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Molybdenum deficiency in plants

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Molybdenum (Mo) is one of the six 'minor' chemical elements required by green plants. The other five are iron, copper, zinc, manganese and boron.

These elements are termed 'minor' because plants need them in only very small amounts (in comparison with the 'major' elements nitrogen, phosphorus, potassium, sulfur, calcium and magnesium). But they are essential for normal growth.

Of these six minor elements, molybdenum is needed in smaller quantities than any of the others. As little as 50 grams of molybdenum per hectare will satisfy the needs of most crops.

Molybdenum is often present in farmyard manure, in seeds or other planting material such as tubers and corms, and as impurities in some artificial fertilisers. The molybdenum supply from the seed appears to be significant only where the size of the seed is fairly large. For example, the molybdenum content of bean, pea and maize seed can be important, but that of tomato seed is probably of little significance.

SOIL ACIDITY

Molybdenum in acid soils tends to be unavailable to plants. This is why most molybdenum deficiencies occur on acid, rather than on neutral or alkaline soils. A few cases of molybdenum deficiency have been reported on soils with a pH above 6.0, but most occur where pH is 5.5 or less. (Note: On the pH scale 7.0 is neutral. Less than 7 indicates acidity, and above 7.0 alkalinity.)

DEFICIENT AREAS

Molybdenum deficiencies occur mainly on acid soils throughout the coastal areas and on much of the Southern Tablelands of New South Wales. Parts of the Central Tablelands and Northern Tablelands are also deficient in molybdenum, and molybdenum responses have been obtained in crops in the Murrumbidgee irrigation areas.

FUNCTION IN PLANTS

Molybdenum is needed by plants for chemical changes associated with nitrogen nutrition. In non-legumes (such as cauliflowers, tomatoes, lettuce, sunflowers and maize), molybdenum enables the plant to use the nitrates taken up from the soil. Where the plant has insufficient molybdenum the nitrates accumulate in the leaves and the plant cannot use them to make proteins. The result is that the plant becomes stunted, with symptoms similar to those of nitrogen deficiency. At the same time, the edges of the leaves may become scorched by the accumulation of unused nitrates.

In legumes such as clovers, lucerne, beans and peas, molybdenum serves two functions. The plant needs it to break down any nitrates taken up from the soil—in the same way as non-legumes use molybdenum. And it helps in the fixation of atmospheric nitrogen by the root nodule bacteria. Legumes need more molybdenum to fix nitrogen than to utilise nitrates.

SYMPTOMS

The main symptoms of molybdenum deficiency in non-legumes are stunting and failure of leaves to develop a healthy dark green colour. The leaves of affected plants show a pale green or yellowish green colour between the veins and along the edges. In advanced stages, the leaf tissue at the margins of the leaves dies. The older leaves are the more severely affected. In cauliflowers, the yellowing of the tissue on the outer leaves is followed by the death of the edges of the small heart leaves. When these develop, the

absence of leaf tissue on their edges results in the formation of narrow, distorted leaves to which the name 'whiptail' has been applied. Affected leaves are usually slightly thickened and the leaf edges tend to curl upwards, especially in tomatoes.

It has been mentioned that legumes such as peas and beans need molybdenum either for utilisation of nitrates (as do non-legumes), or for nitrogen fixation by root nodule bacteria. Where molybdenum is deficient, and adequate nitrogen is available from fertilisers applied to the soil, symptoms of molybdenum deficiency are similar to those seen in non-legumes, namely, interveinal and marginal leaf chlorosis followed by death of the tissue on the leaf margins. These symptoms are seen in a condition found in french beans in the Gosford district, to which the name 'scald' has been applied.

In lucerne, clover and other pasture legumes, the main symptoms are associated with an inability to fix atmospheric nitrogen. This stunting and yellowing is identical with nitrogen deficiency and resembles legumes having no nodules and grown in poor soils.

