INVESTING WISELY IN FERTILIZERS FOR ALFALFA

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Alfalfa is grown on nearly one million acres in California. The importance of alfalfa to the state suggests that wise investments in the fertility program be made to insure profitable production. The nutrients affecting its growth and quality will be discussed in the presentation.

Even with the large acreage of alfalfa grown in California little or no nitrogen is applied on an annual basis. Except for pastures containing legumes, this is quite different from most other crops in that rather large quantities of nitrogen are usually applied to maintain profitable production. Just as high rates of applied nitrogen are necessary to achieve good yields with other crops, alfalfa requires approximately 480 pounds of nitrogen for an 8 ton per acre crop, 600 pounds for 10 tons or 720 pounds for a 12 ton per acre yield. Imagine for a moment if it were necessary to apply these large amounts of nitrogen to produce alfalfa forage. At a very conservative price of only 30 cents per pound of nitrogen, the cost would be $144.00, 180.00 or 216.00 per acre per year respectively for the 8, 10 or 12 ton yields. I should point out that since most crops are only about 50% efficient in the utilization of nitrogen, twice the amounts and costs should be considered. Certainly the depressed market prices of the current year would have resulted in even greater losses had the costs for nitrogen been necessary. Since these costs are not essential for good forage production, one may ask how can we be assured that adequate amounts of nitrogen are made available to alfalfa.

During the past several years I have become aware of several situations where growers have planted new seedings of alfalfa on land that has never grown legumes before. In these sagebrush and other plant type growing areas, extreme care needs to be exercised so that the seed is properly inoculated. It is recommended the inoculation rates be 3 to 5 times the normally suggested amounts to insure that proper infection levels of rhizobium bacteria be established between the alfalfa and bacteria so that the symbiotic relationship operate to its maximum capacity. In cultivated cropping areas it is well to inoculate properly so as to introduce more effective nitrogen fixing rhizobium strains. Other speakers will be addressing soil compaction and water management, several important factors affecting the environment in which the alfalfa root-rhizobium bacteria system functions if the large amounts of nitrogen mentioned above are to be supplied. Just as nitrogen is extremely important in the production of many other crops, it is even more important in alfalfa forage production if 480, 600 or 720 pounds nitrogen are fixed for an 8, 10 or 12 ton per acre yield.

In an effort to investigate the potential for acquiring higher yields and specifically to examine whether large amounts of applied nitrogen would increase production, a field experiment was established in an area recently brought under cultivation. This area, having an average pH of 5.7, was selected to evaluate whether lime treatments and several rates of phosphorus and potassium would increase yield in the presence or absence of rhizobium inoculation. Soil test levels were as follows: bicarbonate-P 23 ppm, exchangeable-K 211 ppm and Hot Nitric-K 373 ppm. Approximately two months after the field trial was initiated on June 4-5, 1981, a number of small plants were carefully dug up and found to have rhizobium nodules in both the areas where acid treated and inoculated seed were planted.

The 1982, 1983, 1984 and three year average alfalfa forage yields are given for all treatments in Table 1. It should be pointed out that the small distance of 90 feet used to isolate the non-inoculated from the inoculated seeding resulted in a marked difference in yields, perhaps an average of 0.3 tons/A. It was observed during all three years that it was more difficult to supply adequate amounts of water to the area where inoculated seed was planted. A slight trend for the alfalfa yields to increase does appear in both inoculated and non-inoculated situations when increasing rates of phosphorus, potassium and lime are applied. There is little, if any, forage yield response to the applications of either ammonium nitrate or calcium nitrate sources of nitrogen. Tissue analyses in 1982 indicated a significantly higher nitrate-nitrogen concentration in the midstem leaves

Table 1. Alfalfa forage yields as influenced by seed inoculation, fertilizer and lime treatments in 1982-1984. Leavers Ranch - Siskiyou County.

