USING CORED BALE SAMPLES TO ASSESS ALFALFA'S NUTRIENT NEEDS

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INTRODUCTION

Adequate plant nutrition is paramount to achieving high alfalfa yield. In addition, nutrient management is an important environmental issue and cost for agriculture. Ever increasing fertilizer costs are a major concern of alfalfa producers and cause growers to question the profitability of applying fertilizer. This is especially true this year because phosphorus prices have skyrocketed to new levels. Figure 1 shows typical retail prices for the most popular phosphorus fertilizer in the West (11-52-0) over the last five years. 11-52-00 prices had been stable for the last 10 years selling for between $260 - $295/ton. Starting about 15 months ago, the price reached $350 per ton and has currently soared to over $700/ ton. These prices underscore the importance of adequately assessing the fertilizer status of your alfalfa field.

Most growers currently fertilize based on past practice with little idea of the actual nutrient status of the field, virtually guaranteeing that many fields have either too much or too little fertilizer applied. Excess fertilizer applications can cause environmental degradation, as well as higher production costs. On the other hand, too little fertilizer may result in dramatically lower yields and poor profitability.

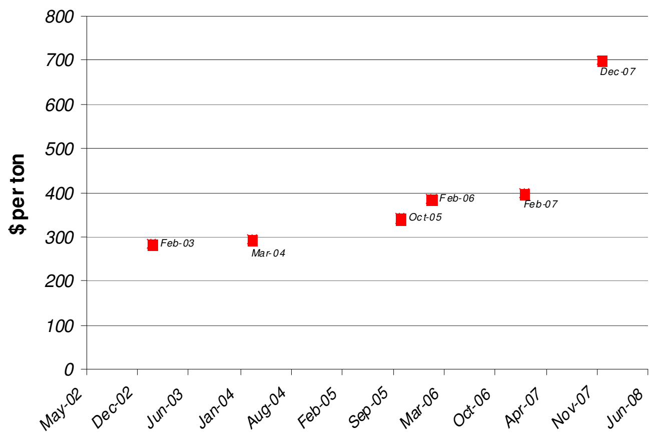

Figure 1. Typical retail price for 11-52-0 over the past 5 years.

The nutrient needs of an alfalfa field can be evaluated using visual plant symptoms, soil analysis, plant tissue analysis, and fertilizer test strips to confirm a suspected nutrient deficiency. As a rule, plant symptoms are unreliable. Many deficiency symptoms are not definitive or readily observable. For example, phosphorus deficiency (the most common nutrient deficiency) is characterized by stunted plants with small leaves that are sometimes dark blue-green. However, these symptoms are also caused by several other common conditions including moisture stress. In addition, significant yield losses may be incurred before visual symptoms become apparent. Soil analysis is valuable but can only provide an estimate of what the plants may be able to uptake. Soil tests are best prior to planting but thereafter plant tissue tests are usually superior to detect nutrient deficiencies. Table 2 shows the relative reliability of soil and plant tissue analysis for detecting a nutrient deficiency.

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Table 1. Relative reliability of soil and plant tissue testing for nutrient deficiency.

NUTRIENT	SOIL TESTING	TISSUE TESTING
Phosphorus	Good	Excellent
Potassium	Good	Excellent
Sulfur	Very poor	Excellent
Boron	Poor	Excellent
Molybdenum	Not recommended	Excellent

Despite the reliability of plant tissue tests, most alfalfa growers at the present time do not conduct tissue testing to assess fertilization needs. The current University of California (UC) recommendation is to sample the standing crop at 10% bloom, and fractionate the sample into three parts (tops, mid stem, and mid-stem leaves) and analyze the different plant parts for specific nutrients. Unfortunately, this process may be too cumbersome for routine analysis and is expensive, as many labs charge producers for three separate samples. Samples must be collected prior to cutting by walking through the field and randomly selecting at least 40 – 60 stems from at least 30 plants. Growers are typically extremely busy during the season when fields are being cut and it is obviously not possible to sample fields after the growing season is completed.

