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Symptoms and treatment of copper deficiency of wheat

By J. W. Garrell and R. F. Brennan, Plant Research Division, and A. D. Robson, Institute of Agriculture, University of W.A.

Copper deficiency in wheat is still common but may not be easily noticed. Many old-established farms, especially in the Great Southern and Victoria Plains districts, lose as much as several thousand dollars worth of wheat per farm each year as a result of copper deficiency. The heavier non-deficient soils on which the districts were originally founded did not require copper but deficiencies have occurred on the sandier soils developed later without copper fertiliser. In newer districts developed on sandy and gravelly soils, farmers recognising the need for copper apply it with the first crop after clearing, and copper deficiency is rarely seen. The exception is in dry years when shallow-drilled, course-granulated copper-superphosphate has been ineffective in the year of application.

Copper is essential for plants and animals, in minute amounts. A heavy, healthy wheat crop of say 5 000 kg of straw and grain may contain only 10 grams of elemental copper—two parts in a million.

It is most needed by plant growing points and young tissues, but cannot move freely within the plant, particularly at high nitrogen and low copper levels. This is reflected in the pattern of deficiency symptoms which are more likely to occur in young than in older tissue.

Symptoms
The appearance of a plant rarely allows positive identification of copper deficiency. Most symptoms are not caused only by copper deficiency, or are often inconspicuous.

With increasing severity of copper deficiency the symptoms are:

- Weak stems between the ear and top node. Normal grain filling in the mildest form of copper deficiency causes the stems to bend under the increasing weight of the ear. However, wheat normally bends a little, particularly due to rain after maturity.

  With slight pressure the stem will collapse and the ear hangs down or breaks off together with a piece of stem. Hail and high winds accentuate this.

- Leaves of copper deficient plants readily become limp as they lose water during warm, dry periods of the day. This may be confused with moisture stress wilting.

  In severely deficient plants, leaves may completely collapse about mid-way between tip and base, but this is easy to confuse with manganese deficiency.

- Restricted grain filling: Mildly copper deficient plants produce shrivelled grain but this may be confused with effects of root rots, frost, drought, herbicide damage or molybdenum deficiency.

- Partially filled ears. Pollen sterility produces uneven or complete failure of grain set in the ears. Affected heads have a loose, open appearance which may be confused with effects of root rots, frost, drought, herbicide damage or molybdenum deficiency.

- Empty ears. Pollen sterility or premature death of developing reproductive tissue produces completely empty ears. In copper deficiency, dead tissue is typically white at first but may darken.

  The tip of the ear may be more affected than the base giving a "rat-tail" appearance, but this may be confused with effects of root rots, frost, drought, herbicide...
Copper deficient plot showing delayed maturity. The deficiency is usually unnoticed until maturity or harvest although there may be occasional leaf symptoms damage, or molybdenum and calcium deficiency. In more severe cases, the ear turns yellow-white, dies and fails to emerge from the boot. This may be confused with effects of insect damage, root rots, frost, drought, herbicide damage or molybdenum and, less likely, calcium deficiency.

- Dark pigments. Conditions such as copper deficiency that may affect heads without killing the leafy portions of the plant, often lead to the accumulation of plant sugars in the stems and any ear tissues. This results in the production of dark pigments as the tissues dry off. Black, brown, grey and mauve-purple pigments can occur on ears, nodes and stems, particularly on the sunny side of the plant. These plants tend to remain green while healthier plants mature and dry off. Darkening due to copper deficiency may be confused with effects of septoria, frost, drought, herbicide damage or mechanical damage such as galahs ripping off green ears.

- Death of growing points. Copper deficiency may stop development and cause death of new leaves and the ear. The first tiller is usually less affected than secondary tillers, and successive tillers are produced and abort until all growing points die. This may be confused with effects of root rots, herbicide and insect damage, and less likely, calcium deficiency.

