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The Use of Copper and Zinc in the Cereal-Growing Districts of Western Australia

By J. TOMS, B.Sc. (Agric.), Plant Research Division

FERTILISERS containing small quantities of copper and zinc are widely used for crops and pastures in Western Australia, and the benefits resulting from the use of one or both of these trace elements—especially on sandy or gravelly soils—have been demonstrated in numerous trials during the past 20 years. It is estimated that about 5,000,000 acres have been treated with copper and zinc in Western Australia in the ten-year period 1947-1956. In this article, an attempt has been made to answer some of the common inquiries made by farmers concerning the use of copper and zinc in cereal-growing districts where large areas of light land are being developed.

Application of copper and zinc to all light land is a sound policy. In most cases it will result in marked improvements in crop yields and pasture growth, and even where no spectacular plant growth responses are obtained, there will usually be improvements in animal health.

WHAT SOILS ARE DEFICIENT IN COPPER AND ZINC?

In general, it is advisable to apply both copper and zinc to the first crop grown on any land with a sandy or gravelly surface.

Soils with such "light" surface characteristics carry a wide range of native vegetation, e.g., the mallees, low scrub and tussocks, the wodgil association, blackboy, red gum, wandoo, jarrah, blackbutt and tamma are all found on soils of sandy or gravelly surface.

All such soils have low copper and zinc content, but in some areas little or no crop response is obtained from copper and zinc fertilisers. These areas, however, are not extensive and the pasture growing on them is generally too deficient in copper for stock to attain perfect health. Also such soils often require addition of zinc when oats are grown.

It is therefore, advisable to apply copper and zinc to all soils of light surface.

Copper should also be applied to all soils in the Gingin and Dandaragan areas.
Even heavy soils in these districts are acutely copper-deficient.

Oats sometimes show zinc deficiency on heavier soils but only on small areas which have been made alkaline by the burning of heaps of stumps or brush. On the alkaline “puffs” of some heavy “crab-hole” soils, zinc deficiency in oats may also occur.

**Fig. 2.—Mild copper deficiency in wheat. Note the bent stems and ears. The straw has been weakened, but there has been little reduction in grain production. The weight of the grain has resulted in the bending of the weak straw.**

**Fig. 3.—Effect of copper deficiency on wheat straw colour. The plot in the middle has not received copper and is much darker than the crop on the extreme left and right which has received copper. This darker colour is sometimes due to the greater incidence of septoria on the copper deficient plants.**

**HOW ARE THE DEFICIENCIES RECOGNISED ON CEREALS?**

Copper deficiency affects wheat, barley and oats, but on similar soils cereal rye grows normally.

Wheat is more susceptible than barley, which in turn is more susceptible than oats.

The symptoms are best seen on wheat, but are similar for wheat, oats and barley.

With mild copper deficiency on wheat, symptoms are seldom seen till the crop is nearly mature. The straw is weakened but a considerable quantity of grain is formed. This causes the weight of the ear to bend the stem often to such an extent that the ear points to the ground (see Fig. 2). When the deficiency is as mild as this, yields may be only slightly increased by addition of copper fertiliser.

When the deficiency is more pronounced, ears form but little or no grain is set. If some grain is produced it is shrivelled. The stem is weak but as it carries no grain it is able to bear the ear erect. These dummy heads
are often referred to as “whiteheads,” but in actual fact they are more often straw-coloured. (Similar “whiteheads” can often be caused by drought or frost). The last leaves to form on the stem often die from the tip backwards, the leaf whitening, twisting and fraying in the process.

When the deficiency is acute, symptoms can show up early in the growing period. The whole terminal shoot dies, whitens and twists (see Fig. 1). Under such circumstances ears do not usually form.

Secondary tillering—the growth of new shoots at the base of the plants—is a characteristic of acutely copper-deficient plants. These secondary tillers become affected like the older growth and their terminal shoots also die, whiten and twist. Thus a plant is produced with a large number of tillers, few or none of which produce ears. Some secondary tillering can also occur on plants less acutely affected by copper deficiency.

The maturity of copper deficient plants is often delayed.

The straw of copper-deficient plants is darker in colour than that of healthy plants.

Copper-deficient plants are more susceptible to “foot rot,” “root rot,” and septoria attack. Attack by septoria can often be severe enough on copper-deficient plants to cause the straw to be dark grey in colour while neighbouring plants receiving copper fertiliser are hardly affected.

Copper-deficient plants are very sensitive to drought, because of poorer root growth and reduced ability to retain water.

It is interesting that although oats are less sensitive than wheat to copper deficiency they normally contain a greater quantity of this element. Oats evidently are more efficient than wheat in removing copper from the soil. (Similarly, wheat contains more zinc than oats, yet responses to zinc are more frequent with oats than wheat.)

