Assessing the Fertility Status of Alfalfa

Roland D. Meyer, Daniel B. Marcum and Steve B. Orloff*

Providing and maintaining an adequate fertility level for alfalfa is essential when producing high yielding excellent quality hay. A systematic approach is necessary to insure that proper diagnostic procedures are used to keep alfalfa growing rapidly with high quality being attained. To gain some prospective as to the nutrient quantities required, let us look at the amounts contained in alfalfa at several annual yield levels (Table 1). More nitrogen is contained in the crop than any other nutrient. The major source is nitrogen from the atmosphere as fixation occurs through the mutually beneficial relationship between the alfalfa plant and the nitrogen fixing rhizobia bacteria located in the nodules on the roots. Potassium and calcium are next in their relative amounts removed by alfalfa. In most situations the potassium supplied by soils is adequate to insure necessary quantities for maximum alfalfa yield production. However, there are several areas in the state known to be low in potassium as well as some sandy soils where response is likely. Calcium is adequately supplied by nearly all soils in California, but lime, which contains mostly calcium carbonate, is often applied when the soil pH is below 6.3 throughout a major portion of the soil profile.

Table 1. Nutrient removal by alfalfa hay 100% dry matter) at various yield levels.

Nutrient	Symbol	Crop removal, lbs/A		
		Four Tons	Six Tons	Eight Tons
Nitrogen	N	240	360	480
Phosphorus	P_2O_5	48	71	95
Potassium	K_2O	173	260	346
Calcium	Ca	128	192	256
Magnesium	Mg	27	40	53
Sulfur	S	16	24	32
Iron	Fe	1.5	2.3	3
Manganese	Mn	1	1.5	2
Chlorine	Cl	1	1.5	2
Boron	B	0.2	0.4	0.5
Zinc	Zn	0.2	0.3	0.4
Copper	Cu	0.06	0.1	0.13
Molybdenum	Mo	0.008	0.012	0.016

Table 2 lists the seventeen essential nutrients for plant growth plus an 18th nutrient, cobalt which is required by legumes for nitrogen fixation. The

*Roland D. Meyer, Extension Soils Specialist, Cooperative Extension, LAWR Dept., University of California, Davis, CA 95616 (916) 752-2531, Daniel B. Marcum, Farm Advisor, University of California Shasta/Lassen Cooperative Extension, P.O.Box 9, McArthur, CA 96056 (916) 336-5784 and Steve B. Orloff, Farm Advisor, University of California Siskiyou Cooperative EXtension, 1655 Main St., Yreka, CA 96097 (916) 842-2711.

table also gives the frequency of occurrence of nutrient needs for alfalfa. The nutrients that are most commonly needed by alfalfa are phosphorus, followed by sulfur, potassium and in some cases boron and molybdenum.

Table 2. Relative alfalfa fertilizer needs of the essential plant nutrients in California.

Nutrient	Symbol	Frequency of Occurrence
Nitrogen	N	Seldom[3]
Phosphorus	P_2O_5	Frequently[1]
Potassium	K_2O	Less Frequently[2]
Calcium	Ca	Never
Magnesium	Mg	Never
Sulfur	S	Less Frequently[2]
Iron	Fe	Very Rare
Manganese	Mn	Never
Chlorine	Cl	Never
Boron	B	Seldom[3]
Zinc	Zn	Never
Copper	Cu	Never
Molybdenum	Mo	Seldom[3]
Nickel	Ni	Never
Cobalt	Co	Never[4]

[1] Frequently - Over 25% of the acreage shows need for fertilization with this nutrient.
[2] Less Frequently - Less than 25% of the acreage shows need.
[3] Seldom - Less than 1% of the acreage shows need.
[4] Necessary for nitrogen fixation only.

