Soil acidity in the eastern wheatbelt

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Although called sandplain, these soils contain from 10 to 20 per cent clay in the topsoil and even higher amounts—often up to 40 per cent clay at one metre deep—in the subsoil. These soils were extremely infertile before fertilisers were applied. Phosphate was the major nutrient needed but the amounts of copper, zinc and molybdenum present were also too low. Nitrogen levels were quickly depleted by cereal cropping. On some areas of the sandplain the acidity of these nutrients was enough to give good wheat yields. Even clover could be established, and persist, as long as the seasons were reasonably wet and the areas were not cropped too often. However, other areas have never produced a good wheat crop. Often the best yield was 500 kilograms per hectare and clover was never established on them.

The sandplain soils

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The acidity of the topsoil, the layer stained with organic matter, was thought to be one possible cause of poor plant growth on these soils. To test this the Department of Agriculture investigated the effects of applying molybdenum and lime on wheat yields at various sites in the eastern and north-eastern wheatbelt in the early 1980s (see map).

Soil acidity reduces the availability of molybdenum to plants. Liming soils can increase its availability, thus overcoming a molybdenum deficiency (Figure 1). Applying molybdenum improved wheat productivity in nearly all the trials on acid, eastern wheatbelt soils between 1981 and 1983, despite its previous applications at all sites. Lime applied at rates of up to four tonnes per hectare to the molybdenum treated topsoils rarely improved wheat yield. At two of the 20 sites added lime increased wheat yield by more than 10 per cent. At one of these two sites the yield response to lime disappeared if nitrogen was applied. Liming can increase the amount of nitrogen available to plants, usually for a brief period only, by improving the soil conditions for the microbes which break down soil organic matter, thereby releasing nitrogen.

Acidity in the topsoil can also reduce the amount of available phosphate to plants. Only one experiment in the eastern wheatbelt has examined the effect of soil acidity on the availability of fertiliser phosphate. In that trial, on a new land, yellow sandplain soil with a topsoil of pH 5.0 in water (pH 4.3 in calcium chloride) east of Hyden, liming increased the availability of phosphate applied as superphosphate. Despite these cases of improved production after applying lime to the topsoil, the yields of wheat were still low relative to the yields which could be obtained on the better sandplain soil of the eastern wheatbelt. There appeared to be some other cause of poor plant growth.

Subsoil acidity

The subsoils of the eastern wheatbelt sandplain are frequently more acid than the topsoils. A survey of all soil types showed that about one-third of the sites sampled had subsoil pH less than 5.0 in water (Table 1). In a laboratory experiment the acidity of two acid subsoils severely reduced root growth of wheat in the deeper subsoil (Figure 2). The main reason for poor root growth in the acid subsoils of the eastern wheatbelt is the very high concentrations of aluminium dissolved in the soil water which are toxic to plants. The stunted roots cannot explore the subsoil thoroughly to extract water and nutrients.

Table 1. Distribution of subsoil pH among 36 sample sites in Meringin area

<table>
<thead>
<tr>
<th>pH range in water</th>
<th>Percentage of subsoil samples from</th>
<th>Percentage of subsoil samples where samples were from</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 4.5</td>
<td>6</td>
<td>32</td>
</tr>
<tr>
<td>4.5 to 4.9</td>
<td>1</td>
<td>27</td>
</tr>
<tr>
<td>5.0 to 5.6</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>5.5 to 5.9</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>6.0 to 6.4</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>greater than 6.4</td>
<td>25</td>
<td>42</td>
</tr>
</tbody>
</table>
Two field experiments were held to test whether subsoil acidity is a major cause of lower wheat yields. The methods used to establish the trials at Merredin are shown in Photographs 1 to 6. The sites were next to trials in which lime added to the topsoil had not improved wheat yields.

The wheat growing in the limed drums grew faster and at one of the sites yielded more than twice the weight of grain than from plants in the unlimed drums (Table 2).

Another trial showed that lime applied in bands about 1 cm by 0.5 cm thick at 20 cm or 45 cm deep, or both, and spaced 30 cm apart, did not affect wheat productivity in the two years after application. Lime applied to the subsoil at rates and depths needed to improve root growth is currently not practical.

Tolerance of aluminium

Different species of crop and pasture plants vary widely in their tolerance of high concentrations of aluminium in the soil water, as do varieties within a species. These variations in tolerance mean farmers can choose a species or variety that is better adapted to growing on the very acid subsoils of the eastern wheatbelt sandplain. Figure 3 summarises the tolerance of a range of plants to available aluminium.

Wheat

All Australian wheat varieties are relatively sensitive to aluminium, so there is currently little advantage in selecting a different Australian variety in the hope of improving yields on areas with acid subsoils.

Plant breeders in the Department of Agriculture have a programme to incorporate the acid tolerance of Brazilian wheats into Australian varieties. The programme is about two years old and will need another few years to produce useful varieties for farmers.

Other crops

The benefits of increased yields from growing acid tolerant crops other than wheat on soils with acid subsoils have been examined in trials in the Merredin area since 1982. All sites were poor, deep sandplain soils. The crops compared were barley, wheat, oats, triticale, cereal rye and lupins.

Among the cereals, barley yielded poorest, on average about 30 per cent less than the yield of wheat. The yields of oats or triticale averaged 40 per cent and 30 per cent more than wheat. At times cereal rye produced more than twice the yield of wheat although its yield was much less reliable than the other cereals.

There has been very little selection of triticale or cereal rye for their suitability to the eastern wheatbelt. After selection of these crops their yield on acid soils in the eastern wheatbelt should be much higher than these experimental yields.

In the long term, the price a farmer will be able to obtain for triticale and oats will be less than that for wheat. However, because these crops yield better on soils with very acid subsoils, the returns per hectare from acid soil may always remain high relative to the return from wheat on these soils.

Lupin yields are usually similar to or slightly higher than wheat yields on these soils. Narrow-leaved lupins are more tolerant of aluminium.
toxicity than wheat (Figure 3). It appears that lupins will be successful as part of the farming system on the acid, eastern wheatbelt sandplain soils.

**Recommendations**

An eastern wheatbelt farmer should suspect subsoil acidity problems if he has an area of light-textured soil on which wheat produces poor yields, even in good seasons, and topsoil tests which show adequate phosphorus and potassium levels.

He should take samples of the subsoil 30 cm down and have their pH measured. If the pH is greater than 4.5 in water (pH 4.3 in calcium chloride) then he can probably rule out subsoil acidity as a problem. If the pH is greater than 5.0 in water (pH 4.7 in calcium chloride) he can confidently rule out subsoil acidity as a problem for wheat growth.

Having identified that subsoil acidity may be a problem, there is currently no way of predicting whether a more acid tolerant crop will yield better than wheat, or, if it does, by how much more. This option is being researched. A farmer could, however, put in his own trials. He should grow wheat and oats or triticale side by side, sown on the same day, at the same depth and with the same fertiliser, and compare their productivities.

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**Field trials**

Trials were established to test whether subsoil acidity significantly influenced wheat productivity at two sites representative of the eastern wheatbelt sandplain soils. These photos show how the trials were set up and the resulting effects on wheat growth.

Layers of soil to 1.6 m deep were removed from a small area and bagged separately (Photo 1). Six open-ended cylinders were placed in the hole (2). The soil was then weighed, mixed in a cement mixer and placed into the drums, layer by layer. Soil in three of the cylinders was mixed with lime (3); the other three drums received untreated soil (4). Wheat was then sown in the drums.

Wheat growing in the limed drums grew faster and at one of the sites yielded more than twice as much grain as wheat growing in the unlimed drums (5 and 6).