INTERNATIONAL MOLYBDENUM ASSOCIATION
THE VOICE OF THE MOLYBDENUM INDUSTRY

Molybdenum in Agriculture

Plant Micronutrients

Molybdenum's contribution to sustainable development in:

- Stainless steels
- Alloy steels
- Superalloys
- Cast iron
- Mo metal
- **Chemicals**

MoRE FOR LESS

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Molybdenum makes an important contribution to sustainable development as a metal, as an alloying element, and as a constituent of chemical products. IMOA's 'MoRE FOR LESS' case studies explore, in more depth, how molybdenum is contributing to sustainable development, a pattern of growth in which resource use aims to meet human needs while preserving the environment.

In particular we will look at how a specific use or application is contributing to the three pillars of sustainability:

ECOLOGY Environmental performance, resource use, energy efficiency & production and recycling

ECONOMY Supply chain, lifecycle and materials performance

SOCIETY Health, safety and wellbeing

This case study explores the sustainability benefits of correcting molybdenum deficiency in soils, which can improve yield significantly.

The challenge

Molybdenum is an important plant micronutrient. Plants pick up molybdenum (as molybdate) from the soil and only small amounts (0.1 to 1.0 ppm) are necessary to meet their dietary requirements.It is essential for the production of two major enzymes in plants – nitrogenase and nitrate reductase – which enable nitrogen to be obtained, or 'fixed', from air or soil.

Nitrogen is needed for compounds such as amino acids, proteins and chlorophyll. Plants suffer from poor growth without it, leaves may become pale and deformed, buds and flowers may not develop properly and fruit setting can be restricted.

Acidic soils prevent the uptake of molybdate even if there are sufficient quantities in the soil. In these instances, lime can be added to the soil to reduce acidity, helping to increase the uptake of molybdate. Soils in some regions of the world are naturally low in molybdenum. This can also occur in peat soils and in highly weathered soils with low levels of nutrients. Since the importance of molybdenum in tomato crops was first recognized in 1939, deficiency symptoms have been identified in a number of crops. The element is critical for the nutrition of legumes, cereal, lettuce, tomatoes, cabbage, cauliflower and citrus fruit.

Samples of wheat grown with and without molydenum deficiency.
© International Maize and Wheat Improvement Center

An international study involving field trials in 15 countries found that molybdenum deficiency was often only revealed by yield effects and without obvious symptoms of stress to the plant, yet was the most widespread deficiency after zinc and boron.[1] In Australia, molybdenum deficiency has been identified as the second most common micronutrient deficiency affecting large areas of cropland with acid soils[2] and can impair yield in cereal crops by as much as 30%.[3] In China, molybdenum deficiency affects nearly half of all agricultural soils and has been identified as an important factor limiting yields of winter wheat and soya beans.[4]

Molybdenum deficiency can be misdiagnosed as nitrogen deficiency and lead to the ineffective overuse of nitrogen fertilizer, which wastes resources and risks oxygen depletion in rivers and

oceans. Certain nitrogen fertilizers can also cause acidification of the soil, which further restricts the uptake of any available molybdate.

As the global population grows, food security will become more important than ever. Global food prices have doubled in the last decade[5] and demand for food and feed crops is estimated to double in the next 50 years as the global population approaches nine billion.[6] In the context of these challenges, optimizing existing production by correcting micronutrient deficiencies (where they exist) becomes even more important.

The solution

Increased demand for food requires increased agricultural production, for both food and feed crops. Optimizing existing agricultural productivity by correcting micronutrient deficiencies can help to provide more food for a growing population while minimizing the amount of additional land turned over to food production. This helps to preserve biodiversity and maintain resistance to some of the impacts of climate change.

Figure 1: Molybdenum can improve yield, juice content and skin thickness. © Linleo-fotolia.com

How molybdenum can help

Improving the quality of soils by correcting deficiencies of micronutrients including molybdenum has been shown to be effective in improving crop yields. Studies in Australia have demonstrated increases in grain yield of up to 60% following the application of molybdate.[7] Fertilizers are an ideal method of delivering molybdenum and other nutrients. The agrochemical industry has developed optimized blends of nutrients and micronutrients tailored to different regions, soils and crops. Molybdenum is typically delivered in the form of ammonium heptamolybdate, ammonium dimolybdate or sodium molybdate.

