MOLYBDENUM, COPPER AND SELENIUM IN ALFALFA AND OTHER FORAGES

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ABSTRACT

There are a number of geographic areas in Northern California where molybdenum concentrations are inadequate (<0.3 ppm) in alfalfa and other legumes to meet the needs for high forage yield production. In contrast, much of the state south of a line between San Francisco and Lake Tahoe may have forages with excessive (>10 ppm) molybdenum concentrations resulting in "molybdenosis" in livestock. Several areas in five counties of Northeast California have been identified as producing forages having low (<5 ppm) copper concentrations with the remainder of the state having normal (5-15 ppm) or higher levels. Much of the northern half of the state along with the eastern side of the San Joaquin Valley and the Sierra range produce vegetation that has deficient to marginally adequate selenium concentrations to meet the nutritional needs of domestic livestock and several species of wildlife. The west side of the San Joaquin Valley and coastal areas south of San Francisco to the Mexican border generally has forages with marginally adequate to sufficient selenium concentrations. A few areas, as in San Luis Obispo, Kern and Imperial counties have forages with high selenium concentrations.

Key Words: alfalfa, quality, utilization, molybdenum, copper, selenium, toxicities, deficiencies.

INTRODUCTION

The quality of alfalfa and other forages and utilization by different classes of livestock or even certain species of wildlife involves the evaluation of many characteristics. Tests to evaluate the energy, fiber type and composition, protein and other nutrient concentrations are some of the measures used to establish the relative feed value or quality of forages for livestock. In some cases, either the deficiencies or excesses of certain elements dramatically effect the value or quality of alfalfa and other forages fed to livestock. In California and the Western United States we have numerous valleys that have been formed geologically by the deposition of sediments from higher elevations. In the more arid climates where rainfall amounts are less than 20 inches per year, less leaching of soluble salts to greater soil depths will occur and the soluble salts are moved to the soil surface and left behind as the moisture is evaporated. In these situations, elements like sulfur in the sulfate form ($SO_4^=$), molybdenum in the molybdate form ($MoO_4^=$), and others may be present in soils in rather high concentrations. Since the pH is often in the alkaline range a number of these elements remain in the oxidized form and are easily taken up by a number of plant species like alfalfa, other legumes and broadleaf plants as

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well as grasses used for livestock forages. The objective of this presentation is to delineate areas in California where excessive as well as deficient concentrations of molybdenum, copper and selenium are present in forages and how these concentrations effect plant and animal growth and production.

MOLYBDENUM AND COPPER CONCENTRATIONS IN FORAGES

Animal Concerns:

During the mid to late 1940's, researchers identified molybdenum-induced copper deficiency in livestock and some of the soil and plant characteristics causing "molybdenosis" in Kern and other counties in the southern San Joaquin Valley.[1,2,3] Characteristic signs of molybdenosis in cattle were straw-colored haircoat, diarrhea, dehydration and general unthriftiness. Dry roughage fed to cattle on pastures and bluestone (copper sulfate) in the drinking water were some of the early recommendations to minimize the effect upon livestock. The application of sulfur, ammonium sulfate and other acidifying materials should be tried to lower the pH of alkaline soils was another recommendation. Using information gathered from several surveys of forage analyses,[4,5,6,7] the following concentrations of copper and molybdenum were suggested as diagnostic criteria.[8]

	Copper (Cu) (ppm)	Molybdenum (Mo) (ppm)
Copper deficiency	0. – 5.0	0.1 – 5.0
Normal	5 – 15	1 – 5
Molybdenum toxicity	5 – 8	5 – 50

Surveys were continued in California during the 1950's and 1960's with a more complete understanding of where low copper and high concentrations of molybdenum in forages might be expected.[9] Copper concentrations in forages were found to be less than 5 ppm in several areas of Lassen, Modoc, Shasta, Sierra and Siskiyou counties of northeast California. Toxic molybdenum concentrations in forages were found in nearly all the San Joaquin Valley and Coastal counties south of Contra Costa and San Joaquin counties as well as Inyo, Mono and other Southern California counties. A more recent survey of previously sampled alfalfa fields indicated that the degree of severity of the molybdenum-induced copper deficiency in livestock has decreased.[10] In 1950, 53.5% of the 71 alfalfa fields sampled in Kern County had in excess of 10 ppm molybdenum and by 1985, all of the same or nearby 82 alfalfa fields had 10 ppm or lower molybdenum concentrations. Even though the molybdenum concentrations were all 10 ppm or less, in 20.5% of the alfalfa samples tested the molybdenum level was sufficiently high that some classes of livestock may need supplemental copper added to the diet. In an additional 24.4% of the samples, the elevated molybdenum and lower copper concentrations may on occasion present animal growth problems particularly if the forage also contains high (>0.3%) sulfur concentrations.

Plant Concerns:

A number of plant analyses from alfalfa and other legumes, both annual and perennial, taken from Northern California (north of a line between San Francisco and Lake Tahoe) have indicated marginally adequate to deficient concentrations (0.05-0.5 ppm) of molybdenum for maximum growth and dry matter yields. In several cases applications of sodium molybdate at one pound per acre (0.4 lb Mo/A) have resulted in significant yield increases (M. B. Jones, D. B. Marcum and R. D. Meyer, unpublished data). Molybdenum responses have also been reported in several vegetable (melon) crops on the West Side of the Sacramento Valley (H. Schulbach and M. Murray, personal communication). The deficiency of molybdenum is most easily identified in alfalfa and other legumes by taking a sample of the upper one-third of approximately 40-60 stems at one-tenth bloom growth stage and having the sample analyzed for molybdenum. If the molybdenum concentration is less than 0.3 ppm it is likely that a plant growth response would be obtained following an application of one pound per acre sodium molybdate (0.4 lb Mo/A). Excessively high concentrations of molybdenum (>100-1000 ppm) in several plant species have been reported. In some cases no symptoms of toxicity have been reported.[11]

SELENIUM CONCENTRATIONS IN FORAGES

Animal Concerns:

Selenium deficiency in animals was first recognized in a number of selenium-responsive diseases such as white muscle disease in calves and lambs.[12] Since its identification in California in the late 1950's and early 1960's, large numbers of animals have be diagnosed as having inadequate selenium concentrations in the blood.[13,14] Selenium concentrations in forage plants of less than 0.05 ppm are usually considered deficient unless animals are receiving other sources of selenium from grain, salt etc. Several researchers have delineated areas within California and the Western United States where both toxicities and deficiencies are likely to occur.[10,15,16] Much of the northern half of the state along with the eastern side of the San Joaquin Valley and the Sierra range produce vegetation that has deficient to marginally adequate selenium concentrations to meet the nutritional needs of domestic livestock and several species of wildlife. The west side of the San Joaquin Valley and coastal areas south of San Francisco to the Mexican border generally has forages with marginally adequate to sufficient selenium concentrations. A few areas, as in San Luis Obispo, Kern and Imperial counties have forages with high selenium concentrations.

Plant Concerns:

Although selenium is taken up by plants, it has not been demonstrated to be essential for plant growth. It is advantageous however to have adequate concentrations of selenium in feeds as a basis for meeting the nutritional needs of animals. When forages having less than 0.05 ppm selenium are the only feed provided to animals they will usually show signs of lower weight gain and even white muscle disease. Forages having greater than 0.1 ppm selenium are generally considered as having adequate levels to meet the nutritional needs of animals.

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