Molybdenum deficiency in the wheatbelt

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The trace element molybdenum is needed in very small amounts in the nitrogen metabolisms of crops and pastures. One of the projects that started as a result of the overall soil acidity research programme was an examination of molybdenum deficiency on acid soils throughout the South-West of Western Australia.

Deficient soils

Molybdenum deficiency was not recognised in the wheatbelt until 1962, although it had been recorded on pasture legumes on some soils in areas with more than 400 millimetres rainfall.

After the discovery of molybdenum deficiency in wheat and oats on a sandplain soil at Gutha in 1962, the Department of Agriculture investigated the distribution of molybdenum deficiency in trials throughout the wheatbelt between 1963 and 1972.

Molybdenum deficiency in wheat was restricted to the acid members (pH less than 6* in the top 10 centimetres) of the yellow and brown lateritic earthy sands and sandy earths. These are the dominant sandplain soils of the south-central, central, eastern, northern, and north-eastern wheatbelt.

The sandplain soils of the eastern wheatbelt can increase in acidity with depth. They contain large amounts of "free" iron and aluminium oxides which colour the soils yellow to brown and give them an earthy or gravelly texture.

These sandplain soils are neither uniformly acidic nor uniformly deficient in molybdenum. Unfortunately the degree of soil acidity or molybdenum deficiency cannot be predicted from observable variations in the natural "Wodgil" vegetation. The most acutely molybdenum deficient soils are the more acid members of the sandplain in the drier regions of the wheatbelt. Areas of mildly or non-deficient light and heavy textured soils may occur amongst areas of deficient sandy soils.

It has been estimated that about half of the three million hectares of wheatbelt sandplain would be deficient in molybdenum for wheat production immediately after clearing if no molybdenum fertiliser were applied. Deficiency is likely to develop on the remainder if acid-forming ammonium fertilisers such as Agras and sulphate of ammonia are repeatedly used.

Molybdenum deficiency has not been recorded in cereals outside the wheatbelt sandplain (see map). In these areas molybdenum applications should generally be avoided. Its use should be confined only to soils where there is sound evidence for real need. Where pastures already contain more than one part per million molybdenum, further applications can be dangerous to sheep and cattle.

The soils outside the wheatbelt are usually less acidic or contain less "free" iron and aluminium oxides than the often severely molybdenum deficient sandy soils of the wheatbelt.
The shading in the map shows the area of yellow brown latentic earthy sands and sandy earths. Molybdenum deficiency in cereals and legumes is associated with the acid members of these sandplain soils.

The author conducting glasshouse experiments. Moist incubation of soil in temperature controlled tanks for short periods of time simulates many years of field conditions.

Symptoms and recognition
Molybdenum deficiency can reduce the potential yield of a crop or legume pasture by 30 per cent before visual symptoms appear.

Deficiency symptoms are often non-specific and can vary with the degree of deficiency and plant species or variety. Symptoms can, therefore, often be misleading and more information is needed to make a positive diagnosis.

Plant tissue analysis gives an indication of the molybdenum status of the wheat plant at the time of sampling. As molybdenum is immobile in the wheat plant under deficient conditions, only the youngest emerged blade (Y.E.B.) should be analysed (Figure 1).

Analytical results from many glasshouse and field experiments indicate that the critical levels of molybdenum in the youngest emerged blade of wheat sampled from the five to eight (or flag) leaf stage are:

- Less than 0.07 parts per million: probably deficient. A grain yield increase would be expected by the addition of molybdenum.
- 0.07 to 0.10 ppm: marginally deficient. A grain yield increase may occur, if not in the current year, within the next few seasons.

“Within the next few seasons” is not a precise time because the rate of decline in plant available molybdenum for different soil types cannot yet be predicted accurately.

Treatment
Molybdenum deficiency is usually corrected by applying the recommended rate of 75 grams of molybdenum per hectare to the soil in a superphosphate-molybdenum fertiliser. The mixes produced by CSBP and Farmers Ltd are:

- Super—Molybdenum.
- Super—Copper, Zinc, Molybdenum No. 1.
- Super—Copper, Zinc, Molybdenum No. 2.
- A new nitrogen and phosphorus fertiliser with trace elements equivalent to the No. 1 mix will be available in 1985.

As all the mixes contain 400 ppm molybdenum, the choice lies in the needs of the other trace elements copper and zinc. Using any of the...
three mixes at a rate of 190 kilograms per hectare will supply the recommended application rate of molybdenum. Applying molybdenum at the recommended rate costs nearly $3 per hectare more than an equivalent rate of plain superphosphate.