Copper deficiency is difficult to recognise in barley or oats unless it is acute. Grain yields can be reduced, and yet there may be no obvious symptoms. When the deficiency is acute, the same symptoms are exhibited as are shown by wheat.

Zinc deficiency mainly affects oats, which are far more susceptible than wheat or barley.

The first signs of the deficiency can occur early in the growing season. In succession the oldest leaves turn a black or grey-black colour, the colour change commencing at the leaf tip and gradually extending until the whole leaf is affected. Multi-colour changes down the leaf are often apparent (see Fig 4). A full range of colours from the leaf tip would be
black, red, orange, yellow and normal green at the base. Often some of these colours are absent, e.g., red and yellow stages may not be apparent, while sometimes the black grades sharply to normal green. The blackened area twists from the tip downwards as the blackening extends. Growth of the plant is arrested and maturity delayed. At maturity the straw is grey in colour, and is easily distinguished from straw of healthy plants.

Some recovery is often made by deficient plants towards the end of the growing season, and reasonable crops are sometimes produced.

**SUMMARY OF RESULTS OF COPPER AND ZINC EXPERIMENTS ON LIGHT LAND IN THE WESTERN AUSTRALIAN WHEATBELT IN THE YEARS 1953-1956 INCLUSIVE**

Table 1

<table>
<thead>
<tr>
<th>WHEAT</th>
<th>OATS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Experiments</td>
</tr>
<tr>
<td>-------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Total number of experiments from which the data were drawn</td>
<td>43</td>
</tr>
<tr>
<td>Experiments showing no effect of copper or zinc alone or in combination</td>
<td>14</td>
</tr>
<tr>
<td>Experiments showing yield increase with zinc application (no copper applied)</td>
<td>8</td>
</tr>
<tr>
<td>Experiments showing yield increase with copper application (no zinc applied)</td>
<td>25</td>
</tr>
<tr>
<td>Experiments showing yield reduction with zinc application (no copper applied)</td>
<td>7</td>
</tr>
</tbody>
</table>

* This reduction was due to shedding of grain on the earlier maturing zinc treated plots before it was convenient to harvest the experiment.

All yield differences used in this table are significant at the 5 per cent. level.

For barley and wheat, symptoms of zinc deficiency have not been clearly demonstrated. Large yield increases have never been obtained with zinc on wheat or barley except on coastal limestone soils. In one experiment, however, definite symptoms occurred on wheat plants not receiving zinc fertiliser.

Longitudinal yellow strips appeared, one each side of the leaf between the margin and centre. These eventually extended to the leaf edge and then into the leaf centre with accompanying death of affected tissue. Older leaves were first affected. As this symptom rarely appears in the field it is of little importance to farmers.

**HAVE THERE BEEN ENOUGH EXPERIMENTS WITH COPPER AND ZINC TO DEMONSTRATE THE NEED FOR GENERAL APPLICATION ON LIGHT LAND?**

The Tables 1 and 2 show the general results of experiments carried out in the Western Australian wheatbelt for the period 1953-1956 inclusive.
SUMMARY OF RESULTS OF COPPER AND ZINC EXPERIMENTS ON LIGHT LAND IN THE WESTERN AUSTRALIAN WHEATBELT IN THE YEARS 1953-1956 INCLUSIVE

Table 2
Effects of Copper and Zinc applied together

<table>
<thead>
<tr>
<th></th>
<th>WHEAT</th>
<th>OATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Experiments</td>
<td>Average effect on yield at each site in bushels per acre</td>
<td>Number of Experiments</td>
</tr>
<tr>
<td>38</td>
<td>...</td>
<td>25</td>
</tr>
<tr>
<td>15</td>
<td>...</td>
<td>8</td>
</tr>
<tr>
<td>22</td>
<td>4</td>
<td>16</td>
</tr>
</tbody>
</table>

Total number of experiments from which the data were drawn
Experiments showing no effect of copper and zinc applied together ... ... ... ... ... ... ...
Experiments showing a yield increase with copper and zinc applied together ... ... ... ... ... ... ...
Experiments showing a yield reduction with copper and zinc applied together ... ... ... ... ... ... ...

* This reduction was due to shedding of grain on the earlier maturing zinc treated plots before it was convenient to harvest the experiment.

All yield differences used in this table are significant at the 5 per cent. level.

be expected. It is seen that in quite a number of experiments no response was obtained to copper or zinc. In some cases this has been due to the poor season or to shedding of oats on plots receiving zinc (earlier maturity).