Many other states recommend using the top one-third of the plant for nutrient analysis. This is simpler than fractionating the plants but the sample collection process is still time consuming and usually does not get done. Even though plant tissue testing is far more accurate than soil sampling (it better reflects nutrient uptake and avoids limitations of soil sampling and nutrient extraction), plant tissue testing has not been widely adopted.

Many growers routinely take cored samples of haystacks for forage quality analysis (ADF, NDF, CP and DM) with the current emphasis on forage quality testing of alfalfa for the dairy industry. In order to encourage adoption of plant tissue testing for nutrient analysis, we initiated a multiyear project to evaluate the feasibility of using a cored-hay sample for both nutrient and forage quality analysis. If such methods are valid, this could be incorporated into routine testing practices and greatly simplify the tissue analysis process and reduce costs. Also, due to the fact that core sampling of hay stacks represents a wide range of plant material (greater than standing crop samples), it may be more successful at representing the average nutrient concentration values of a field.

Samples were collected over the 2006 and 2007 growing season to compare bale samples or whole-top samples with the standard UC-recommended tissue testing protocol involving fractionating plant parts. Samples were collected per year from the fields of 15 to 20 cooperating farmers each year. Standing plant samples were taken just prior to cutting immediately ahead of the swather. Three different locations in each field were sampled. The standing plant samples from each location were halved and analyzed as both whole tops and the fractionated plant part method for specific nutrients. Cored bale samples and soil samples were taken from each respective area before the hay was hauled off the field.

There are indications that the phosphorus level in alfalfa plant tissue declines as the plant matures. However, current recommendations are based on alfalfa at one-tenth bloom and do not account for the effect of alfalfa maturity. Therefore, additional field studies were initiated to evaluate the effect of alfalfa maturity in order to develop critical phosphorus levels for different growth stages since most alfalfa is no longer harvested at the one-tenth bloom stage). In addition, since the cored-bale samples show potential to be used for phosphorus analysis, critical values are needed for whole tops (rather than the critical values we currently have for mid-stems). Fertilizer rate studies were established in 2006 and 2007 with a range of phosphorus rates (from 0 to 180 lbs P_2O_5 per acre). Plant samples were taken at different growth stages and at harvest (3-4 sampling dates per cutting for the first two cuttings). This will enable us to better define critical values for different alfalfa growth stages and determine critical values for whole-top samples (similar to cored-bale samples) versus mid-stem samples.

Our goal is to develop different critical phosphorus concentration levels for alfalfa at various maturity levels. However, it can be difficult to assess alfalfa maturity and the commonly used descriptive terms such as pre-bud, mid-bud, late-bud and one-tenth bloom are vague and subject to user interpretation. Alfalfa maturity is strongly correlated with its fiber concentration [both acid detergent fiber (ADF) and neutral detergent fiber (NDF)]. Therefore, the value of using ADF or NDF as an indicator of plant maturity to adjust critical values is also being assessed.

RESULTS

Laboratory analysis for the 2006 samples has been completed, but the results for 2007 are still pending. The results for the 15 different grower fields that were sampled during the 2006 growing season show a wide range in fertility status—all the way from very deficient to high. Mid-stem phosphorus values ranged from a low of 283 to a high of 1980 (300–550 is considered *Deficient* while >1500 is considered to be *High*). Soil levels ranged from 2.4 to 49.1 ppm phosphorus where values less than 5 ppm are considered *Deficient* and values above 20 ppm are *High*.

This wide range of phosphorus values in plant tissue and soil emphasizes the importance of conducting plant tissue and/or soil tests. Many growers do not have an adequate assessment of the fertility status of their field, which is extremely important with today's alfalfa prices and fertilizer costs.

Table 2. Mid-stem phosphate-P and soil P levels (ppm) for 15 alfalfa fields in the Intermountain Region of Northern California. Values shown represent an average of three samples.

