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Rock phosphates : fertilisers for sandy soils?

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Rock phosphates, from which water soluble phosphorus fertilisers such as superphosphate are manufactured, sometimes appear attractive to farmers because of their relatively low cost. But research has shown that on most Western Australian soils they are not economical fertilisers. However, some deep sandy soils of the State’s high rainfall area are exceptions. On these soils, rock phosphates compare favourably with superphosphate for plant growth. But how can these deep sands be identified?

This article describes research to define the soil characteristics necessary for rock phosphates and fertilisers containing rock phosphate, such as Coastal superphosphate, to be effective substitutes for superphosphate.

Applying fertiliser on the Swan Coastal Plain.
Background

Recent articles in this Journal have discussed the results of field trials in Western Australia in which rock phosphates were tested as phosphorus fertilisers. On most soils, rock phosphates were ineffective and not economical substitutes for superphosphate (Bolland, 1985). The only exceptions were some deep leaching sands in areas with more than 750 mm average annual rainfall, such as in the catchment of the Peel-Harvey Estuary on the Swan Coastal Plain, and along the south coast (Yeates et al. 1984). On these sands as much as 80 per cent of the phosphorus in superphosphate can be leached within a year of application.

Field trials on these sands showed rock phosphates were as effective as superphosphate in the year of application, and had a better residual value. In the long term, therefore, phosphorus applications using fertilisers containing rock phosphate can be reduced compared to superphosphate requirements, resulting in cost savings for farmers on deep sandy soils in the high rainfall area, and less phosphorus leaching into drainage systems.

Besides the deep grey sands of the high rainfall areas, phosphorus is also known to leach from some sandy clay duplex soils such as the Coolup sands on the Swan Coastal Plain, and from the grey sands north of Perth and east of Albany, although leaching losses are less severe in the lower rainfall areas. The small number of trials conducted in the past with rock phosphates on sands in the lower rainfall areas showed they were ineffective phosphorus fertilisers compared with superphosphate, but the reasons were not defined.

Effectiveness as a fertiliser

Superphosphate is made by treating rock phosphate with strong sulphuric acid to dissolve the phosphorus and convert it into water soluble forms available to plants. In most, but not all soils, rock phosphate dissolves too slowly to be effective as a fertiliser. The rate of dissolution is controlled by the nature of the rock phosphate itself, soil acidity, and the rate at which products from the dissolving phosphate rock disperse from around the particle, allowing more to dissolve.

In comparing rock phosphate with superphosphate, factors affecting superphosphate are important—such as how rapidly water soluble phosphorus is leached from sandy soils. Even a small amount of clay in the soil is sufficient to react with water soluble phosphorus, slowing or preventing leaching.

Recent research

An extensive glasshouse project to determine the soil conditions necessary for rock phosphates to be effective fertilisers on sandy soils compared with superphosphate has nearly been completed. The work was part of the Peel-Harvey Estuary study into phosphorus leaching from agricultural land on the Swan Coastal Plain. The objective was to improve our advice on the use of fertilisers containing rock phosphate (such as Coastal superphosphate) in the high rainfall areas, and to assess their usefulness on sandy soils elsewhere in the agricultural area.

In the glasshouse experiments different rates of rock phosphate and superphosphate were applied at seeding to Trikkala subterranean clover which was grown in drained pots for eight weeks. To simulate leaching in the field, pots were watered at a rate equivalent
to the average June and July rainfall on the lower west coast. After the plants were harvested, the growing procedure was repeated in some experiments to assess the residual value of the rock phosphates.

The experiments concentrated on:
- the type of rock phosphate,
- the acidity of the soil, and
- the soil's clay content.

**Type of rock phosphate**

Ordinary 'A' grade phosphate rock (from which superphosphate is made), 'reactive' phosphate rock from North Carolina (which is more soluble than most other rock phosphates) and calcined (heated) Christmas Island 'C' grade rock phosphate were compared with superphosphate. Each rock phosphate has different characteristics, particularly in the portion of phosphate which is citrate soluble, but all are poorly soluble in water (Table 1).

**Soil acidity**

The influence of soil acidity on the effectiveness of rock phosphates for plant growth was studied by adding various rates of lime to deep grey Bassendean sand from west of Harvey, and by using very sandy soils of widely varying natural pH levels collected from throughout the south-west.

Results can be expressed as the effectiveness for plant growth of each type of rock phosphate relative to the plant response to superphosphate applied to the same soil type. A value of 100 per cent indicated that the rock phosphate was equally as effective as superphosphate, and 10 per cent indicated that the rock phosphate was only one-tenth as effective as superphosphate (or ten times as much phosphorus as rock phosphate was required to give the same plant growth as from superphosphate).

The effects of soil pH were very marked (Figure 1, Table 2). Increasing soil pH by liming, or applying rock phosphates to soils of naturally high pH, gave the same results. All three rock phosphates studied, including North Carolina 'reactive' rock phosphate (the best of the three), were effective only on very acid sands, such as those common throughout the high rainfall coastal areas.

(Figure 2). On less acid sands—such as those north of Gingin and east of South Stirlings—rock phosphates were poor phosphorus fertilisers.

Despite substantial leaching of phosphorus from superphosphate on all the sands—and a leaching rate in the experiments which was much higher than that likely to be experienced in the field throughout much of this area—the results showed that large and uneconomical quantities of rock phosphate would have to be applied to soils other than the very acid sands to achieve the same plant growth as from superphosphate. Except on the very acid sands, rock phosphates had a low residual value compared with superphosphate.

**Clay content**

West Harvey soil used in the soil pH experiments was also mixed with an equally acid heavy loam from Benger to produce soils of various clay contents. When more than 9 per cent loam (about 3 to 4 per cent clay) was mixed into the sand, rock phosphates were again very poor phosphorus fertilisers for plant growth (Figure 3).

**Table 1. Phosphorus content of the fertilisers investigated**

<table>
<thead>
<tr>
<th></th>
<th>Total phosphorus (%)</th>
<th>Water soluble phosphorus (%)</th>
<th>Citrate soluble phosphorus (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superphosphate</td>
<td>10.1</td>
<td>7.6</td>
<td>2.2</td>
</tr>
<tr>
<td>'A' grade rock phosphate</td>
<td>16.6</td>
<td>&lt; 0.1</td>
<td>0.8</td>
</tr>
<tr>
<td>North Carolina rock phosphate</td>
<td>13.0</td>
<td>0.1</td>
<td>2.6</td>
</tr>
<tr>
<td>Calcined 'C' grade rock phosphate</td>
<td>14.9</td>
<td>0.6</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Figure 1. Effectiveness of phosphorus from three phosphate sources relative to superphosphate as influenced by soil pH.
Where rock phosphates can be used

In Western Australia, rock phosphates are likely to be effective phosphorus fertilisers only on highly leached, very acid sandy soils. On other soils—the less acid grey sands of the medium and low rainfall areas, the yellow sands of the wheatbelt, sandy clays and gravels, and heavy soils—the very low effectiveness of rock phosphates precludes them being economical alternatives to water soluble phosphate fertilisers such as superphosphates, even if the problems of the powdery nature of rock phosphates, and the lack of sulphur, were overcome.

The use of fertilisers containing rock phosphate, such as Coastal superphosphate, which is well granulated and contains sulphur, can reduce farmers' fertilisers costs and phosphorus pollution problems in the State's high rainfall areas, but they are never likely to be economically viable fertilisers in other areas.

Further reading


Acknowledgement

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