Diagnosing Nutrient Deficiencies

Fertilizing alfalfa may involve considerable cost, thus it is important to properly identify which nutrients are needed to maintain rapid growth of high quality alfalfa. Four methods can be utilized to diagnose the nutrient status of alfalfa: 1) visual observation of deficiency symptoms, 2) soil testing, 3) plant tissue testing, and 4) applying strips of single nutrient fertilizers alone or in combination.

Visual observation of deficiency symptoms. This is perhaps the easiest and most striking method to detect deficiencies, but often the most difficult to positively identify inadequate supplies of one or more nutrients. Table 3 gives the nutrient deficiency symptoms that may be seen in alfalfa. Nitrogen, sulfur and molybdenum all show deficiency in the same manner, that of yellow, stunted growth of plants which most be confirmed by the use of a plant tissue test. The symptoms shown by alfalfa that are listed for phosphorus are not specific and may indicate a number of growth limiting factors including inadequate water or high salt levels in the soil. If more severe deficiencies of potassium or boron occur, the symptoms can be specific and identify quite positively the need for one of these nutrients. More detailed descriptions of deficiency symptoms are given in the discussion of each nutrient.

Soil and Plant testing. When a new planting is being considered, it is best to learn if the field has had any history of alfalfa, whether there were parts

Table 3. Nutrient deficiency symptoms in alfalfa.

Deficiency	Symptoms
Nitrogen	Generally yellow, stunted plants.
Phosphorus	Stunted plants with small leaves, sometimes leaves are dark blue-green.
Potassium	Pinhead yellow or white spots on margins of upper leaves. Yellow turning to brown leaf tips and margins of more mature leaves.
Sulfur	Generally yellow, stunted plants.
Boron	Upper part of plant has yellow top side of leaves with reddish-purple undersides and short internodes. Multiple stem tops of 3-5 internodes length may develop on a single plant stem.
Molybdenum	Generally yellow, stunted plants.

of the field that produced lower yields and, if so, sample the soil from each area separately. In addition to using soil testing to estimate the nutrient availability, sampling can be used to observe soil compaction, note layers that may impede root growth or water movement and collect soil at different depths for laboratory analysis of potential salt or other growth limiting conditions.

Soil and plant sampling procedures are critical, since samples should adequately reflect the nutrient status or growing conditions of the whole field. Because a representative sample of an entire field gives an average of all the variation in that field, it may not be the best for developing recommendations for certain parts of the field which are less productive and need specific treatment. Since most fields have some variation in crop growth and productivity, the best technique to use in sampling is to divide each field into two or three areas representing good, medium and poorer alfalfa growth. Within each area, permanent benchmark locations approximately 50 x 50 feet in size should be established (Figure 1). These permanent benchmark areas should be identified with measured distances to specific landmark points on the edge of the field so they can be sampled repeatedly over a ten to fifteen year period.