	Midstems	Soil	
Grower	PO4-P	pH	Olsen-P
A	*1663*	*5.8*	*37.0*
B	*1187*	*7.2*	*3.2*
C	*950*	*7.3*	*11.2*
D	*623*	*6.9*	*6.9*
E	*1317*	*7.2*	*9.5*
F	*283*	*7.2*	*2.4*
G	*1043*	*7.4*	*4.9*
H	*1093*	*5.6*	*49.1*
I	*1247*	*6.9*	*9.2*
J	*1347*	*7.0*	*14.6*
K	*1980*	*7.3*	*21.5*
L	*1787*	*6.7*	*32.9*
M	*1150*	*7.2*	*6.1*
N	*517*	*7.2*	*2.2*
O	*1103*	*7.6*	*4.5*

Figure 2 shows the relationship between both whole top and bale PO_4-P and soil phosphorus level. Phosphorus levels in plant tissue increased as soil phosphorus level increased up to about 20 ppm. While plant tissue levels decreased after that point is unclear. However, plant tissue levels were well correlated with soil phosphorus content when soil levels where in the deficient to adequate range (from 0 to 20 ppm).

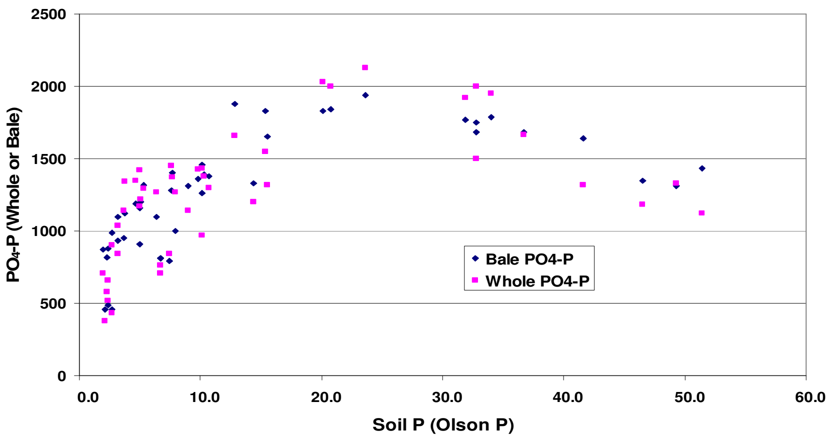

Figure 2. Relationship between soil phosphorus level (Olsen P) and the phosphorus content of bales and whole tops for 15 different alfalfa fields in the Intermountain Region of Northern California.

The results to date suggest that bale sampling for phosphorus may be a viable alternative to sampling standing plants and analyzing the mid stem section for phosphorus (the current UC method). The two methods were strongly correlated (R^2= 0.7945). Not only is the bale sampling method much easier, it could be superior because the sample may more accurately represent the whole field (many more plants sampled) than 40–60 stems sampled at random. Only phosphorus has been evaluated to date but we are also analyzing the samples for potassium and sulfur. The critical values in whole plant samples taken from bales are shown in Table 3.

Table 3. Interpretation of test results for alfalfa plant tissue samples taken at 1/10 bloom for whole plant samples collected from baled hay.

Nutrient		Deficient	Marginal	Adequate	High
Phosphorus	%	<0.20	0.21-0.22	0.23-0.30	>0.30
Potassium	%	<0.80	0.81-1.09	1.10-1.40	1.40-3.00[c]
Sulfur	%	<0.20	0.20-0.22	0.23-0.30	>0.40[d]
Boron	ppm	<15	16-20	21-80	>200[e]
Molybdenum	ppm	<0.3	0.4-1.0	1-5	5-10[f]

The fertilizer rate study showed that phosphorus concentration declines significantly as the alfalfa matures. To meet the forage quality demands of the dairy industry, most growers do not harvest at the one-tenth bloom stage, the maturity stage plant tissue levels are based on. Original estimates were that tissue levels should be multiplied by 1.1 if alfalfa was harvested in the bud stage instead of one-tenth bloom. However, it appears that the difference is much greater and that bud-stage alfalfa should have significantly higher levels than that. Figure 4 shows the phosphorus levels in mid stems and whole tops as alfalfa matures from early bud to late bud to one-tenth bloom. Tissue levels appear to decline more dramatically in mid stems than in the whole plant samples.

CONCLUSION

Plant tissue testing is extremely important with the current high prices for fertilizer. While results are still preliminary, initial results indicate that a new method of tissue testing using cored bale samples shows significant promise to assess the fertility status of an alfalfa field.

