Maximizing Returns in an Alfalfa Fertility Program

Daniel B. Marcum[1] and Roland D. Meyer[2]

Abstract

Most alfalfa fields in Northeastern California require application of fertilizer to obtain high yields. The most common fertilizer needs are for the essential mineral supplied elements sulfur, phosphorus, potassium, molybdenum and boron. Successful fertilizer programs include careful analysis of factors limiting growth of alfalfa in the field to be fertilized, systematic use of diagnosis by soil and tissue sampling, and measurement of yield response to fertilizer.

Key Words: alfalfa, fertilizer

Introduction Alfalfa is a desirable crop for forage production in Northeastern California because it does not need costly nitrogen fertilizer and an economical demand exists for the crop. Applied fertilizer is usually required for high, profitable yields. The basis for fertilizer needs of alfalfa come from the fact that the crop removes from the soil large amounts of essential mineral supplied elements (sulfur, phosphorus and potassium) and smaller amounts of essential minor elements (boron and molybdenum). When soil reserves of these minerals are depleted, yield declines as growth of alfalfa slows. This paper discuses corrective practices for these nutrient deficiencies in Northeastern California. Emphasis is placed on careful evaluation of yield potential, straightforward correction of mineral deficiencies and systematic evaluation of crop response.

The Importance of Understanding Yield Potential The potential yield that can be obtained by irrigated alfalfa in Northeastern California is high; about 8 tons per acre or more for a single season. Many factors can limit yields to less than that level. Some of the most obvious factors include insufficient water, nutritional deficiencies, thin stands, competition from weeds, and harvest scheduling. Thus, growers need to evaluate the yield potential of individual alfalfa fields, determine the factors or causes which limit yield and provide economical input to reach the expected yield goals. Always begin with the most limiting factor.

Usually only a single factor is the most limiting for growth; addition of other growth factors will fail to increase growth until the primary limiting factor is provided in adequate quantities for growth. An example of this commonly occurs with dryland alfalfa production. Many soils have low, but adequate, nutrients for low yield potential. In years of poor rainfall, moisture becomes the most limiting factor for growth. But, in years of high rainfall, alfalfa growth exceeds the capacity of the soil to provide essential elements and the shortage of the most limiting element becomes the most limiting factor to high yields. Once the essential elements are provided by fertilizer, soil moisture again becomes the most limiting factor to alfalfa growth.

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[1] Corresponding Author: Daniel B. Marcum, Shasta/Lassen Cooperative Extension, P.O. Box 9, McArthur CA 96056 (916) 336-5784.

[2] Extension Soils Specialist, Cooperative Extension, University of California, Davis CA 95616 (916) 752-2531

Another misunderstood yield potential factor is variety selection. A high yielding variety will not directly overcome the negative effects of other yield limiting factors. Usually, variety choice affects yield most significantly only when the yield potential of the field is high (i.e. 6 to 8 tons/acre), or when the the variety choice is responsible for managing a factor limiting high yields (i.e. providing disease and pest resistance to maintain growth and/or stand longevity). Thus, selection of a variety normally improves yield only after other non-variety yield factors such as water and fertilizer are adequate to allow the variety to reach it's full genetic potential.

The Importance of Proper Diagnosis of Mineral Nutrition Deficiencies in Alfalfa Profitable alfalfa fertilization requires a systematic approach to both diagnosis and correction of problems. Periodic soil and tissue samples should be obtained and records of the results should be carefully maintained to maximize benefits from the information. Historical information is invaluable in "fine tuning" an alfalfa fertilization program because the same questions repeat themselves year after year.

Alfalfa growers should understand that information from soil and tissue tests has limitations. Although soil tests can examine levels of more than one nutrient at a time, the results are usually less accurate than tissue tests. Tissue tests, on the other hand, often have a greater diagnostic capacity than soil tests, but can only evaluate one element at a time; the one most limiting to growth. The best detection of mineral nutrition deficiencies in alfalfa usually involves interpretation of a combination of soil and tissue testing information.

Soil and Tissue Test Interpretation Diagnostic information (soil and tissue test results) should be interpreted in relation to the yield potential of the field. If the yield potential of a field is less than 5 tons/acre then lower soil and tissue tests should be considered used to indicate the need for fertilizer. (Table 1). Conversely, if the yield potential of the field is 6 or more tons/acre, slightly higher soil and tissue tests should be used to indicate the need for fertilizer.

Table 1. Alfalfa Soil and Tissue Test Levels Which Indicate Need For Fertilizer.