DIAGNOSIS

In some crops, especially cauliflowers, there are very characteristic molybdenum deficiency symptoms. In others it is not always possible to diagnose with certainty whether a plant or a crop is suffering from a low supply of molybdenum. The best way to find out is to apply a solution of sodium molybdate or ammonium molybdate to the leaves of the plants or to the soil at their base, and see whether there is any response. This would be in the form of improved growth or development of a healthy leaf colour, compared with similar, untreated plants.

Certain chemical tests can help diagnose molybdenum deficiency. In addition, the following can often help determine whether it is worthwhile making a trial application of molybdenum:

- **Occurrence of whiptail in cauliflowers in the same locality**. Cauliflowers have a high molybdenum requirement. If they are growing well on an unlimed soil, and without any trace of whiptail disease, it is unlikely that other crops in that area would suffer from molybdenum deficiency.
- **Soil acidity**. As mentioned earlier, molybdenum deficiency is more likely on acid soils having a pH of 5.5 or less.
- **Use of farmyard manure**. Where large amounts of farmyard manure have been used, molybdenum deficiency is less likely.
- **Patchy distribution of affected plants**. Patchy distribution is characteristic of molybdenum deficiency. The whole crop may be affected, but it is much more usual to find patches of affected plants in an otherwise healthy crop, or vice versa.

CONTROL

In most soils, molybdenum present in an unavailable form will be released by applying lime or dolomite. The effect of liming on molybdenum availability is slow and it may take several months to correct the deficiency. The amounts of lime or dolomite needed may range from 2 to 8 tonnes per hectare, depending on initial pH of the soil and whether it is sandy or heavy textured. Unless lime is likely to be beneficial for other reasons, it is quicker and cheaper to apply a molybdenum compound to the soil or to the crop.

Where one of the molybdenum compounds is used, the quantities recommended vary from 75 g to 1 kg/ha depending on the crop and the molybdenum material.

Molybdenum can be applied in the following ways:

- mixed with fertiliser; or
- in solution, to
  - — seedlings in the seedbed before transplanting;
  - — the leaves of plants in the field; or
  - — the soil at the base of plants in the field.

CROP RECOMMENDATIONS

Clovers and lucerne

Molybdenum trioxide (or equivalent amounts of sodium molybdate or ammonium molybdate): 75 g/ha mixed with superphosphate.