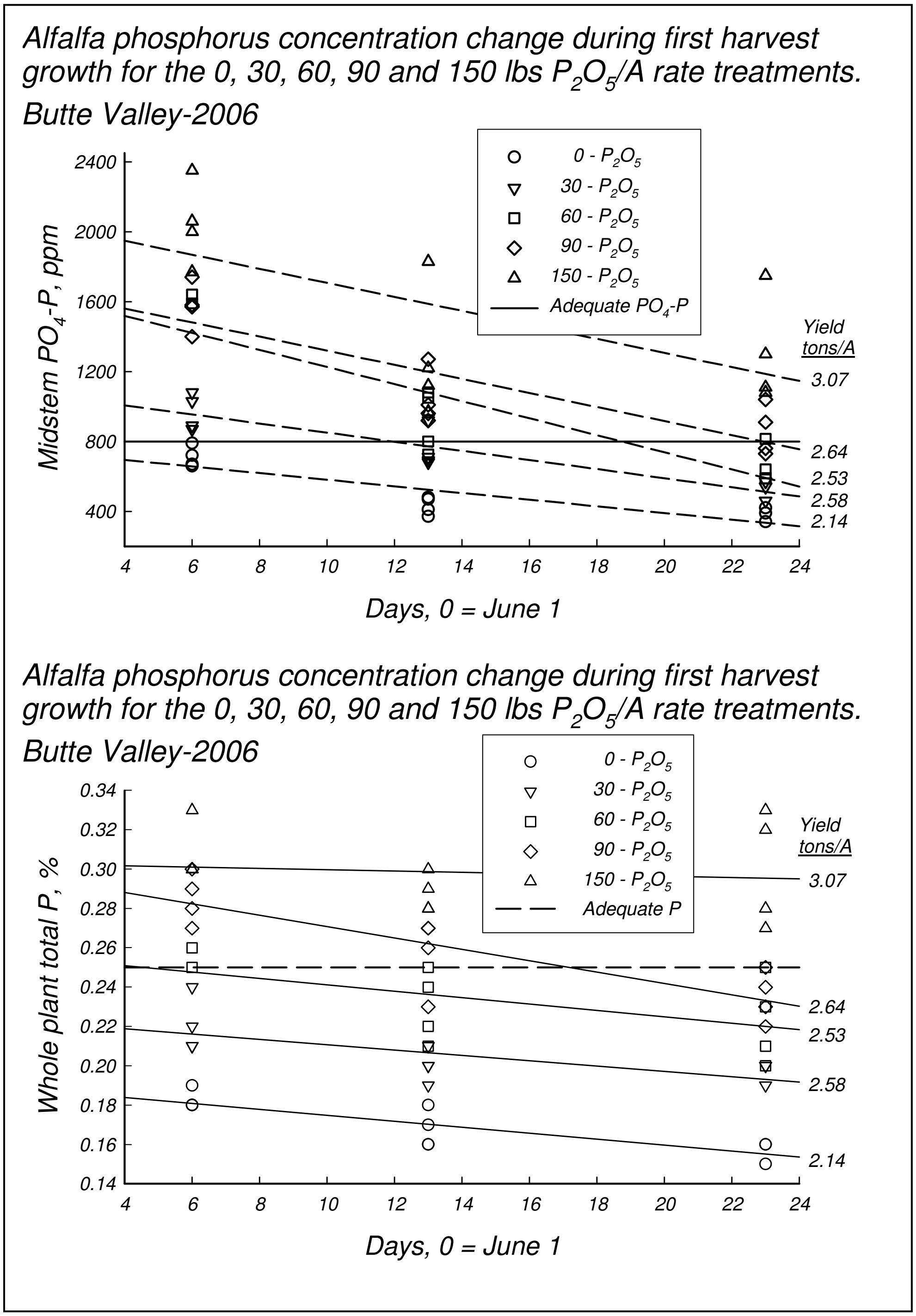

Figure 3. Alfalfa concentration change in mid stems and whole plant samples for 0, 30, 60, 90 and 150 P_2O_5/A rates.