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The Molybdenum Problem in Oregon

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THE MOLYBDENUM PROBLEM IN OREGON*

Molybdenum may increase crop yields under some conditions. Under other conditions it may be detrimental or toxic to your livestock. This in a "nutshell" is the molybdenum problem in Oregon.

This is a summary of the known facts in Oregon and elsewhere. We will interpret some of them according to our best judgment. But the final decision and responsibility for applying molybdenum as a fertilizer or treating livestock for molybdenum toxicity must be yours. We do not have adequate information to develop clear-cut recommendations for all conditions.

Summary of Oregon Information

Coastal Area -

One field experiment and 6 greenhouse experiments have been conducted on coastal soils. There has been no indication of response from molybdenum on any of these experiments. On the contrary, there is some evidence that forage produced on some soils from this area may have levels of molybdenum that are higher than would be desirable.

Our present recommendation: do not use molybdenum on a trial basis in this area until further research indicates the possibility of crop response.

Willamette Valley -

Response from application of molybdenum for the production of alfalfa has been observed on some soils. Most of these responses have been on hill soils surrounding the valley floor that are acid, low in phosphorus, and high in manganese. Field and greenhouse experiments were conducted on soils where molybdenum deficiencies were suspected. Response from molybdenum was observed on all of the 4 field experiments established during the last 3 years and in 5 of the 14 greenhouse experiments established. The responses have been larger when the soils have not been limed. On these soils, applications of lime alone increased the molybdenum content of the forage. Molybdenum contents have been markedly increased when lime and molybdenum have been applied together. This suggests some caution in applying lime and molybdenum together until further research information under western Oregon conditions is available.

Northeastern and North Central Oregon -

Preliminary data obtained on established stands of alfalfa during 1958 have indicated response on 4 out of 13 field experiments.

These responses were on acid soils on the footslope of Mt. Hood in

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* Prepared by Departments of soils, agricultural chemistry, dairy and animal husbandry, farm crops and veterinary medicine of Oregon State College.

Wasco county, and the Couse and Tolo soil series in Union county. Field trials not showing responses were in Baker, Wallowa, Wheeler and Wasco counties.

Alkaline Soils of Eastern Oregon - and Alkaline or Acid Peats and Mucks

To date, molybdenum applications have not been made on the alkaline soils of eastern Oregon or on peat and muck soils. Actually, many forage samples from some of these contain molybdenum levels which may be detrimental to livestock. The availability of molybdenum is higher on alkaline soils than on acid soils.

Our present recommendation: do not apply molybdenum on alkaline soils or on alkaline or acid mucks and peats.

Effect of Liming -

Molybdenum availability increases as the soil pH increases (becomes less acid). This general effect has been observed in many areas as well as here in Oregon. Consequently, molybdenum response has been observed largely on some unlimed acid soils. Molybdenum responses on limed soils have been less marked or absent. Since liming increases the availability of molybdenum, its content in the forage also is increased. Increase in molybdenum content has been particularly marked when lime and molybdenum fertilizers are applied together. It is recognized that some question exists on the possibility of molybdenum application in combination with low levels of lime (less than optimum amounts). However, until further experimental data on this question are available, use caution in applying both lime and molybdenum together. Note also that repeated applications or large applications of molybdenum may well result in production of forage toxic to livestock if these soils are limed at a future date.