Treatment						Yield, Tons DM/A			
		Application Rate*							
No.	Seed Inoculated	N	P_2O_5	K_2O	Lime	1982	1983	1984	3-Year Average
		--------	lbs/A	-------	Tons/A				
1.	No					4.56	4.27	4.53	4.45
2.	No		80			4.44	4.55	4.76	4.58
3.	No		80	200		4.70	4.59	4.52	4.60
4.	No		80	200	2	4.85	4.59	4.91	4.78
5.	No	300	80	200	2	4.82	5.00	4.92	4.91
6.	No	600	80	200	2	5.06	4.98	5.11	5.05
7.	No	900	80	200	2	5.04	5.25	4.86	5.05
8.	No	1200	80	200	2	4.76	4.69	4.66	4.70
9.	Yes					3.99	4.12	4.43	4.18
10.	Yes		40			4.06	4.18	4.37	4.20
11.	Yes		80			3.97	4.49	4.28	4.25
12.	Yes		160			4.49	4.64	4.56	4.56
13.	Yes		80	200		4.10	4.40	4.44	4.31
14.	Yes		80	200	2	4.30	4.62	4.62	4.51
15.	Yes		160	200	2	4.55	4.39	4.33	4.42
16.	Yes		160	400	2	4.76	4.43	4.48	4.56
17.	Yes	300	80	200	2	4.50	4.29	4.68	4.49
18.	Yes	600	80	200	2	4.60	5.03	4.98	4.87
19.	Yes	900	80	200	2	4.53	4.35	4.36	4.41
20.	Yes	1200	80	200	2	4.74	4.78	4.51	4.68
21.	No	600**	80	200	2	4.96	5.01	5.04	5.00
22.	Yes	600**	80	200	2	4.68	4.88	4.50	4.69

All plots fertilized and seeded on June 4 and 5, 1981.

*NH_4NO_3 was applied 3 times/year, P_2O_5 applied as 0-45-0, K_2O applied as 0-0-60, lime applied as 100% $CaCO_3$ equivalent.

**$Ca(NO_3)_2$ was applied 3 times/year.

with increasing rates of applied nitrogen. This was reflected as well with increases in total nitrogen concentration of the top one-third of the plant. Certainly if one were to use an economic analysis to look at the cost of nitrogen versus alfalfa forage yield benefit, the approximate quarter ton yield increase per year would not result in a profit from the purchase of nitrogen.

Perhaps the most important nutrient which limits alfalfa forage yields statewide is phosphorus. The use of plant tissue or soil tests can be used as a guide to indicate when a plant growth response could be expected. Confirmation of these guides may be implemented along with documenting actual yield increases by applying alternate or randomly selected and well marked strips with phosphorus fertilizer.

A slightly different approach to soil and plant tissue testing may be more desirable than a traditional random sample. It would involve selecting bench mark areas perhaps 50' by 50' or 100' by 100' in size from good, intermediate and poor growing locations in the field. These would be permanently marked areas from which samples could be taken every two years or as deemed necessary. From each area a random sample of 12 to 15 cores of soil and 40 to 60 stems of alfalfa should be taken for analysis. Plant tissue samples should be taken at a specific stage of plant growth when the regrowth from the crown is about 1/2 to 1 inch in length. This is approximately when the plants are at 1/10 bloom. Another word of caution should be mentioned with regard to plant tissue analysis and that is only the one nutrient which is most limiting can be examined and the deficiency corrected before evaluating the other nutrients. Mapping the areas with relatively different growth patterns in a field or whole ranch and having permanently marked areas identified for sampling from each provides a basis for monitoring trends in nutrient level changes over several years and whether it is necessary to consider different fertilizer or other management regimes.

Bicarbonate-P soil test levels below 5 ppm would indicate the likelihood for phosphorus response. Levels greater than 10 ppm would generally show a lower likelihood for a response to phosphorus applications. Alfalfa midstem tissue levels below 800 ppm PO_4-P would generally be expected to show a response to applied phosphorus whereas levels greater than 800 ppm would not. If it is found that an established stand of alfalfa shows low test levels phosphorus should be applied at the earliest possible time so that plant response will not be delayed. Fertilizer applications on the soil surface have been found to give equivalent growth response to injected placement considering the damage done to the stand. Application rates should be approximately 80 to 100 pounds P_2O_5/A when test levels are low, or 40 to 60 pounds P_2O_5/A when in the intermediate range.