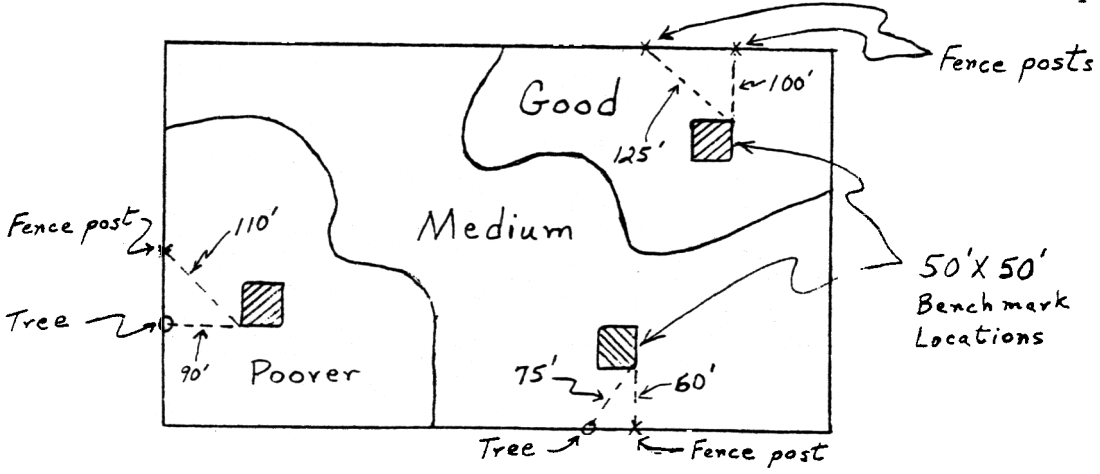

Figure 1. Soil and plant sampling procedure showing good, medium and poorer areas of alfalfa growth and how benchmark locations should be established.

Initially, both soil and plant tissue samples should be taken from these benchmark areas annually for 2 to 3 years. Once historical trends have been established, they can be sampled every 2 to 3 years or when alfalfa is replanted. Plant sampling at least annually should be used to more effectively guide fertilization practices. Another important point to remember is that soil and plant tissue testing differ in there ability to evaluate the nutrient status of alfalfa (Table 4). Plant tissue testing indicates directly which nutrients are at inadequate concentrations. Soil testing has the advantage of measuring each nutrient or characteristic independently while plant tissue testing indicates only the most limiting nutrient. Fertilization to supply an adequate amount of the most deficient nutrient most be done before other plant nutrient levels can be evaluated. The sampling approach described provides a more comprehensive manner in which to compare areas of the field with regard to yields, fertilizer inputs as well as soil and plant tissue test level changes over the years.

Table 4. Relative reliability of soil and plant tissue testing for diagnosing nutrient deficiencies in California.

Nutrient	Soil Testing	Plant Tissue Testing
Phosphorus	Good	Excellent
Potassium	Good	Excellent
Sulfur	Very poor	Excellent
Boron	Poor	Excellent
Molybdenum	Not recommended	Excellent

Soil Testing. The best time to sample soil is soon after an irrigation or rainfall when the soil is moist and the probe will easily penetrate the soil. Before taking a soil core, excess debris or plant residues should be removed from the soil surface. Samples can be taken with a shovel, but an "Oakfield" or similar sampling tube is preferred so that the soil depths are equally represented. Cores should be taken from the top 6 to 8 inches unless deeper depths should be evaluated for possible salt or acid soil conditions. Take 15 to 20 cores at random from each benchmark area, place in a plastic bucket, break up and mix thoroughly. A single composite sample of about a pint in size from each of the three benchmark areas should be placed in a double-thick paper bag and dried immediately at room temperature before mailing to the laboratory. To get a complete evaluation of the soils, request all of the tests listed in Table 5. A list of laboratories which perform soil analysis can be found in University of California Special Publication 3024, California Commercial Laboratories Providing Agricultural Testing. Table 6 gives guidelines for interpreting the results of soil nutrient analysis. Values are indicated for deficient, critical and adequate levels. An economic yield response to fertilizer applications is very likely for values below the deficient level, somewhat likely for values in the critical range and unlikely for values above the adequate level.

Plant testing. Plant tissue tests are used to measure the concentrations of various nutrients contained in plants. Since these tests reflect the rate that plants are taking up nutrients, they are usually much more accurate than soil tests, particularly for nutrients such as sulfur, boron and molybdenum. Samples can be taken of any cutting, but sampling the first cutting is pre-

ferred because it is the best time to detect a sulfur deficiency. It is important to remember that sampling most be done at a specific stage of growth and a particular plant part be used for the evaluation of each nutrient.

Table 5. Suggested tests on soil and plant tissue samples for guiding fertility programs in alfalfa.

Soil	Plant Tissue
pH[1]	phosphorus (PO_4-P)
phosphorus	potassium
potassium	sulfur (SO_4-S)
EC_e[1]	boron
calcium[1]	molybdenum
magnesium[1]	copper
sodium[1]	
SAR[1]	

[1]These tests evaluate factors that affect the availability of nutrients or the presence of undesirable salt levels. EC_e = electrical conductivity of saturation extract (mmho/cm). SAR = Sodium absorption ratio.