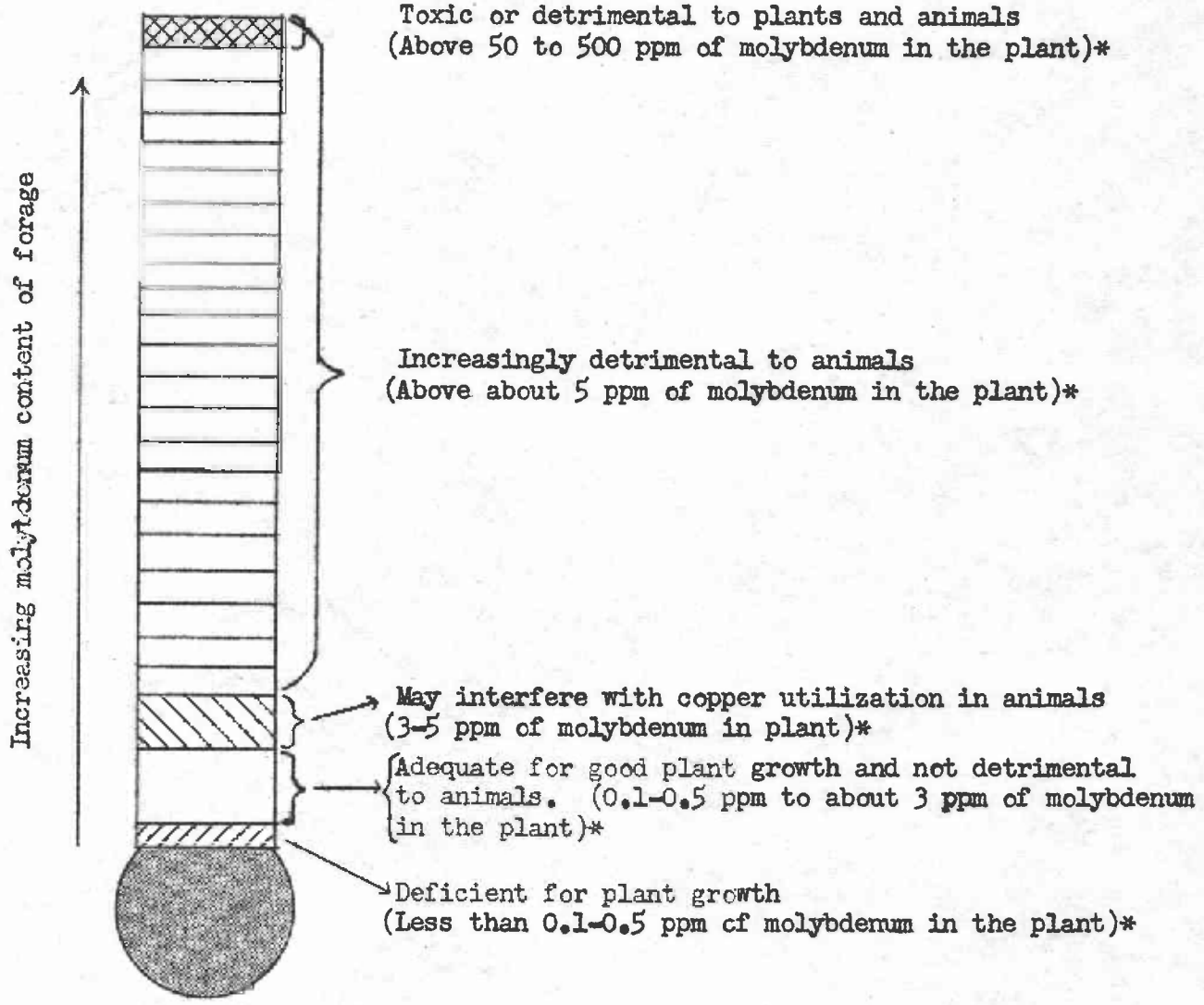
Discussion

Molybdenum applications appear to offer an efficient method of increasing legume yields on some acid soils, provided we can learn how to use it without causing nutritional disorders in animals that eat the forage. Research data in Oregon and elsewhere clearly emphasizes the complexity of the molybdenum problem Numerous reasons, such as soil acidity, available level of sulfur, phosphorus, iron manganese and copper in the soil, organic matter content of soil, and others influence both yield and molybdenum content of the plant. Likewise, animal nutrition is influenced not only by the molybdenum content of the feed but also by copper content, sulfate sulfur content, and others.

Forage which is detrimental to livestock may contain only a few more parts per million molybdenum than forage produced on soils where application of molybdenum fertilizer will increase yields. An application of only a few ounces of molybdenum fertilizer per acre may increase the molybdenum content of forage to the danger point. Consequently, extreme caution is necessary when applying molybdenum fertilizer to avoid plant accumulation that will upset livestock nutrition.

The Molybdenum Thermometer

The overall molybdenum problem may be illustrated schematically with the following diagram: These conditions probably occur naturally in Oregon except possibly where available molybdenum is so extremely high that it is detrimental to plants. The zone of molybdenum content between sufficiency for plant growth but avoidance of animal toxicity is narrow.