	High Yield Potential	Low Yield Potential	High Yield Potential	Low Yield Potential
	Tissue Test	**Tissue Test**	**Soil Test**	**Soil Test**
Sulfur	less than 800	less than 400	-	-
Phosphorus	less than 800	less than 500	10 to 15	less than 10
Potassium	less than 1%	less than .65%	less than 120	less than 80
Boron	less than 20	less than 15	less than .2	less than .1
Molybdenum	less than .9	less than .3	-	-

Amounts of Fertilizer to Apply The amount of fertilizer to apply depends upon the yield potential of the individual alfalfa field. Table 2 shows a potential scenario for application of fertilizer to alfalfa under low yield potential conditions (4 to 5 tons/acre) and table 3 shows a scenario for application of fertilizer to alfalfa under high yield potential conditions (6 to 8 tons/acre). Note that soil and tissue testing is recommended at least every other year to provide a measurement to: 1) continually evaluate the need and response to fertilizer and 2) provide a basis for adjustment of fertilizer rates.

Table 2. Fertilizer Recommedations For Low Yield Potential Alfalfa - An Example.									
Soil/TissueTesting	Yes		Yes		Yes		Yes		
Year	1	2	3	4	5	6	7	8	
\\\\\\\\\\\\\\\\\\\\	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	Total
Nutrient	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac
Sulfur	200				200				400
Phosphorus	100			100			100		300
Potassium	150			150			150		450
Boron	5					5			10
Molybdenum	0.4								0.4

Table 3. Fertilizer Recommedations For High Yield Potential Alfalfa - An Example.									
Soil/TissueTesting	Yes		Yes		Yes		Yes		
Year	1	2	3	4	5	6	7	8	
\\\\\\\\\\\\\\\\\\\\	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	Total
Nutrient	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac
Sulfur	300			300			300		900
Phosphorus	400	100	100	100	100	100	100		1000
Potassium	400	150	150	150	150	150	150		1300
Boron	5			5					10
Molybdenum	0.4								0.4

Fertilizer Choices For Alfalfa In Northeastern California Generally, the best bargain for fertilizer is the one that has the lowest cost per unit of nutrient. With a relatively low value crop such as alfalfa, cost containment is important. When more costly crops are produced such as vegetables or tree crops, more expensive fertilizer products may be desirable. Also, little if any, critical information exists to justify purchasing anything more than the basic nutrient products for alfalfa fertilization in Northeastern California. Some of the more common choices of fertilizer products for alfalfa are listed below.

Sulfur Sulfur is by far the most common mineral deficient in Northeastern California alfalfa fields. Yields can be depressed to less than 2 tons per acre by sulfur deficiency. The most popular long-term correction of sulfur deficiency comes from application of elemental sulfur. Although more economical than sulfate-sulfur sources, elemental sulfur needs 9 months or more in the soil for microorganisms to break the elemental sulfur down to sulfate-sulfur which is available to the alfalfa plants. Thus, applications of elemental sulfur need to be months before crop sulfur demand occurs. Incorporation of elemental sulfur into soil is also recommended to facilitate breakdown of the product into available sulfate-sulfur.

Rapid short term correction of sulfur deficiency may be done by application of sulfate-sulfur sources such as gypsum (17%S), ammonium sulfate (21%S) or even 16-20-0 (12-15% S) at planting or as a midseason application. The response of sulfur deficient alfalfa to sulfate-sulfur is rapid. Plants will turn from canary yellow to dark green in only a couple of weeks, but the growth and yield lost because of the deficiency before application of fertilizer is gone forever.

Phosphorus Phosphorus deficiency in alfalfa occurs primarily where yield potential is high (over 6 tons/acre per year). The most commonly used fertilizer is 11-52-0. On very deficient soils, large amounts of phosphorus fertilizer are needed to maintain yields. Although large applications of phosphate fertilizer applied at planting will last several years, growers usually apply small amounts every year or every other year to manage fertilizer costs. Because phosphate fertilizer moves very slowly in soil, preplant incorporation is preferred for the first application and subsequent surface applications should be made at least 3 months before the time a significant amount of phosphorus is needed by the alfalfa. Since 1992 some growers have used co-generation ash as a low grade phosphate source.

Potassium Potassium deficiency of alfalfa is relatively rare, but easily diagnosed by visual symptoms (flecking on leaves of selected individual plants), soil tests or tissue tests. The most commonly used fertilizer is 0-0-60. Fertilizer performance is similar to phosphate fertilizers; incorporation at planting followed by subsequent surface applications at least 3 months before the time a significant amount of potassium is needed by the crop. Also, since 1992 some growers have used co-generation ash as a low grade potassium source.

Boron Boron deficiency is relatively rare. Growers usually spot suspect plants and confirm the deficiency with a tissue test. The most common boron fertilizer is a 14.3% granule formulation applied at relatively low rates by air or with a grain drill on the soil surface. Care should be taken to not use high rates of boron prior to rotation to boron sensitive crops such as cereals.

