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MOLYBDENUM:
An Essential Plant Micronutrient

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Molybdenum (Mo) is required by both plants and animals in very small amounts, which explains why it is classed as a micronutrient. Both deficiencies and toxicities of Mo are very uncommon in Michigan. Because of this, more is known about needs and uses of micronutrients which have received more research attention.

MOLYBDENUM IN ANIMALS

Simple deficiencies of Mo probably do not occur in Michigan animals, although Mo is sometimes included in feeding programs. Nutrient imbalances involving Mo and copper (Cu) on occasions cause problems in cattle and sheep. Toxicity from excessive Mo levels is unknown in Michigan but has been reported in other states.

MOLYBDENUM IN PLANTS

Molybdenum is one of the most recently recognized essential plant food elements. Its exact functions are not well known but are closely related to the enzyme systems involved in nitrogen fixation and nitrate reduction. For example, Mo is thought to be specific for the activation of the enzyme nitrate reductase and is required by Rhizobia for fixation of nitrogen.

Molybdenum tends to accumulate in the interveinal areas of leaves, where it occasionally reaches levels four times in excess of those in stems. Normal plant tissue contains between 0.8 and 5.0 ppm.

Deficiency symptoms are similar to those of nitrogen starvation. Symptoms have been observed in Michigan on several vegetables grown on organic soil. In the early deficiency stages, leaves of cauliflower and broccoli may be scorched along the edges and curl or roll upward. Leaves may appear to be withered or crinkled. When severe, the deficiencies show as "whiptail" on the newest leaves. Older leaves may be mottled. Since Mo deficiencies are not well known in Michigan, such symptoms are rarely seen. When they are observed, the situation should be evaluated with plant tissue analysis and an Mo-containing foliar spray or a seed treatment should be used the following season.

In legumes, Mo is closely related to nitrogen fixation. In non-legumes growing on soil with ample available nitrogen (N), nitrate (NO_3^-) may not be metabolized in the absence of adequate amounts of Mo. Molybdenum is absorbed by all plants as the molybdate anion[1] (MoO_4^{--}).

The "sufficiency range" concept may be used to evaluate the Mo status of a crop. The values shown in Table 1 are the best known values. Because of limited research on this nutrient, extremes in the range represent levels that are not as well defined as with other micronutrients. Levels that are greatly outside of the range undoubtedly reflect problem situations.

As with other micronutrients, it is possible to divide Michigan crops into groups according to their responsiveness to fertilizer Mo (Table 2). This is a somewhat arbitrary classification, but it is only remotely possible for those crops in the "low" range to respond to fertilizer Mo. The low

[1] *Anion — a negatively charged form of the element.*

Table 1. The sufficiency range for molybdenum of selected Michigan crops.*

Crop	*Sampling Notes*	*ppm*
Corn	Ear leaf prior to silking	0.1-2.0
Soybeans	Fully-matured leaf prior to flowering	1.0-5.0
Alfalfa	Top 6 inches prior to flowering	1.0-5.0
Wheat	Upper leaves prior to first bloom	0.03-5.0
Sugarbeets	Center mature leaf—midseason	0.15-5.0
Vegetables	Top fully-developed leaf—midseason	0.5-5.0
Potatoes midseason	Petioles from newly-matured leaf—	0.5-4.0

**From MSU Ext. Bul. E-486*

Table 2. Relative response of selected crops to molybdenum.

High Responsive	*Medium Responsive*	*Low Responsive*
Broccoli	Alfalfa	Asparagus
Cauliflower	Bean	Barley
Lettuce	Cabbage	Carrot
Onion	Clover	Celery
Spinach	Pea	Corn
Table beet	Radish	Grass
	Soybean	Oat
	Sugarbeet	Peppermint
	Tomato	Potato
	Turnip	Rye
		Sorghum
		Spearmint
		Sudan grass
		Sweet corn
		Wheat

responsive crops, such as small grains and corn, frequently contain as little as 0.1 ppm Mo.

MOLYBDENUM IN SOIL

Molybdenum occurs in soil in many forms. When present as the anion, MoO_4^{--} is adsorbed by colloids[2] where pH levels are low. Liming usually releases sufficient Mo to meet plant needs. This practice also reduces opportunities for aluminum (Al) toxicity in addition to creating a better environment for the nitrogen fixing rhizobium bacteria.