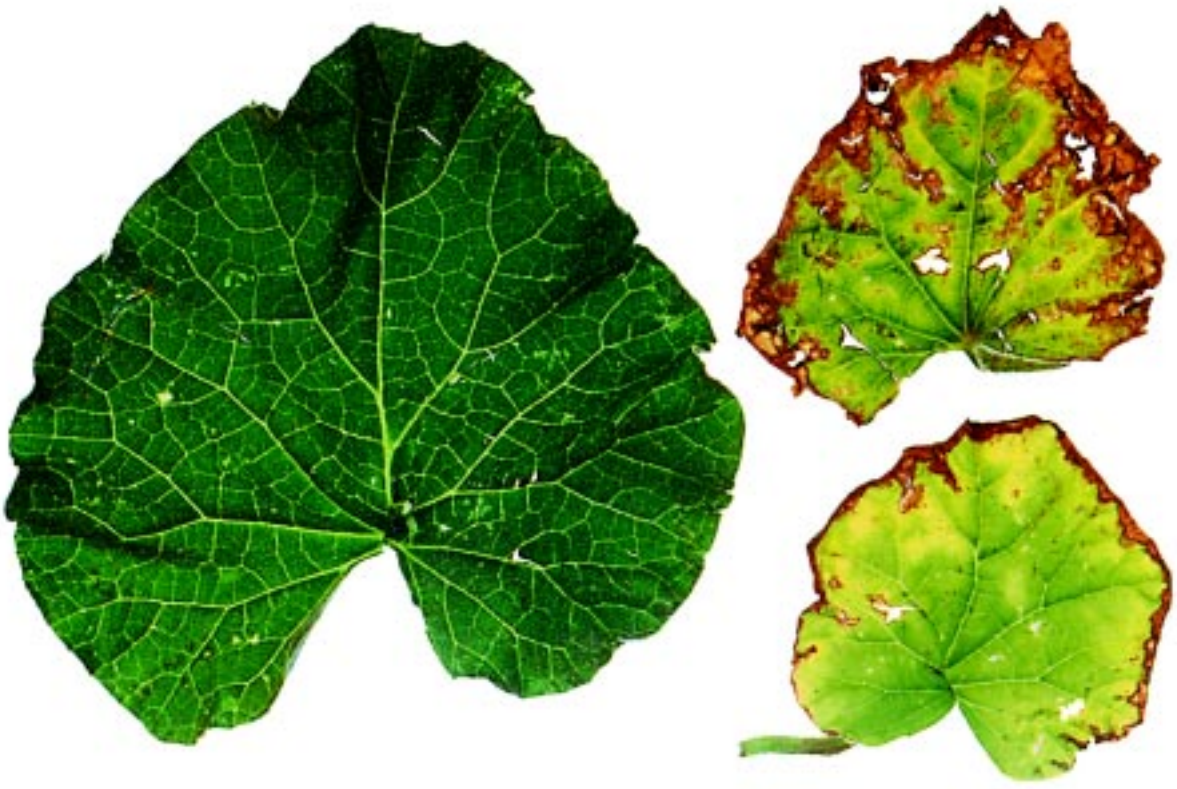
Vegetable crops

(a) Mixed with fertiliser. Ammonium molybdate or sodium molybdate, 1 kg/ha.

(b) Seedbed application to crops such as cauliflower, broccoli, cabbage and tomato. Ammonium molybdate or sodium molybdate, 40 g dissolved in 50 L water and watered on to each 10 m^2 of seedbed about one to two weeks before transplanting. (Following such seedbed applications, cauliflower seedlings often develop a distinct blue colour in the stems and leaves. This blue colour gradually disappears when they are transplanted.)

Above: Early signs of molybdenum deficiency in sunflower are seen as paleness of the leaves of the affected plant on the right compared to those of the healthy dark green plant on the left. Later signs are shown in the photo on page 4. Photo: R. Weir.

Molybdenum deficiency of rockmelons. Below left: a healthy leaf from a plant treated with sodium molybdate. Below right: leaves from an untreated plant showing advanced stage of yellowing with death of leaf edges. Photo: R. Weir.



Later signs of molybdenum deficiency of sunflower. The leaves have become yellow with burnt areas around the edges and between the veins. Photo: R. Weir.

(c) Field application to growing crops. About 50 g of ammonium molybdate or sodium molybdate in 100 L water. This may be sprayed onto the leaves of plants such as tomatoes and beans or it can be applied to the ground at the base of the plants, giving each cauliflower or tomato plant about 150 mL of solution.

These recommendations are usually more than enough to supply the molybdenum requirements of crops. Lower rates may be adequate, but more than the recommended rate is a waste of money, and may injure the plants.

Mo COMPOUNDS AVAILABLE

Molybdenum compounds used for crops include molybdenum trioxide, sodium molybdate and ammonium molybdate. Choice of the material to be used depends on whether it is to be applied with fertilizer or as a solution

Molybdenum trioxide is only partially soluble in water. It is the form usually used in molybdenized superphosphate but is not suitable for making up sprays to treat a growing crop. Molybdenum trioxide (also called molybdic oxide) contains 66 per cent molybdenum.

Ammonium molybdate contains 54 per cent molybdenum. Though it is soluble in water, it is frequently sold in large lumps which dissolve slowly in cold water. It is better either to use hot water to dissolve the lumps or to crush them to a fine powder before adding to the water.

A molybdenum deficient rockmelon plant showing pale leaves which have become burnt around the edges and between the veins. This burning develops because a molybdenum deficient plant cannot use the nitrates it takes up from the soil to build proteins. Photo: R. Weir.

Sodium molybdate is usually sold in a form containing 39 per cent molybdenum. It is sold as fine crystals which dissolve readily in cold water and this material is undoubtedly the most convenient for the preparation of solutions to be used for spraying.

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