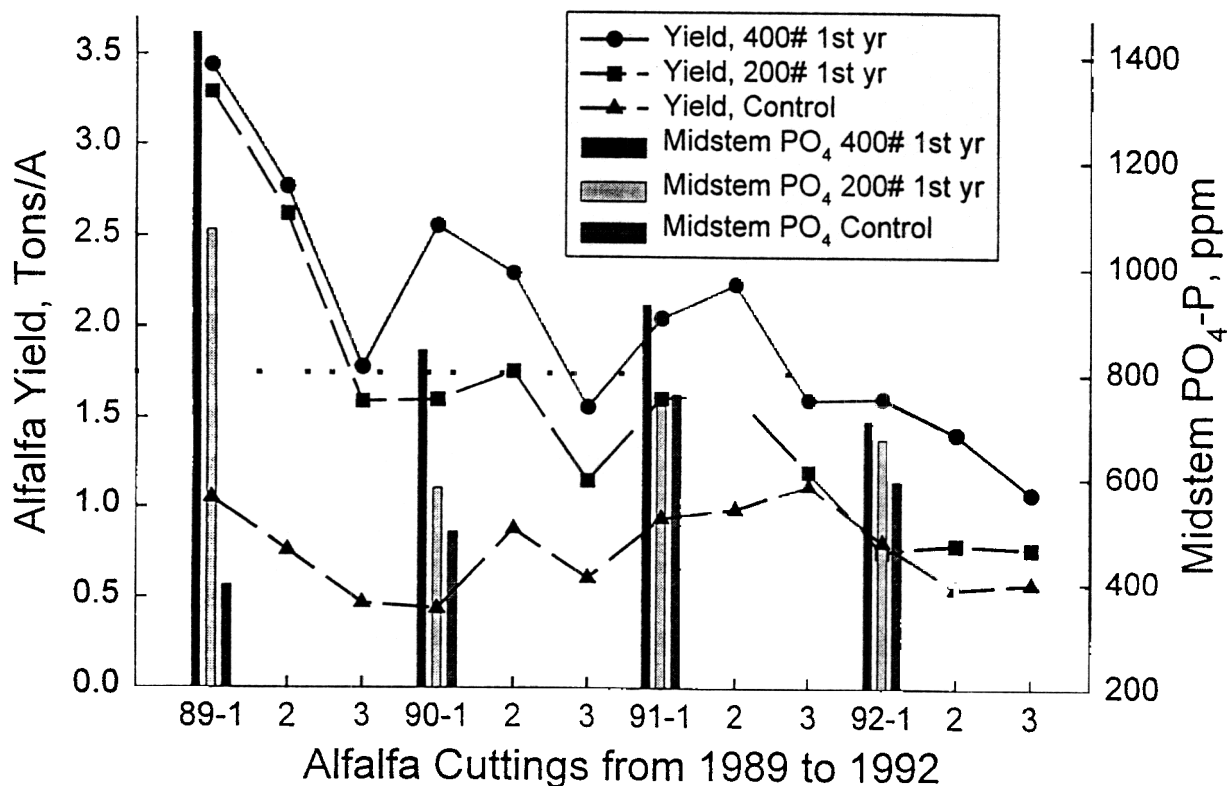
Treatment Number	Rate & No. of Applications	Phosphorus applied (lbs P ₂ O ₅ /A)				
		1988	1989	1990	1991	Total
1.	0	0	0	0	0	0
2.	50 x 4	50	50	50	50	200
3.	100 x 2	100	0	100	0	200
4.	200 x 1	200	0	0	0	200
5.	100 x 4	100	100	100	100	400
6.	200 x 2	200	0	200	0	400
7.	400 x 1	400	0	0	0	400

Table 3. Alfalfa yield response to phosphorus (11-52-0) applied on the soil surface in the winter prior to each year of harvest indicated. (Lassen County, Jerry L. Schmierer and Roland D. Meyer).

