Nutri-Facts

IPNI

Agronomic fact sheets on crop nutrients

Molybdenum

NO. 13

North American Edition

Molybdenum (Mo) is a trace element required in very small amounts for the growth of both plants and animals. Crop deficiencies of Mo are fairly uncommon, but there are a variety of soil and foliar fertilizers that can be used to correct this condition when it occurs.

Molybdenum in Plants

All plants require very small amounts of Mo for normal growth and development. However, among the plant micronutrients, Mo and nickel (Ni) are required in the lowest concentrations.

Within the plant, Mo is primarily used in the production of "molybdoenzymes" that regulate various plant functions. The most well known of these Mo-containing enzymes regulate nitrogen (N) nutrition. In non-legumes, Mo-enzymes regulate the conversion of nitrate into proteins (nitrate reductase). In legume crops, another Mo-enzyme (nitrogenase) is needed by the root nodule bacteria for N fixation. The Mo requirement of legumes is greater than that of grasses and other crops.

Molybdenum toxicity in plants is rare under most agricultural conditions. However, sheep and cattle feeding on plants with a high Mo concentration may suffer from molybdenosis. This condition is a result of high Mo concentrations suppressing the availability of dietary copper (Cu) in these animals.

Molybdenum in Soils

Plant-available Mo is in the anion form of MoO_4^{2-}; or molybdate. It is released from solid minerals through normal weathering processes and then undergoes various reactions in the soil. Once it is dissolved, MoO_4^{2-} anions are subject to adsorption processes on clays, metal oxides of iron (Fe), aluminum (Al), and manganese (Mn) as well as organic compounds, and carbonates.

IPNI PHOTO/SNYDER

Soybeans showing Mo deficiency in the foreground.

The solubility of MoO_4^{2-} is greatly influenced by soil pH, similar to the chemically analogous nutrient phosphate (PO_4^{3-}). Molybdenum is the only micronutrient that has increased plant availability as the soil pH rises. Molybdate solubility increases approximately 100 times for every unit increase in soil pH. Therefore, the use of lime to increase the pH of acid soils is an important management tool to improve Mo availability. In soils with a pH of 6 or greater, it is uncommon to encounter Mo deficiencies.

Addition of sulfate (SO_4^{2-}) fertilizer tends to decrease MoO_4^{2-} uptake, as they both compete for root uptake sites. For example, one study showed that the plant Mo concentration of peanuts was decreased by more than 70% following fertilization with SO_4^{2-}-containing single superphosphate (SSP), but Mo concentrations increased by 20% following fertilization with triple superphosphate (TSP) fertilizer that contains no sulfate[1]. The addition of phosphate often results in the release of Mo that is adsorbed on soil solids, leading to greater Mo uptake and accumulation in plants.

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This Nutri-Fact is one of a series of fact sheets written by scientific staff of the International Plant Nutrition Institute (IPNI) that is focused on essential plant nutrients and their use. This series is available as PDF files at www.ipni.net/nutrifacts.

Fertilizing with Molybdenum

In many soils, application of a liming material to increase pH will release Mo from insoluble forms. For example, a study showed that addition of lime alone resulted in the same soybean yield as when Mo fertilizer was added to unlimed soil[2]. However, the chemical release of soluble Mo following lime application may take weeks or months to occur.

If lime is not required for crop growth or when the Mo concentration of the soil is low, it may be useful to fertilize with additional Mo in the following ways:

Soil: Molybdenum fertilizers can be banded or broadcast on the soil. It is commonly added in small amounts, ranging from 0.5 to 2 lb/A. It is often mixed with other fertilizer materials to help with uniform application or it may be dissolved in water and sprayed on the soil before planting. Molybdenum trioxide (MoO_3) is only suitable for soil application due to its low solubility.

Foliar: Soluble Mo sources, such as sodium or ammonium molybdate, are used for foliar application to plants. Foliar application of dilute solutions of Mo is generally most effective when applied at earlier stages of plant development. Foliar applications are beneficial for immediate correction of Mo deficiency symptoms, compared with soil applications, which have a longer residual benefit.

Seed: Treatment of seed with small amounts of Mo fertilizer is common in regions where deficiency occurs. This technique ensures that each seed is uniformly provided a small, but adequate amount of Mo for healthy growth. *Rhizobia* inoculants for legume crops are sometimes amended with small amounts of Mo to promote vigorous N fixation. Excessively high application rates can lower seed germination or cause Mo accumulation to concentrations that may be harmful for grazing animals.