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*- The values for molybdenum content (ppm means parts per million) of the plant indicate the general magnitude of the range of values associated with the different conditions. They should not be considered fixed established values since many factors will cause them to vary widely. One ppm (part per million) equals 0.002 lbs. in one ton (2000 lb.)

Questions and Answers

Here are some questions with our answers that may help you better understand the molybdenum problem and decide what to do about it.

1. Q. Where does molybdenum occur in nature?

   A. Very widely distributed in the earth's crust, in soils and in plant and animal tissues.

2. Q. How much molybdenum do soils contain?

   A. Most soils in the United States contain only 2 to 7 pounds (1 to 3.5 ppm) of total molybdenum per acre in the surface 7 inches. Most soils are not deficient but release enough molybdenum to meet plant needs. Extremely small amounts are required by plants. For example, 3,000 tons of alfalfa hay, grown with adequate but not excessive molybdenum, would contain from 3 to 6 pounds of molybdenum.

3. Q. Why are scientists so concerned about the few ounces of soil molybdenum <u>available</u> to plants?

   A. The level of <u>available</u> molybdenum determines whether plants may obtain enough for best growth, or whether they may absorb enough to become detrimental to man and his animals.

4. Q. Where is research work with molybdenum as it affects plant growth being conducted in the Pacific Northwest?

   A. The Washington Agricultural Experiment Station started field research about six years ago. In Oregon, greenhouse experiments were started about five years ago and field experiments in 1956. The Idaho Agricultural Experiment Station also has done some work on the problem.

5. Q. Is there evidence that application of molybdenum will increase yields of crops in Oregon?

   A. Yes, research data from field experiments have shown that this is possible where legumes are grown on certain acid soils. Research now underway and that planned will provide more specific answers. Due to the comparatively low cost per acre, even small increases in yield will be profitable, provided the molybdenum content of forage is not increased excessively.

6. Q. Where in Oregon have applications of molybdenum increased crop yields?

   A. Increased legume yields have been obtained only on some acid mineral soils where response from application of lime has been demonstrated or expected. Marked response has not been observed when these soils were limed. Some acid soils, such as peats, mucks, and coastal soils appear to have adequate available molybdenum for plants.

Recent Oregon experiments, where alfalfa was grown in field experiments on soils where molybdenum response was expected, have shown a response from applications of molybdenum at two locations on Cascade soil series from Columbia County, Willamette soil series in Benton County, Melbourne soil series in Polk County, an acid soil on the footslope of Mt. Hood in Wasco County, Couse and Tolo soil series in Union County. Additional field experiments were established in Polk, Marion, Douglas and Tillamook Counties during 1958. Locations have been selected for establishment of additional field experiments in Polk, Yamhill, Marion, Linn, Union, Baker, and Wasco Counties in 1959.

Greenhouse experiments have shown a response from application of molybdenum on several soils as follows: Cascade soil series from Columbia County; Willamette soil series from Benton County; Olympic soil series from Clackamas County; Melbourne soil series from Polk County; Aiken soil series from Douglas County.

7. Q. Where have responses from molybdenum been obtained in Washington?

   A. The Washington Agricultural Experiment Station has obtained molybdenum response with peas, sweet clover, and alfalfa in eastern Washington mostly on eroded hilltops and on previously forested soils. We have only a little information on similar soils in eastern Oregon. Responses also have been observed on alfalfa in south-central and southwestern (Vancouver area) Washington.

8. Q. Where in Oregon is the available molybdenum in the soil sufficient for crop production?

   A. Adequate amounts of molybdenum appear to be available in (1) soils that are neutral or alkaline in reaction, (2) alkaline and acid peat or muck soils, (3) acid mineral soils high in organic matter content. The Astoria, Tillamook, and similar soils along the coast are examples of acid mineral soils high in organic matter.

9. Q. Under what conditions in Oregon may molybdenum accumulate naturally in plants (without molybdenum applications) in amounts detrimental to livestock nutrition?

   A. Forage samples that might naturally contain excess molybdenum are expected to occur, or have occurred under the following soil conditions: (1) alkaline mineral soils (2) alkaline and acid peat and muck soils (3) acid lowland soils high in organic matter.