Table 6. Interpretation of soil test results for alfalfa production.

	Phosphorus	Potassium	
Response Category[1]	Bicarbonate[2] Extract	Ammonium[2] Acetate Extract	Sulfuric[2] Acid Extract
	(ppm)	(ppm)	(ppm)
Likely	<5	<50	<300
Probable	6 - 10	50 - 80	300 - 500
Unlikely	>10	>80	>500

[1]An economic yield response to fertilizer application is likely for values below the deficient level, somewhat likely for values in the critical range and unlikely for values above the adequate level.

[2]Soil test values are based on the use of the extract listed, values for other extracts are different.

The best time to take a plant sample is when the crop is in the 1/10th bloom growth stage or when regrowth measures 1/4 to 1/2 inch in length. Collecting 2 to 3 stems from about 30 plants for a total of 40 to 60 stems will make a good sample. Take one sample from each of the benchmark locations to provide the best information for making fertilizer decisions. Cut the 40 - 60 stem sample into three sections of equal length and discard the bottom third. Place the remaining two sections in paper bags marked top 1/3 and middle 1/3 along with the field location number and dry samples in a warm room or oven. After samples have dried, separate the leaves and stems of the middle 1/3 part

of the plants by letting the leaves fall between your fingers while rubbing and retaining the stems in your hand. Place the midstems in one bag for phosphorus (PO_4-P) and potassium analysis and the leaves from this middle section in another bag for sulfur (SO_4-S) analysis. The top 1/3 of the plant sample should be analyzed for boron, molybdenum and copper. A list of laboratories which perform plant tissue analysis can be found in University of California Special Publication 3024, California Commercial Laboratories Providing Agricultural Testing. Table 7 gives guidelines for interpreting the results of plant nutrient analysis. Values are indicated for deficient, critical and adequate levels. An economic yield response to fertilizer application is likely for values below the deficient level, somewhat likely for values in the critical range and unlikely for values above the adequate level.

Table 7. Interpretation of plant tissue test results for alfalfa production. Values are for samples taken at 1/10th bloom, levels should be approximately 10% higher at bud stage.

	Midstems		Midstem leaves	Top 1/3 of plant	
Response Category	Phosphorus (PO_4-P)	Potassium (Total K)	Sulfur (SO_4-S)	Boron (B)	Molybdenum (Mo)
	(ppm)	(%)	(ppm)	(ppm)	(ppm)
Deficient	300-500	.40-.65	<400	<15	<0.3
Critical	500-800	.65-.80	400-800	15-20	0.3-0.9
Adequate	800-1500	.80-1.5	800-1200	20-40	1 - 5
High	>1500	>1.50	>1200	>200[1]	5 - 10[2]

[1]More than 200 may cause reduced growth and vigor.
[2]More than 10 may cause molybdenosis in ruminants.

Fertilizer Strips. Applying single nutrient fertilizers such as treble superphosphate (0-45-0) as a phosphorus source, potassium chloride (0-0-60) as a potassium source or gypsum as a sulfur source at fairly high rates in strips across an alfalfa field provide an excellent way to observe growth responses. They should be applied alone and in combination if response is expected from several. Likewise, it is advisable when fertilizing the entire field to leave check strips across the field where no fertilizer is applied. Areas in the field which indicate a larger response should receive a higher rate of application during the next fertilization or an earlier reapplication. It is important to carefully mark the fertilized or unfertilized strips so that correct observations and management decisions can be made from these efforts. Also, if these strips are well marked and of convenient size for harvesting separately, bale counts and harvest weights can be taken to measure yield responses and determine economic benefit. Several points to remember are that phosphorus or potassium growth responses may require as much as 60 to 90 days or more before they become visible or can be measured. Sulfate-sulfur applications usually give an immediate (within 30 days) response if an irrigation or rainfall follows fertilization but elemental sulfur may require a much longer time before a response can be observed unless about 25 percent of the fertilizer has a very fine particle size (less than 100 mesh).