It can be seen from Table 1 that:

1. Wheat responds mainly to copper application.
2. Oats respond mainly to zinc application.
3. Wheat can respond to zinc, and oats can respond to copper.
4. Reductions in yield can often be expected when zinc is applied to wheat without the application of copper at the same time. This rarely occurs with oats.

As both wheat and oats can benefit from copper and zinc, the use of both in fertilisers on new light land is recommended rather than applying copper to wheat and zinc to oats. If both wheat and oats are grown in a rotation, necessitating the application of both copper and zinc, one fertiliser mixing charge is avoided by applying copper and zinc together, rather than in separate years. Also, subter-
Fig. 6.—Effect of zinc on oat maturity. The plot on the left has received zinc and is more mature than the plot on the right that has not received zinc.

Ranean clover often responds to zinc and copper application, while copper is often of advantage for stock health. Copper and zinc may therefore be of great value for the pasture in following years and for improving stock health. It is therefore always advisable to apply both copper and zinc to new light land.

**AT WHAT RATES SHOULD COPPER AND ZINC BE APPLIED?**

This question is very difficult to answer, and only general recommendations can be made. Optimum rates of application vary appreciably for different soils and different seasons. Any general recommendation must be suitable for land acutely deficient in copper or zinc as well as land where only small responses are obtained. The recommended rates have therefore been made ample for most districts but low enough so that toxicity does not occur. Now that oxidised copper ore is used in fertilisers instead of copper sulphate, toxicity is not likely.

The recommended rate of application has been two-thirds of a bag (120 lb.) to one bag (187 lb.) of copper-zinc-superphosphate to the acre. This supplied approximately 20 to 30 lb. of copper ore (6 per cent. copper) and 2 to 3 lb. of zinc oxide (71 per cent. zinc).

On new land a bag to the acre of the mixture should be used as this supplies 150 lb. of superphosphate to the acre. Practically all new light land is phosphorus-deficient a dressing of at least 150 lb. of superphosphate to the acre is generally recommended.

Recently the fertiliser companies have increased the copper content of the copper ore to 7 per cent. at no extra charge. This could benefit stock and increase the residual value (the time this one application will continue to give responses) of the application, but is unlikely to benefit cereals as the previous recommendation was adequate for most areas.

Recent work (1955) showed that wheat at Esperance required no more than 1 lb. 13 oz. of copper sulphate to the acre (equivalent to 6½ lb. of 7 per cent. copper ore), and wheat at Newdegate required no more than 20 lb. of 6 per cent. ore (the lowest rate tried).

Further experiments on rates of copper and zinc are now in progress at Newdegate and Hyden.

**HOW OFTEN SHOULD THESE FERTILISERS BE APPLIED?**

It has not yet been shown that a second application of copper and zinc is required on the deficient coarse-textured soils of the major part of the wheatbelt. A second application of copper would be advisable on copper-deficient limestone soils as at Dongara or the deficient soils at Bremer Bay, while at Dandaragan and Gingin repeated dressings are often required. These areas, however, are not large.
Plain superphosphate made in Western Australia has appreciable amounts of copper and zinc in it as an impurity. The application of 100 lb. of superphosphate to the acre will supply as much zinc and more copper than that removed from the farm in the grain of a good crop. As copper and zinc tend to be held in the soil against leaching it is probable that it would be many years, if ever, before the soil copper and zinc was reduced to a deficient level once the original deficiency has been corrected by application of copper and zinc. Previous experiments have shown that this residual effect has lasted at least five years.

**IS THE USE OF COPPER AND ZINC ECONOMICAL?**

One bag of copper-zinc-superphosphate costs just over 12s. more than the amount of superphosphate it contains.

Therefore, to use this fertiliser at recommended rates the cost is not small, but for this outlay a farmer will probably:

1. Receive at least an equivalent return from the increase in yield of the first crop.
2. Obtain increases in yield of subsequent crops due both to residual value of the initial dressing and the better growth of pasture during the ley period.
3. Gain from improved subsequent pasture growth and animal health.

There is some variation from district to district but, in general, farmers cannot afford to farm light land without the application of copper and zinc.

In the main cereal-growing districts the Department has advisers of the Wheat and Sheep Division stationed at Geraldton, Moora, Northam, Narrogin, Katanning and Mt. Barker. (Their names are listed in the front pages of the Journal of Agriculture). These officers know the various districts intimately and have been trained to identify crop deficiencies. If you have any doubts about the use of copper and zinc write or telephone them and they will answer your queries. If necessary, they will arrange to visit your farm.

Use your advisers. Their services are free.

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Fig. 7.—Effect of zinc deficiency on oat straw colour. The centre plot received zinc and the straw is much brighter in colour than on those plots to the left and right which did not receive zinc.
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