10. Q. Where are molybdenum applications being recommended as a standard practic to increase crop yields?

    A. In New Zealand and Australia sodium molybdate fertilizer has been applied by farmers to forage crops for several years. An application of about 2.5 ounces of sodium molybdate (one ounce of molybdenum per acre) is sufficient to satisfy the requirements of forage plants for 4 to 6 years on some soils.

In western Washington farmers started using soil applications about two years ago. Last year many farmers in eastern Washington applied a seed treatment of ¼ to ½ ounce of sodium molybdate per acre to legumes. This method was developed by Dr. H. M. Reisenauer of Washington State College. Some molybdenum fertilizer also is used in other areas.

It has been used only to a limited extent in Oregon.

11. Q. How does liming a soil affect molybdenum?

A. Liming increases the availability of molybdenum in the soil.

12. Q. Can molybdenum replace all lime needs?

A. No - one result of liming an acid soil is to increase availability of molybdenum. Molybdenum can undoubtedly replace part of the lime application on some soils. But remember, liming an acid soil has many benefits such as increasing availability of phosphorus, decreasing soil acidity, increasing release of nitrogen from soil organic matter, and supplying calcium. See Oregon Agricultural Experiment Station Circular of Information No. 549 for additional information on liming acid soils. Remember--on the basis of present information here and elsewhere--we cannot expect to replace lime in western Oregon with molybdenum.

13. Q. What have been the primary objectives of Oregon research on molybdenum as a fertilizer or plant nutrient?

A. We have had two primary objectives in most of the experiments conducted to date, namely answering these questions:

(1) Do we have soils in Oregon that are deficient in molybdenum? If so, which ones are deficient?

(2) How does rate of liming and other factors affect the yield response obtained from molybdenum applications?

14. Q. What rates of molybdenum should be used on farmer trials?

A. Our research has not answered this question. Until additional information is available we suggest that molybdenum application rates not exceed the following on soils where response is a possibility:

(1) <u>For seed treatment</u> - ½ ounce of molybdenum seed treatment (approximately 40 percent molybdenum) on the seed to be used to plant one acre.

This will supply 0.013 pounds of molybdenum per acre. This is probably enough to supply the molybdenum required in 6 to 10 tons of alfalfa hay. For example, if all of it were contained in 3 tons of hay grown on a molybdenum deficient soil, the hay would likely contain about 2 ppm of molybdenum.

(2) For soil application - 4 ounces (0.25 pounds) of sodium molybdate (or other fertilizer material containing approximately 40 percent molybdenum) per acre.

This supplies 0.1 pound of molybdenum. This is higher than the 2.5 ounces of sodium molybdate used in New Zealand and Australia but lower than the one pound suggested in Washington. Some work in Washington on unlimed acid soils suggest the need for rates higher than 1 to 2 ounces of material per acre. Because of the complexity of the nutritional problem in livestock, we suggest that the rate be kept moderate (4 ounces of material or less per acre) until more adequate information is available on Oregon soils.

Numerous reasons--especially soil acidity--affect the release of molybdenum from the soil and the availability of that applied as a fertilizer. Even moderate applications of lime on acid soils increases the availability of both soil molybdenum and that applied. Thus, where lime is applied at the optimum level for alfalfa, applications of low rates of molybdenum may increase the molybdenum content of the forage until it is detrimental to livestock. Where lime is applied at less-than-optimum levels on soils low in available molybdenum, low molybdenum applications are less likely to increase molybdenum in the forage to detrimental levels.

15. Q. What methods of molybdenum application can be used?

A. (1) Molybdenum seed treatment can be applied to the seed before planting.
(2) Molybdenum can be custom mixed with other fertilizer and broadcast on the soil surface. Do not attempt to mix molybdenum with other fertilizer on the farm as uniform mixing is important.
(3) Molybdenum can be sprayed on the soil with weed spray equipment. Spraying on growing plants may be hazardous since the molybdenum content of the plants may be increased sharply to the point where the forage will be detrimental or toxic to livestock.

16. Q. What molybdenum fertilizer materials are available?

A. Sodium molybdate containing approximately 40 percent molybdenum and a commercial seed treatment compound containing approximately 40 percent molybdenum.

17. Q. How frequently should molybdenum fertilizer be applied?

A. Again, no research data are available in Oregon. Information from other areas indicates that a soil application of 4 ounces of material per acre should last 5 years or longer. The rate for seed treatment is low enough to suggest that it may not be effective for more than 1 to 2 years if the forage is removed.