Correcting Nutrient Deficiencies

Nitrogen. Large quantities of nitrogen are needed to produce high yields and the desired protein levels. The major source is nitrogen from the atmosphere as fixation occurs through the mutually beneficial relationship between the alfalfa plant and the nitrogen fixing rhizobia bacteria located in the nodules on the roots. If this relationship is well established, there is seldom an economic yield response when alfalfa is fertilized with nitrogen. Nitrogen deficiency of alfalfa usually results from one of two situations: poor inoculation and nodule formation at planting or molybdenum deficiency.

Field symptoms of nitrogen deficiency caused by poor nodulation include plants which are generally light green or yellow and stunted, but also with scattered individual healthy plants which are inoculated and have grown taller and appear darker green in color. Poor nodulation is often associated with fields having no history of alfalfa production, outdated inoculant, or planting of seed in hot, dry seedbed conditions. To insure effective nodulation, inoculate seed with fresh inoculant and do not allow it to experience hot, dry conditions prior to germination. This is particularly critical in fields planted to a first crop of alfalfa. If poor nodulation is suspected in a young stand of alfalfa, heavily inoculated seed (2 to 3 times normal) may be drilled into the stand at 3-5 lbs seed per acre followed by a light irrigation. Usually after a growing season, all plants in the field will be inoculated.

Light green or yellow symptoms may also indicate sulfur and/or molybdenum deficiency and a plant tissue test can be used to identify the specific nutrient deficiency. Nitrogen deficiency may also result from a molybdenum deficiency since molybdenum has a role in nitrogen fixation by rhizobia bacteria. The correction of sulfur and molybdenum deficiencies will be discussed later in this chapter.

Phosphorus. As was indicated earlier in Table 2, phosphorus is perhaps the plant nutrient which most frequently limits maximum alfalfa production. The nature of phosphorus in soil chemical reactions is such that only low concentrations are normally available to growing plants. These concentrations are even much lower if soil temperatures are lower. Soil pH, whether acid where iron, aluminum and manganese tend to render phosphorus unavailable, or alkaline where calcium and magnesium precipitate phosphorus, should be in the desired range of 6.5 to 7.0.

Phosphorus deficiency is one of the most difficult if not impossible to identify visually. Stunted plants and small sometimes dark blue-green leaves are often listed as symptoms but without a strip of phosphorus fertilizer to contrast adequate and deficient plants, it is extremely difficult to say that the symptoms are caused by phosphorus. Although purple colored stems and leaves can be used in some other plants to indicate a lack of phosphorus, alfalfa can become very deficient without ever showing these symptoms. Since alfalfa grows well during periods of cool temperatures, particularly in the spring and fall, purplish plant parts are more likely to be caused by the wide day and night temperature changes. Phosphorus deficiency may be diagnosed by either a soil or plant tissue test. A soil test should be taken prior to planting to assess the phosphorus status of the soil. A plant tissue test is preferred after alfalfa has been established.

To correct a phosphorus deficiency, the higher analysis phosphorus fertilizers (0-45-0 or 11-52-0) are usually the most economical. They are equally effective in providing phosphorus to alfalfa. Even though phosphorus fertilizers have a wide range in water solubility, values greater than 55 percent are nearly equal in terms of plant availability. Rock phosphate is not recommended because of low phosphate availability, particularly when applied to anything other than very acid (pH<5.5) soils. Sometimes, the nitrogen-phosphorus-sulfur containing fertilizer, 16-20-0 (12 to 14 percent sulfur), is used by growers to stimulate young seedlings, but care must be taken to control weeds.