Since large amounts of potassium are taken up by alfalfa it is advisable to check soil and plant tissue test levels for guiding the fertilization program. Soil test levels below 40 to 50 ppm exchangeable-K would indicate a likelihood for potassium response whereas levels greater than 100 ppm would usually not result in a response. If the levels are below 100 ppm, it is advisable to request the laboratory to run a hot nitric acid extractable-K test. If these test levels are below 200 ppm a response is likely. Levels greater than 300 ppm would not generally result in a plant growth response. Alfalfa midstem tissue levels below 0.8 % would be expected to result in a plant growth response to applied potassium. Application rates should be approximately 100 to 150 pounds K_2O/A when test levels are low, or 50 to 100 pounds K_2O/A when in the intermediate range.

The potassium deficiency symptoms of white speckled leaves can also be used to detect areas that may respond to potassium fertilizers. These leaf symptoms are sometimes very difficult to distinguish from insect or disease problems and may even be caused by nematodes that interfere with the normal uptake and utilization of potassium. Rather large amounts of applied potassium will be only partially successful in relieving the symptoms. Control of the nematodes will be necessary to cause the symptoms to disappear.

Sulfur is another important nutrient for profitable alfalfa forage production, particularly in the intermountain areas of the northern part of the state. Soil tests for sulfur have been used in the past but have been found to be of little value. Plant tissue testing with the use of the midstem leaves is the best diagnostic test for determining sulfur deficiencies. Levels below 400 ppm generally indicate a likelihood for sulfur response whereas values greater than 800 ppm usually indicate sufficient nutrient concentrations of sulfur. In known areas of sulfur deficiency it is common practice to incorporate approximately 200 pounds of elemental sulfur per acre into the top 4 to 6 inches of soil before seeding alfalfa. This will provide an adequate supply of sulfur for 5 to 7 years. Applications of elemental sulfur are effective when placed on the soil surface but usually require 4 to 6 months time before maximum plant response can be expected. Gypsum, single superphosphate (0-25-0), ammonium sulfate (21-0-0) and several other sulfate containing dry or liquid fertilizers can be used to supply the readily available sulfate form of sulfur for immediate plant response. Usually no more than 20 to 30 pounds of sulfate-sulfur per acre per year is required to achieve maximum forage yields.

The nutrient boron has been found to limit forage yields of alfalfa in some parts of northern California. It is extremely important in the production of alfalfa seed but can also influence forage yields. Plant tissue analysis of the top 1/3 of the plant is the best way to determine if boron is deficient. Levels below 15 ppm would generally result in a plant growth response to applied boron, whereas values greater than 15 ppm would not. Application rates should be approximately 2 to 3 pounds of actual boron per acre spread on a broadcast basis. Caution should be exercised if higher rates are used, particularly if cereal grains or other susceptible crops follow within a year of the application.

The range in nutrient concentrations for specific parts of plant samples taken when regrowth from the crown is 1/2 to 1 inch in length (approximately 1/10 bloom) is summarized in Table 2.

2. Nutrient concentrations in alfalfa at different response levels

	Midstems		Leaves	Top 1/3 of Plant	
Response Category	Total K (%)	PO_4-P (ppm)	SO_4-S (ppm)	Total Mo (ppm)	Total B (ppm)
Deficient	.40-.65	300- 500	<400	<.3	<15
Critical	.65-.80	500- 800	400- 800	.3-.9	15-20
Adequate	.80-1.5	800-1500	800-1200	1-5	20-40
	1.5+	1500+	1200+	5-10[1/]	200[2/]

1/ Forage containing more than 10 ppm of Mo may produce "Molybdenosis" in ruminant animals.

2/ Boron concentrations in alfalfa greater than 200 ppm are associated with reduced growth and vigor.