Alternatively, farmers can treat the crop seed or apply specially formulated foliar sprays to correct molybdenum deficiency. A study in Egypt[8] demonstrated that adding 24 mg of molybdenum per mandarin tree, in the form of a foliar spray containing sodium molybdate, increased fruit yield by 37% (**Figures 1** and **2**). Another study in Sweden[9] showed that applying just 0.25 liters per hectare of a molybdate-based foliar spray increased the yield of rapeseed plants from 1.76 to 1.89 tonnes per hectare, as shown in **Figure 3**.

Better micronutrient management can prevent the inefficient overuse of nitrogen fertilisers and therefore help to minimize nitrate run-off, saving resources and reducing pollution.

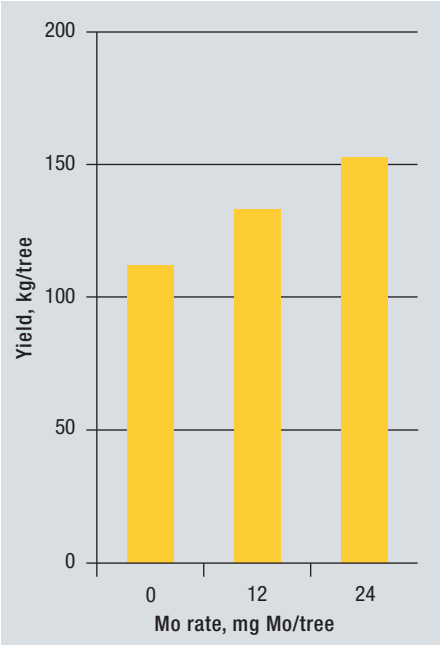

Figure 2: Adding 24 mg of molybdate per tree raised the production of mandarins in Egypt by 37%.

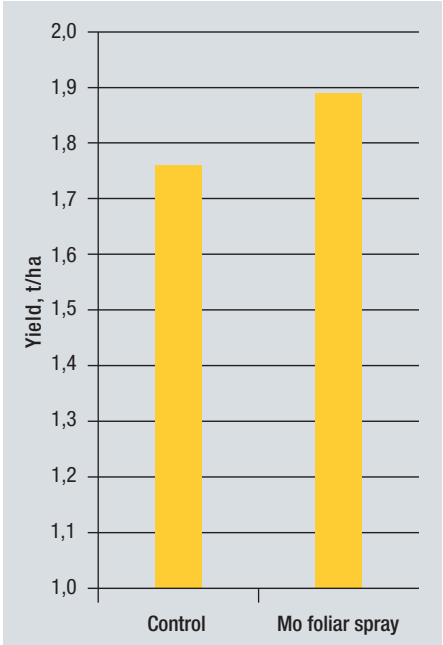

Figure 3: Adding 0.25 liters per hectare of molybdate foliar spray increased the yield of rapeseed in Sweden.

Key sustainability benefits

Benefit	Sustainability attribute		
Correcting molybdenum deficiency in soil helps to increase crop yield and improve land productivity	ECOLOGY	ECONOMY	SOCIETY
Increased crop production helps to ensure that more food is available for a growing population and that price hikes due to shortages are less common		ECONOMY	SOCIETY
Better micronutrient management helps to avoid the overuse of fertilisers and minimizes nitrate run-off, thus reducing pollution and helping to prevent further acidification of the soil	ECOLOGY		SOCIETY
The productivity of existing agricultural land is improved, preserving biodiversity	ECOLOGY		SOCIETY

Summary

Molybdenum is essential to plant growth. Deficiencies are often caused by acidic soils which prevent uptake and can be corrected by liming. However, where there is not enough in the soil, applying fertilizer, seed or foliar treatments containing molybdenum can increase productivity significantly. Correcting molybdenum deficiency also ensures that the use of nitrogen fertilizer is more efficient, cost effective and less harmful to the environment. Optimizing output from existing production minimizes the amount of additional land turned over to food production as demand increases, thereby helping to preserve biodiversity.

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8 Ezz, TM and Kobbia, AM, 'Effect of molybdenum nutrition on growth, nitrate reductase activity, yield and fruit quality of Balady mandarin trees under low and high nitrogen levels', Alexandria Journal of Agricultural Research
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