Fluid fertilisers free phosphorus for crops

Fluid phosphorus fertilisers are showing promise on the calcareous soils of Eyre Peninsula, South Australia, where soil chemical reactions frequently bind granular phosphorus and render it unavailable for plant use. But what of non-calcareous, alkaline and acid soils? This article details the impact of fluid phosphorus on a range of soil types.

**by Mike McLaughlin, CSIRO LAND AND WATER**

Early results suggest fluid phosphorus fertilisers could provide yield benefits over granular products on soils other than calcareous types.

But more research is needed to gain a better idea of the cropping benefits of fluid versus granular phosphorus, especially on acidic soils.

Wheat grown on sodosol and calcarosol soils from the Victorian Mallee treated with the fluid fertilisers ammonium polyphosphate and phosphoric acid produced more dry matter than plants fertilised with granular phosphorus (see Table 1).

There are also indications that fluid phosphorus could be superior to granular products under some circumstances on vertosol soils from the Wimmera, Victoria, district.

**Fertiliser rendered unavailable**

Calcareous and acid soils are widespread across Australia and are commonly used for cereal production.

But these soils present challenges for crop phosphorus nutrition because they can bind granular fertiliser phosphorus into forms unavailable for plant use.

Researchers from CSIRO, University of Adelaide, the Victorian Department of Primary Industries and the South Australian Research and Development Institute compared wheat growth response to fertiliser type on a range of Australian cropping soils. The fertilisers tested were triple-superphosphate, phosphoric acid, ammonium polyphosphate and a control of no phosphorus fertiliser.

The amount of phosphorus applied to each pot was equivalent to 12 kilograms of phosphorus per hectare with added nitrogen and trace elements for balanced nutrition.

Wheat responded to phosphorus application on 70 per cent of the soils tested (see Table 1).

In about 60% of soils, wheat plants grew significantly more when fluid fertilisers rather than granular fertilisers were used.

Soil pH and calcium carbonate content were the key soil properties controlling crop response to the fluid phosphorus fertilisers (see Figure 1).

Wheat grown on soils with high levels of calcium carbonate (free lime) responded best to fluid fertilisers.

Surprisingly, fluid fertilisers also performed well on some acidic soils (see Figure 1).

**Fluid phosphorus more available**

Researchers suspect crops find it easier to access phosphorus from fluid fertilisers rather than granular products on some soils.

For example, on calcareous soils supplied with granular triple superphosphate, the amount of plant tissue phosphorus was below the critical phosphorus deficiency limit.

Fr... **TABLE 1 Impact of fertiliser type on plant growth in different soils***

<table>
<thead>
<tr>
<th>Soil type</th>
<th>pH (water)</th>
<th>No phosphorus</th>
<th>APP**</th>
<th>H3PO4**</th>
<th>Triple-super phosphate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wimmera, Victoria</td>
<td>8.2</td>
<td>1.03</td>
<td>1.67</td>
<td>1.69</td>
<td>1.44</td>
</tr>
<tr>
<td>Birchip, Victoria</td>
<td>6.8</td>
<td>1.36</td>
<td>1.71</td>
<td>1.80</td>
<td>1.55</td>
</tr>
<tr>
<td>Northern Mallee, Victoria</td>
<td>8.0</td>
<td>0.71</td>
<td>1.31</td>
<td>1.38</td>
<td>1.03</td>
</tr>
<tr>
<td>South Australia</td>
<td>8.5</td>
<td>0.45</td>
<td>0.86</td>
<td>0.86</td>
<td>0.51</td>
</tr>
<tr>
<td>Acid soils</td>
<td>5.8</td>
<td>0.49</td>
<td>1.33</td>
<td>1.28</td>
<td>1.12</td>
</tr>
</tbody>
</table>

* Plant growth (grams per pot) of wheat grown in pots of different soil types and fertilised with either granular or liquid phosphorus fertilisers. Phosphorus was applied at 12 kilograms per hectare with added nitrogen and trace elements. ** APP = ammonium polyphosphate; H3PO4 = phosphoric acid.

Source: CSIRO Land and Water.
But when the same amount of phosphorus was applied in fluid form, plant growth increased by more than 40%.

In contrast, neutral pH soils do not fix phosphorus as strongly as alkaline and acidic soils and fluid fertilisers therefore do not seem to offer a benefit over granular fertilisers on neutral soils.

**Soil chemistry binds phosphorus**

In calcareous soils, chemical reactions occur around phosphorus granules, which render much of the granular phosphorus unavailable for plant use.

For example, when granular phosphorus fertilisers are applied to grey or red calcareous soils, 10–20% of the total phosphorus remains precipitated within the granules after five weeks and is therefore inaccessible to plant roots.

Granular fertiliser which dissolves and diffuses out of the granules quickly forms less soluble products (compared with fluid fertilisers) in the area immediately next to the granule.

In contrast, fluid fertilisers progressively diffuse away from where they are placed within the soil, creating a larger volume of soil with elevated and available phosphorus levels and increasing the likelihood of roots coming into contact with the phosphorus.

An interesting finding from the research indicates ammonium polyphosphate could possibly mobilise soil phosphorus which has been previously rendered unavailable for plant use.

This means the fluid fertiliser could supply not only more plant-available phosphorus but also could solubilise some of the fixed phosphorus held within these soils and potentially reduce the amount of phosphorus application required.

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**Liquid phosphorus increases profits by $25/ha**

**Hypothetical scenario**

- **Location**: Eyre Peninsula, South Australia
- **Property size**: 1500ha
- **Enterprise**: Cropping
- **Annual rainfall**: 300mm
- **Soil type**: Calcareous
- **Soil pH**: More than 8

Yield increases generated by switching from granular to fluid phosphorus fertilisers on calcareous soils could increase net returns, despite higher input costs.

Using a hypothetical but typical cropping property on Eyre Peninsula, South Australia, Horizon Rural Management established the economic benefit of changing from granular to phosphorus fertiliser.

The farm is sown to 1200 hectares of wheat each year with about 300ha sown to legumes or canola in years with an early break. Average wheat yields are potentially 1.2 tonnes/ha but phosphate binding on the highly calcareous soil means only 1t/ha is achieved. The analysis compares the use of phosphoric acid fluid fertiliser with granular phosphorus di-ammonium phosphate. The cost of storage tanks and converting farm equipment for fluid fertiliser is $15,000. The cost of di-ammonium phosphate sown at 50 kilograms per hectare (10kg phosphorus/ha) is $450/t or $27,000 for the whole farm. The cost of phosphoric acid (6kg phosphorus/ha) is $3.50/kg or $25,200 for the whole farm.

Additional nitrogen is required with the fluid fertiliser to make up for that usually supplied with the granular product. Ten kilograms of nitrogen per hectare cost $0.85/kg and amounts to $10,200 for the whole farm.

Annual interest and depreciation on $15,000 worth of fluid fertiliser equipment is $2700.

The total cost of phosphoric acid and starter nitrogen is $38,000 for the entire farm.

Additional benefits from 0.2t/ha extra wheat yield from the fluid fertiliser equals $40,800 (1200ha x 0.2 x $170/t). Therefore, the additional profit from the use of phosphoric acid is $29,800 ($40,800 returns minus $11,000 costs). Provided the yield benefits continue, the use of fluid phosphorus on calcareous soils makes economic sense.

Farmers have also noted additional benefits from fluid phosphorus on calcareous soils — enhanced early growth provides better protection against soil erosion and increased competition against weeds.

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