Recommended rates of phosphorus fertilizer to be applied to alfalfa are listed in Table 8. Preplant applications should be based upon soil tests and incorporated into the top 2 - 4 inches of soil before planting. Use plant tissue testing to determine the need after the seedling year. Applying phosphorus fertilizers on the soil surface in an established stand has been very effective. Fertilizer applications can be made any time, but during the fall early dormant season is preferred to allow time for the phosphorus to be moved into the soil by winter rains and be taken up as soon as root growth is initiated in the spring. Alfalfa responses to applied phosphorus fertilizer are often not seen until 60 to 90 days after application.

Table 8. Recommended phosphorus and potassium application rates for four and eight tons per acre yield levels when soil or plant tissue test values are deficient, critical or adequate.

Nutrient	Response Category					
	Deficient		Critical		Adequate	
	Alfalfa Yield Level					
	4 tons/A	8 tons/A	4 tons/A	8 tons/A	4 tons/A	8 tons/A
	Application Rate, lbs P_2O_5 or K_2O/A					
Phosphorus	60-90	120-180	30-45	60-90	0-20	30-45
Potassium	100-200	300-400	50-100	150-200	0-50	0-100

A range of application rates are given because some soils and growing conditions will require larger amounts to adequately meet the nutritional requirements and maintain high alfalfa yields. Various combinations of rates and timing of phosphorus fertilizer can be used to achieve the rates recommended. Recent research has indicated that fewer applications (at least every 2 years) of higher rates can be applied more economically than lower rates (less than 50 pounds P_2O_5 per acre) applied each year. Take plant tissue samples 60 to 90 days after a fertilizer application to re-evaluate the fertility status.

Potassium. Although potassium chemistry is much different in the soil, the rate of movement by water is comparable to only slightly greater than phosphorus. Fortunately, the majority of soils in California are well supplied with potassium bearing minerals. There are however several areas in the state where potassium responses have been noted, sandy or acid sandy soils on the east side of the San Joaquin Valley, large areas on the east side of the Sacramento Valley and a number of the intermountain valleys in the northeast-

ern part of the state.

Potassium deficiency symptoms are first observed as pinhead size white or yellow spots on the margins of upper leaves. As plants become more deficient, the older, mature leaf tips and margins become more chlorotic, turning from yellow to brown as the plant tissue dies. Unlike many other deficiency symptoms, those of potassium are distinctive and fairly reliable. Note, however, that several insects and diseases cause symptoms very similar to those of potassium deficiency. Potassium deficiency can be diagnosed by either a soil or plant tissue test.

The most economical fertilizer for correcting potassium deficiency is muriate of potash or potassium chloride (0-0-60). Sometimes potassium sulfate (0-0-52, 18 percent sulfur) is used when sulfur is also deficient. The potassium in potassium sulfate or other mixed fertilizers is often more costly however. Rates of potassium to be incorporated preplant based on a soil test are listed in Table 8. Subsequent surface applications should be based upon plant tissue analysis. Applications on the soil surface are very effective and can be made anytime. Like the response to phosphorus, the growth response to applied potassium may not be observable until 60 to 90 days after the fertilizer application.

Sulfur. Sulfur has been the most common nutrient deficiency in alfalfa for northeastern California and to a lesser extent the sandy soils of the upper San Joaquin Valley and the Sacramento Valley when soils are cold and wet. Sulfur deficiency symptoms include stunted growth with light green or yellow color very similar to those of nitrogen or molybdenum. Deficiency symptoms can appear at any growth stage of alfalfa. They are more apt to appear early in the spring soon after alfalfa starts growing when soil temperatures are cool and the soil is wet, perhaps even excessively wet or water logged. Under these cool and/or wet soil conditions the bacteria which provide plant available sulfate-sulfur may not be active enough to supply the amount needed for alfalfa growth. The above situation becomes even more severe when the supply of total sulfur in the soil is limited. Sulfur deficiency can only be diagnosed by plant tissue analysis as soil testing does not provide reliable results.