The selection of a specific Mo fertilizer depends largely on how the material will be applied. Some common fertilizer products containing Mo are given in **Table 1**.

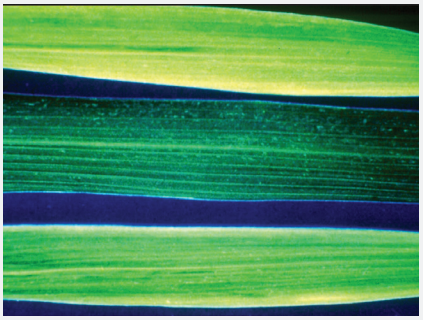
Table 1. Some common fertilizer products containing Molybdenum (Mo).

Name	Chemical formula	Mo content	Solubility
Sodium Molybdate	$Na_2MoO_4 \cdot 2H_2O$	39%	653 g/L
Ammonium Molybdate	$(NH_4)_6Mo_7O_{24} \cdot 4H_2O$	54%	400 g/L
Molybdenum Trioxide	MoO_3	66%	3 g/L

Molybdenum Deficiency Symptoms

Molybdenum is mobile within plants and deficiency symptoms can appear on the entire plant.

Non-legumes: Since adequate Mo is essential for proper N metabolism, deficiencies commonly appear as stunted plants and failure of leaves to develop a dark green color. In more severe deficiencies, the leaves may develop a pale green or yellow area around the edges and between the veins.



IPNI PHOTO/YAMADA

Varying degrees of Mo deficiency on rice leaves.

Advanced symptoms of insufficient Mo may appear as burning (necrosis) around the leaf edges and between the veins, because the plant cannot assimilate the nitrate and convert it to protein.

A well-known Mo deficiency symptom has been described for cauliflower, which develops a "whiptail" when the leaf tissue fails to develop surrounding the mid-leaf vein.

Legumes: These plants have an additional requirement for Mo, since it is required for N fixation by the root nodule bacteria, in addition to the internal utilization of nitrate. The symptoms of insufficient Mo include a general stunting and yellowing, typically seen as a result of insufficient N supply.

Crop Response to Molybdenum

The benefit of supplying adequate Mo most commonly relates to boosting the ability of plants to utilize N. Plant Mo deficiencies may not always require supplemental fertilization, especially in acid soils where application of lime will increase Mo availability to plants. Similarly, addition of P fertilizer releases Mo into solution after it exchanges with MoO_4^{2-} on soil adsorption sites.

Where adequate Mo is lacking, supplemental fertilization has resulted in large increases in plant growth and yield. One study demonstrated large yield increases in legumes from both Mo application and additions of lime[3] (**Figure 1**). Another study found that melon yields increased from 19 melons in plots with unfertilized soil to over 250 melons following a foliar spray of Mo[4].

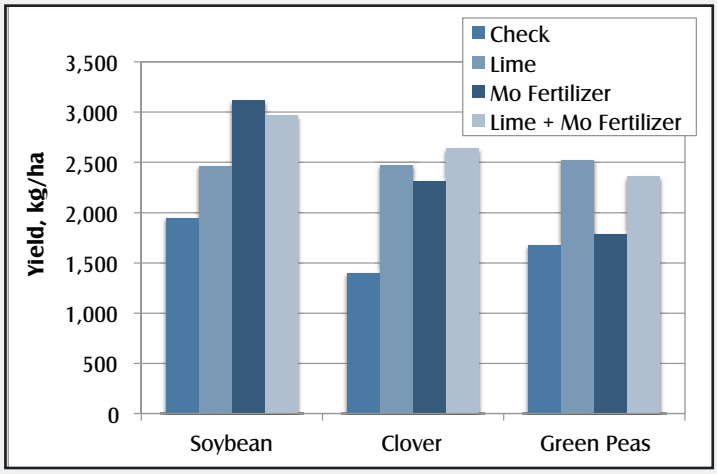


Figure 1. Effect of lime and fertilizer Molybdenum (Mo) application on yields of three crops[3].

References

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3. Hagstrom, G.R. and K.C. Berger. 1963. Agron J. 55:399-401.
4. Gubler, W.D. et al., 1982. Plant Disease. 66:449-451.