Treatment Number	Rate & No. of Applications	Forage yield (Tons DM/A)				
		1989	1990	1991	1992	Total
1.	0	2.27	1.93	3.06	1.94	9.20
2.	50 x 4	4.74	3.83	5.37	4.41	18.34
3.	100 x 2	6.38	3.10	5.59	3.80	18.87
4.	200 x 1	7.50	4.50	4.44	2.32	18.76
5.	100 x 4	6.55	5.22	5.56	5.45	22.77
6.	200 x 2	7.24	4.69	6.12	4.89	22.94
7.	400 x 1	7.98	6.41	5.89	4.10	24.38

Figure 4 illustrates the alfalfa yields for three cuttings per year--1989 through 1992 along with the midstem PO_4 -P levels in the first cutting of each year in response to the phosphorus treatments 400, 200, or 0 lbs P_2O_5/A applied the winter of 1988. Note the decline in both the alfalfa yields and the midstem PO_4 -P levels over the 4-year period. Also note that the midstem PO_4 -P levels for the 0 and 200 lbs P_2O_5/A treatments are well below the desired 800 ppm level in the first cutting of 1990 and that even the 400 lbs P_2O_5/A treatment had a midstem PO_4 -P level only slightly greater than 800 ppm. Even with slightly higher midstem PO_4 -P levels the first cutting of 1991 the yields and midstem PO_4 -P levels decline in 1992. Figure 5 shows the alfalfa yields for three cuttings per year--1989 through 1992, and midstem PO_4 -P levels in the first cutting each year in response to phosphorus applied as 400 lbs P_2O_5/A the first year only and 100 lbs P_2O_5/A annually for four years. Note first of all that the data given for the 400 lbs P_2O_5/A the first year only treatment is the same as in Figure 4. Observe that in the first cutting of 1991, the midstem PO_4 -P level for the 3 annual applications of 100 lbs P_2O_5/A treatment is substantially higher than for the 400 lbs P_2O_5/A the first year only treatment and that yields are similar for the two treatments in the second and third cuttings of 1991. During 1992, when both treatments had received a total of 400 lbs P_2O_5/A , the yields and midstem PO_4 -P level are much higher for the 100 lbs P_2O_5/A annually for four years treatment than for the single application of 400 lbs P_2O_5/A in the winter of 1988. Noting the low midstem PO_4 -P level in the first cutting of 1990, a grower would probably have chosen to apply additional phosphorus during the 1990 growing season even though 400 lbs P_2O_5/A was applied a year earlier so that optimum yields would have been maintained.

Figure 4. Alfalfa yields for three cuttings per year 1989-1992, and midstem PO₄-P levels in the first cutting each year in response to phosphorus (400, 200, or 0 lbs P₂O₅/A) applied the winter of 1988. (Lassen County, Jerry L. Schmierer and Roland D. Meyer).



SUMMARY

Tips when using plant tissue sampling and analysis to guide fertilizer applications:

- Establish permanent benchmark areas (50 ft. by 50 ft. in size) for sampling in the lowest, intermediate and highest yielding portions of the field.
- Conduct plant tissue sampling early (first cutting) so that fertilizer applications can be made mid to late season and sample mid season to guide winter-early spring fertilizer applications.
- Expect alfalfa growth response to phosphorus and potassium applied on the soil surface 60 to 90 days after fertilizer application.

Apply fertilizer to correct nutrient deficiencies detected with plant tissue analysis after careful consideration of the amount of nutrients removed by alfalfa, the yield potential of the field, current soil-test levels, and historical responses to fertilization. Consult the publication "Intermountain Alfalfa Management" University of California, Division of Agriculture and Natural Resources Publication #3366 Chapter 5 for a more comprehensive discussion of alfalfa fertilization.

Figure 5. Alfalfa yields for three cuttings per year 1989-1992, and midstem $\text{PO}_4\text{-P}$ levels in the first cutting each year in response to phosphorus applied as 400 lbs $\text{P}_2\text{O}_5/\text{A}$ the first year only or 100 lbs $\text{P}_2\text{O}_5/\text{A}$ annually for four years. (Lassen County, Jerry L. Schmierer and Roland D. Meyer).