- Bleaching of leaf tips. Chlorophyll production fails in youngest developing leaf tissue in plants affected by severe copper deficiency. This usually shows as yellow-white or white tissue extending back from the tip of the youngest expanded leaf, while any emerging leaves are usually totally affected and eventually die. Sometimes the expanded leaf will only show broad yellow-white or yellow streaks back from the tip. This is the most specific of all copper deficiency symptoms but it may be confused with herbicide and insect damage or phosphate and salt toxicities. Dead tips turn pale brown and may roll and twist but this may be confused with herbicide, drought and wind damage. Only in the most severe cases of copper deficiency are the whole plants strikingly pale as in manganese deficiency. Usually younger tissues are markedly more affected than older tissues.

If the production of chlorophyll is stopped at a later stage, tipped ears result, often with none of the effects showing on leaves.

**Treatment**

A single application of 3 to 9 kg/ha copper sulphate provides enough copper for more than a hundred years for the systems of agriculture now in use in Western Australia.

In commercial copper-superphosphate mixtures the copper is incorporated into the superphosphate granule. This normally provides a satisfactory copper supply, but failures have occurred in the year of application due to poor positioning of the copper in relation to the wheat roots. This has occurred particularly where the granule size of the mix has been more than 3 mm diameter, reducing numbers of granules per unit length of row, and also where seed and fertiliser have been sown less than 4 mm deep in dry years. In dry conditions root development is poor in the copper fertiliser zone.

Once in the soil, applied copper is highly insoluble and hardly leaches. Fertiliser copper is less
Severe copper deficiency in early stages of growth. It may be as early as two weeks after germination if shrunken seed low in copper is sown on severely deficient soil. Nearly all tillers fail to emerge fully, and those that do die prematurely. Plants continue to tiller from the base but are generally pale and wilted. Little grain can be harvested. Older leaves may also be affected and the contrast between old and young leaves is therefore less, resembling manganese deficiency.

Available when banded with the seed than when mixed through the soil by cultivation so that uptake is much greater in years after the first crop.

A second application some years after the first may be desirable to ensure that no patches such as windrows, root heaps and fallen trees are missed. Drill application is recommended because spinner broadcasters have often given appalling failures through missed strips.

A foliage spray of 1.5 kg copper sulphate in 50 to 100 litres of water per hectare has proven fully effective and is particularly useful where the need for copper application is not recognised until after the crop has been planted, but before flowering.

However for complete effect, this must be repeated with subsequent crops until the total recommended for soil application is reached. Higher copper applications in a single foliage spray cause burning. Corrosion of metal parts of spray equipment is another problem with spraying, and the period in which copper sulphate is in spray equipment should be minimised.

Soil and tissue levels

Used correctly, the ammonium oxalate extractable soil copper level can be useful in gauging the copper-supplying status of a soil. It also gives an indication of whether copper fertilisers have previously been applied to a paddock by a previous owner.

A level of 0.3 ppm ammonium oxalate extractable copper or less in the top 10 cm of soil indicates almost certain deficiency for wheat; 0.3 to 0.8 ppm copper may be deficient; and 0.8 ppm copper and above is almost certainly adequate. However, soil analyses for copper can easily be wrongly interpreted.

Analysis of the youngest fully expanded leaf at the five to eight leaf stage, but before flowering, is the most accurate method of assessing copper status. Provided the sample does not contain a mixture of healthy and deficient plants, the interpretation is relatively simple (see table).

Where growth has been limited up to the time of sampling such as by severe moisture stress, nitrogen and other nutrient deficiencies, the tissue sampling will not accurately predict whether the crop will become copper deficient at a later date. It merely assesses the copper status of the plant when sampled.

However, it has already proved invaluable when used to identify severe copper deficiency in time to apply a copper spray to save the crop.

Copper status of wheat from analysis of the youngest fully expanded leaf

<table>
<thead>
<tr>
<th>Copper (ppm) in youngest fully expanded leaf</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 or more</td>
<td>Healthy</td>
</tr>
<tr>
<td>1.6 to 2</td>
<td>Marginal</td>
</tr>
<tr>
<td>1.3 to 1.6</td>
<td>Mildly deficient</td>
</tr>
<tr>
<td>Less than 1.3</td>
<td>Moderately to severely deficient</td>
</tr>
</tbody>
</table>