It is important to have an adequate supply of available sulfate sulfur in the soil at the time of planting. Two principal sources of sulfur can be used: 1) long-term slowly available elemental sulfur and 2) short-term rapidly available sulfate sulfur. The most economical practice is to apply and incorporate before planting 200 to 300 pounds of elemental sulfur per acre. Elemental sulfur is gradually converted to the sulfate form and will last from 5 to 7 years. To ensure a multiple-year supply of available sulfur, the particle size of elemental sulfur must range from large to small. Small particles are rapidly converted to the sulfate form; the large particles will continue to release sulfate over several years. Ideally, 10 percent of the elemental sulfur should pass through a 100-mesh screen; 30 percent, through a 50-mesh screen; and the remaining 60 percent, through a 6-mesh screen. Very fine grades of sulfur are readily available but do not persist long enough to provide a multiple-year supply.

Fertilizers used to supply the sulfate form of sulfur include gypsum (12 to 17 percent sulfur), 16-20-0 (12 to 14 percent sulfur), potassium sulfate

(0-0-52, 18 percent sulfur) or ammonium sulfate (21-0-0, 24 percent sulfur). Some growers apply 300 to 500 pounds gypsum per acre every other year rather than using elemental sulfur. The advantage to this practice is the quick response time in correcting sulfur deficient alfalfa (about 2 weeks). The disadvantages are the higher cost per pound of sulfur and the fact that more sulfur is applied than is necessary. Perhaps the most important reason to avoid overfertilization with sulfur is that it can decrease the selenium concentration in the alfalfa hay. Livestock producers throughout the Intermountain Region and several other areas of the state in particular want forage that is as high in selenium as possible because their animals often suffer from selenium deficiency.

Iron. Iron deficiency has been observed in alfalfa, but it is quite rare and plant tissue tests have only been marginally effective in confirming the deficiency. The deficiency is usually recognized by the nearly white or "canary yellow" appearance of the plants in affected spots of fields where drainage is poor. Iron deficiency in alfalfa is characteristically associated with high pH, poorly drained soils which are usually high in lime. If the soil pH is greater than 7.5 and free lime is present, correction of iron deficiency begins with application of high rates of elemental sulfur (at least 1000 pounds per acre) to lower the soil pH. Establishing good drainage in these low areas will often result in better alfalfa growth and reduce or eliminate the symptoms.

Boron. Boron deficiency has been observed in a number of the intermountain valleys and to a limited extent in the sandy soils of the eastern San Joaquin Valley. Adequate supplies of boron are far more important for alfalfa seed production than hay. Boron deficiency may be somewhat similar to the marginal chlorosis of potassium (yellow leaf tips and margins) but usually the undersides and sometimes the tops of the leaves are a reddish-purple. After an irrigation or when regrowth occurs, a new growing stem is initiated from the third or fourth leaflet below the top of the plant that appears normal at first, but the internodes (distances between new leaflets) become increasingly shorter and later, the leaves show the same yellow and reddish-purple symptoms. Boron deficiency is effectively diagnosed only by a plant tissue test.

The most common boron fertilizers are the 45 to 48 percent borate (14.3 to 14.9 percent boron) or 65 to 68 percent borate (20.4 to 21.1 percent boron) materials. Boron is usually applied as a granular product, either by air or through the small seed box in a grain drill. Some forms can be applied as a liquid along with herbicide applications but make sure the boron and herbicide materials are compatible before mixing them in the tank. When tissue tests indicate boron is deficient and boron-sensitive crops such as cereals are likely to be planted in the field within 12 months, apply 1 to 3 pounds boron per acre on the soil surface. Higher rates of 3.5 to 7 pounds boron per acre may be used if tolerant crops such as alfalfa, sugar beets, or onions will be grown for the next 24 months. Use the lower rates on sandy soils; the higher rates are suggested for fine-textured soils. Higher rates of boron will often last 5 to 7 years.