Frequent soil applications, especially at rates higher than 4 ounces (0.25 pounds) per acre of sodium molybdate, will lead to a build-up of molybdenum in the soil. These may not cause trouble on acid soils for several years. But, if the soil is limed following a build-up of molybdenum, toxic levels of molybdenum in the forage likely will occur.

18. Q. Have experiments using seed treatment with molybdenum been conducted in the Pacific Northwest?

A. Experiments using a sodium molybdate seed treatment were conducted by the Washington Agricultural Experiment Station during 1957 and 1958 but none have been conducted in Oregon. The new preparation used for molybdenum seed treatment is a different chemical compound that supplies molybdenum and has been prepared especially for this job. Optimum yields in 1958 experiments in Washington with peas were obtained with ½ ounce of material per acre when applied on the seed. Since the relative uptake of molybdenum from seed treatment is high, low rates (not more than ½ ounce of material per acre) appear to be in order.

19. Q. Will a soil test tell me if my soil is deficient in molybdenum?

A. No soil test for molybdenum is presently considered reliable. No research work has been conducted on this in Oregon but some work has been done elsewhere.

20. Q. Will an analysis of the plant tell me if my soil is deficient in molybdenum?

A. For some plants, a determination of the molybdenum content of a specific plant part at a particular stage of growth may be helpful in diagnosing probable molybdenum deficiency. For example, if the molybdenum content of alfalfa leaves falls below about 0.5 ppm, a deficiency likely exists. Incidentally, the content of molybdenum in alfalfa leaves is about 4 times that of the stems.

Considerable research is necessary to calibrate such a test for each set of environmental conditions. Even then, many factors may affect the results. Moreover, the determination of molybdenum requires a skilled analyst and is expensive.

At the present time Oregon State College does not make molybdenum analysis of plants for diagnostic purposes.

21. Q. Why are animal scientists concerned about the amounts of molybdenum occurring in food and feedstuffs?

A. It has long been known that animal tissues contain traces of molybdenum. About 20 years ago it was found that certain forages causing severe scouring in cattle contained excessive amounts of molybdenum. Of perhaps academic interest is the recent demonstration that some animals actually require very minute traces of molybdenum in their diets.

22. Q. How do animals respond to detrimental amounts of molybdenum?

A. Varies with species and dosage. Cattle and sheep are far more susceptible than horses to forages containing high levels of molybdenum.

23. Q. How do cattle, for example, respond to increasing levels of molybdenum?

A. Forages containing not over 1-3 ppm molybdenum are commonly accepted as "normal". When the molybdenum level reaches 3-5 ppm, some interference with copper utilization may be expected. As the molybdenum level increases, this interference becomes more pronounced. Finally, at levels of some 10-15 or more ppm molybdenum, forages become toxic, as for example in "teart" or "peat scours".

24. Q. What remedial measures are available to the livestock producer in overcoming the detrimental affects of excessive molybdenum?

A. Mild to moderate interference with copper utilization can be largely, if not entirely, overcome by appropriate copper supplementation. More severe molybdenum toxicity can be alleviated to some extent by copper supplementation.

25. Q. Is the effectiveness of copper supplementation such that we should depend upon it to safeguard the livestock industry against hazards created by excessive use of molybdenum applications?

A. No.

Some Molybdenum Conversion Factors

1 ppm (part per million) = 0.002 pounds in one ton (2,000 pounds)
1 ppm (part per million) = 0.032 ounces in one ton (2,000 pounds)

Sodium molybdate fertilizer contains approximately 40 percent actual molybdenum.

Molybdenum seed treatment compound also contains approximately 40 percent actual molybdenum.

1 ounce (0.0625 pounds) of molybdenum fertilizer or seed treatment compound contains

approximately 0.025 pounds of molybdenum. This is equal to 12.5 ppm of molybdenum in one ton of forage.

A 5 ton yield (dry weight basis) of hay per acre grown where molybdenum is not deficient may contain only 0.005 to 0.01 pounds of molybdenum. Thus, 1 ounce of molybdenum fertilizer supplies as much molybdenum as may be contained in 12 to 25 tons of hay. This is based on hay containing from 0.5 to 100 ppm molybdenum.