Further applications on old land

Although there are recommendations for initial applications of molybdenum on new land, little is known about the need for further applications on old land. The availability of molybdenum declines at different rates for different soil types, depending mainly on:

• Soil acidity. Less molybdenum is available to wheat plants growing in acid soils than in neutral or alkaline soils. As soils become more acid (decreasing pH) the soil pool of available molybdenum decreases because soil constituents adsorb more molybdenum, making it less available to plants. Liming acid soils can increase the availability of molybdenum by reducing acidity.

• Iron and aluminium. In acid soils, iron and aluminium oxides strongly bind molybdenum in forms unavailable to plants.

In some soils a single application of 75 g of molybdenum per hectare has remained effective for 15 years or more. These soils usually have a surface pH above 5.5.

However, on some yellow-brown sandplain soils of the central and north-eastern wheatbelt, the effectiveness of molybdenum applications has declined rapidly over one to two years. In these situations the top 10 cm of soil has usually been below pH 5.5, and the 10 to 20 cm layer has usually been more acidic at pH 4.5 or lower.

Table 1 shows the results of a long term field experiment at Tammin on a responsive sandplain soil of pH 5.0. As indicated by the molybdenum concentration in the youngest emerged blade, the relative effectiveness of molybdenum applied to the soil declined rapidly within one year to restrict maximum grain yield.

Application methods

Molybdenum deficiency, as established by the youngest emerged blade tissue test, can be overcome by the following methods:

<table>
<thead>
<tr>
<th>Year of molybdenum application</th>
<th>Grain yield (t/ha)</th>
<th>Molybdenum concentration in Y.E.B. (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No molybdenum</td>
<td>0.73</td>
<td>0.02</td>
</tr>
<tr>
<td>1981</td>
<td>0.86</td>
<td>0.04</td>
</tr>
<tr>
<td>1982</td>
<td>0.83</td>
<td>0.06</td>
</tr>
<tr>
<td>1983</td>
<td>0.96</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Drill with superphosphate

Molybdenum can be applied with phosphorus by drilling the superphosphate-molybdenum mix (400 ppm molybdenum). Applying 190 kg/ha of this mix will supply the recommended rate of 75 g of molybdenum per hectare. Although this amount of superphosphate exceeds normal rates of phosphorus application on old, acid light land, the increased yields obtained ensure net profit is maintained near maximum.

Old pastures can also be topdressed with the superphosphate-molybdenum mix but must be managed to avoid the risk of molybdendosis to stock. Sheep and cattle should not be allowed to graze pastures topdressed with molybdenum until heavy rains have washed the fertiliser dust from the plant and no granules are readily available to the stock.

Soil sprays

Molybdenum can be sprayed on the soil at a rate of about 200 g of sodium molybdate (39.6 per cent molybdenum) in 50 litres of water per hectare. The soil must be cultivated after spraying or the molybdenum will not be available to the plant.

Sodium molybdate cannot be applied with copper sulphate from the same boom spray tank, and its compatibility with the wide range of existing pre-emergent herbicides has not been evaluated. Soil sprays can, therefore, need a separate application. This disadvantage can make soil spraying a less economical method.

Foliar sprays

Foliar sprays can be used to apply molybdenum to crops and pastures. The current recommendation is 50 g of sodium molybdate in 50 to 100 litres of water per hectare which gives 20 g of molybdenum per hectare.

Although this is about one-quarter of the rate recommended for soil application, foliar sprays are not generally recommended because of the need for more regular applications and the associated risk of molybdendosis developing in grazing stock.

The most effective time to apply a foliar spray to a wheat crop appears to be at the six leaf stage. The possibility of applying molybdenum with post emergent herbicides to reduce application costs is being investigated.

Further research

Other application methods are being evaluated in the molybdenum research programme. The aim of the research is to increase the period during which molybdenum in the soil is available to plants. This is relevant to those acid soils of the wheatbelt sandplain where conventional molybdenum fertilisers are effective for only a short period.
Three methods are being investigated.

- **Limestone-molybdenum granular fertilisers.** The limestone in these granules will provide the molybdenum with a less acidic microenvironment in high absorbing (molybdenum fixing) acid soils. This could result in increased initial and residual (long term) availability of molybdenum to plants.

- **Molybdenite.** The use of the primary mineral molybdenite is being studied to increase the residual availability of molybdenum to plants. This method uses the slow release principle as applied to insoluble rock phosphates.

- **Seed dressing.** Could greatly reduce the amount of molybdenum that needs to be applied. If proven effective, the molybdenum could be applied with fungicidal dust at seed cleaning and dressing. Molybdenum cannot be applied to inoculated legume seed as it will kill the rhizobia.

**Acknowledgements**

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**Further reading**