The availability of Mo as related to soil pH levels is the opposite of other essential micronutrients (Figure 1). Solubility or availability of Mo decreases with a decrease in soil pH.

Very few Michigan soils need Mo fertilizer. Those that may be deficient include the fibrous peats and the very acid sands. Organic soils that contain bog iron may need fertilizer Mo to provide normal plant growth.

There are no well-accepted soil tests for evaluating Mo availability.

CARRIERS OF MOLYBDENUM

There are four common carriers of molybdenum as shown in Table 3. Ammonium molybdate and sodium molybdate are more soluble than molybdenum trioxide or molybdenum frit. All have proven to be satisfactory sources of molybdenum.

[2]*Colloid—Inorganic or organic matter having very small (submicroscopic) particle size and a correspondingly high surface area per unit of mass; e.g., clay and humus.*

Figure 1. Relative availability of soil micronutrients as related to soil reaction.

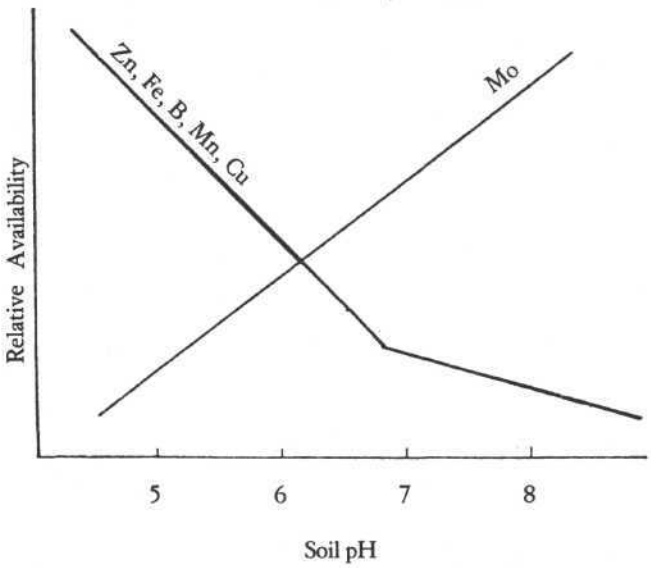

Table 3. Carriers of molybdenum*

Source	*Formula*	*Percent Mo*
Ammonium molybdate	$(NH_4)_6MO_7O_{24}\cdot 2\,H_2O$	54
Molybdenum trioxide	MoO_3	66
Molybdenum frit	Frit	30
Sodium molybdate	$Na_2MoO_4\cdot 2\,H_2O$	39

**From The Fertilizer Handbook — The Fertilizer Institute*

RECOMMENDATIONS FOR MOLYBDENUM

There is little evidence that Mo is needed for high yields of field crops in Michigan. Where deficiencies are suspected on acid soil, lime at a rate high enough to increase the soil pH to 6.0. This will increase the solubility (availability) of soil Mo and prevent a deficiency. On organic soils, frequently it is more economical to use fertilizer Mo. Good results have been obtained by using sodium molybdate as a seed treatment.

Suppliers of fertilizer Mo often sell two-ounce packages which are sufficient to treat enough seed for four acres.

Foliar sprays have been effective on onions and cauliflower when used at two to three ounces of sodium molybdate per acre. Wetting agents are recommended for this kind of treatment. Follow the recommendations that accompany the wetting agent.

OTHER SOURCES OF MOLYBDENUM

Molybdenum levels in many materials have not been well evaluated. Therefore, little is known about the content of such materials as livestock manure, municipal sludges, wastewater effluents and irrigation water.

Recent analyses of livestock manure show levels approximating 0.01 pound per ton in poultry manure and 0.001 pound in cattle, hog, horse and sheep manure.

Municipal sludges are likely to be variable in Mo content, depending upon the industries that contribute to the sludge. At the moment there is more concern about possible toxicities from Mo in sludges used for crop production than whether the material is a possible source of Mo in crop production. This is also the situation for wastewater effluents.

Practically no information is available in Michigan on the Mo content in water used for irrigation. Well, pond, and lake water probably contain such low levels as to be insignificant in crop production. River water probably contains variable amounts, depending upon the industries feeding the streams.

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