Molybdenum. Molybdenum deficiency has been observed in a number of the intermountain valleys of northeastern California. The general light green or yellow stunted plant deficiency symptoms are much like those of nitrogen or sulfur. Molybdenum deficiency generally occurs after the first or perhaps

second cutting of alfalfa. The gradual release of molybdenum by soil during the dormant or overwinter period allows for some spring growth of alfalfa followed by lesser regrowth after each cutting if severe deficiencies exist. Molybdenum is required in the nitrogen fixation as well as utilization role in alfalfa, hence growth is dramatically reduced without a supply of molybdenum and nitrogen. Plant tissue testing and/or trial strips of sulfur and molybdenum fertilizers are the best way to diagnose and clearly distinguish the deficiencies.

The most common molybdenum fertilizer is sodium molybdate (40 percent molybdenum) but ammonium molybdate may also be used. Apply 0.4 pound molybdenum per acre (or one pound of sodium molybdate per acre) during the winter or before regrowth has occurred after cutting the alfalfa. It is very important not to apply molybdenum on the leaves and foliage of a growing alfalfa crop because this may result in such high concentrations in alfalfa that the forage becomes toxic to livestock. Extreme caution should be taken during application not to have double or triple coverage since this increases the toxicity very dramatically as well. Analyzing the top third of the plant for both copper and molybdenum provides a way to detect deficiencies and also potential suboptimal ratios of these nutrients. Consult a veterinarian or nutrition specialist if you suspect molybdenum problems. A single application of molybdenum should last from 5 to 15 years. Good records of molybdenum application times and amounts along with repeated tissue testing is essential in determining when to apply or reapply molybdenum to alfalfa fields.

Record Keeping

Complete records are essential to managing a successful alfalfa fertility program. Keep a record for each field and include the location of permanent benchmark sampling areas, dates of sampling, soil and plant tissue test results, fertilizer application dates, fertilizers applied and the rate of application, and crop yields. This information can help you evaluate both the need for and the response to applied fertilizer and allow you to develop an economical, long-term fertilization program.

Further Information

DANR Analytical Laboratory. 1991. California Commercial Laboratories Providing Agricultural Testing. Special Publication 3024, Division of Agriculture and Natural Resources, University of California, Oakland, CA 94608-1239. 22 p.

Meyer, R.D. and W.E. Martin. 1983. Plant analysis as a guide for fertilization of alfalfa. In Reisenauer, H.M. (Ed.) "Soil and Plant Tissue Testing in California" Bulletin 1879. Division of Agricultural Sciences, University of California, Oakland, CA 94608-1239. pp 32-33.

Reisenauer, H.M., J. Quick, R.E. Voss and A.L. Brown. 1983. Chemical soil tests for soil fertility evaluation. In Reisenauer, H.M. (Ed.) "Soil and Plant Tissue Testing in California" Bulletin 1879. Division of Agricultural Sciences, University of California, Oakland, CA 94608-1239. pp 39-41.

Soil Improvement Committee, California Fertilizer Association. 1985. Western Fertilizer Handbook. 7th Edition. The Interstate Printers and Publishers Inc., Danville, IL 61832-0594. 288 p.

Martin, W.E. and J.E. Matocha. 1973. Plant analysis as an aid in the fertilization of forage crops. In Walsh, L.M. and J.D. Beaton (Ed.) "Soil Testing and Plant Analysis," Revised Edition. Soil Science Society of America, Inc., Madison, WI 53711 pp 393-426.

Kelling, K.A. and J.E. Matocha. 1990. Plant analysis as an aid in fertilizing forage crops. In Westerman, R.L. (Ed.) "Soil Testing and Plant Analysis," Third Edition. Soil Science Society of America, Inc., Madison, WI 53711 pp 603-643.