Molybdenum Molybdenum deficiency is often confused with the other causes of yellow, stunted plants; nitrogen deficiency caused by poor inoculation on new fields and sulfur deficiency. Clear diagnosis is obtained only by tissue testing alfalfa, although a rapid greening response to application of a fertilizer lacking sulfur or molybdenum such as urea (46-0-0, 0%S) provides a strong clue that the nitrogen fixation process is not working properly. However, always take tissue samples to confirm molybdenum deficiency of alfalfa before applying any molybdenum to fields. Application of too much molybdenum or application of molybdenum to an alfalfa field which already had adequate molybdenum in the soil can lead to production of alfalfa hay high in molybdenum which could be potentially toxic to livestock. Sodium molybdate (40% molybdenum) is used for correction of this deficiency. The water soluble material must be sprayed on the soil surface, not on the leaves and stems. It is usually applied by airplane, sometimes in combination with dormant applications of herbicides on established stands.

Nitrogen Nitrogen deficiency of alfalfa is directly related to poor nitrogen fixation. Molybdenum deficiency causes nitrogen deficiency in alfalfa because of it's essential role in the nitrogen fixation process. In new alfalfa fields, nitrogen deficiency is sometimes caused by poor inoculation resulting from old or ineffective inoculum, or where hot dry conditions kill inoculum bacteria on seed before infection of the young alfalfa seedlings occurs. If poor inoculation occurs in a young stand of alfalfa, heavily inoculated seed (two to three times normal) may be drilled into the stand at 3 to 4 pounds/acre followed by a light irrigation. Sometimes ammonium sulfate (21% N, 24% S) can be used to stimulate growth in the young seedlings until inoculation bacteria increase, usually within one season. However, weed competition can also be stimulated with an application of ammonium sulfate so the practice is not encouraged unless weed populations are low and/or the grower has implemented weed control practices.

Fertilizer Costs and Returns Table 4 shows the cost of common fertilizers for alfalfa and the approximate cost per acre per year. Growers should verify the response of alfalfa to fertilizer by measuring yield in both treated and untreated field locations. A good way to do this is to simply not treat a few strips in the field and counting bales for 3 to 4 cuttings after the application. Measured yield increases can often be 1 to 2 tons/year from a single application of a single element. Nevertheless, growers should resample soil and tissue at least every other year to verify either the reoccurrence of a deficiency or the presence of an adequate nutrient level.

Table 4. Cost of Fertilizer For Alfalfa - Estimated 1994.

Element	Fertilizer Cost/Ton	Element Cost/LB	LB/Element/Year Low Yield	LB/Element/Year High Yield	Cost/Acre/Year Low Yield	Cost/Acre/Year High Yield
Sulfur	$90.00	$0.05	50	113	$2.34	$5.27
Phosphorus	$235.00	$0.26	38	125	$9.79	$32.64
Potassium	$229.00	$0.19	56	163	$10.73	$31.01
Boron	$662.00	$2.22	1.25	1.25	$2.78	$2.78
Molybdenum	$14,500.00	$18.13	0.05	0.05	$0.91	$0.91

Maximize Your Returns As yields increase from alfalfa, profits per ton of production usually increase because fixed costs become a smaller portion of production costs (Table 5). Also, as yields increase each increment of variable input (e.g. pounds of fertilizer or inches of applied water) becomes a larger percentage of the total production cost. But, as yields improve, the probablilty of a new factor slowing growth becomes greater and the risk of misidentification of the "most limiting factor" slowing growth increases. More factors become critical as alfalfa yields in a field increase. Growers should be very careful to avoid misidentifying the factor which limits yields below highest levels for the field.

Table 5. Generalized Production Cost Percentages for Alfalfa In Northeastern California.

	4 Tons/acre	Production %	8 Tons/acre	Production %
Cost				
Land	$100.00	27%	$100.00	16%
Stand	$60.00	16%	$60.00	10%
Water	$60.00	16%	$120.00	20%
Fertilizer	$26.55	7%	$72.61	12%
Harvest	$128.00	34%	$256.00	42%
Total	$374.55	100%	$608.61	100%
Cost/ton	$93.64		$76.08	
Income	$400.00		$800.00	
Net Income	$25.45		$191.39	

Economic losses from fertilizer usage occur where: 1) either the element is applied and not needed for growth or 2) where other factors limit the growth response to the fertilizer. Regular evaluation of the crop response to fertilizer is essential to a successful fertilization program.

Important Points to Remember When Fertilizing Alfalfa

---- Growers should fertilize alfalfa to match the yield potential of the crop. It makes little sense to fertilize heavily when the crop is light because of another factor limiting yield.

---- Growers should measure the crop yield response from fertilizer. Always leave an untreated portion of the field, put markers (steel "T" posts) at the edge of the field and write down the location so you can return for evaluation. Ideally, replicated unfertilized strips should be left in a field and bales counted to determine the benefits from fertilization. Even an observation of treated vs untreated windrows is better than the "treat everything" or "treat nothing" approach. Always evaluate the effect of your management decisions.

---- Growers should regularly use soil and tissue testing to evaluate fertilizer needs for alfalfa. There is no better way to fully understand your alfalfa fertility needs over a long period of time than to have a consistent set of records for each field. Research based recommendations provide a good beginning for a successful alfalfa fertilization program, but a truly successful program is one in which fields are continually evaluated and management practices are continually reexamined and adjusted to obtain high, profitable yields.

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