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Seed phosphorus - its effect on plant production

By Mike Bolland, Mike Riley, Brett Thomson, Blakely Paynter and Mike Baker, Nutrition Branch, Division of Plant Industries

The amount of phosphorus in the seed of annual crop and pasture species influences production of plants grown from that seed. It appears the more phosphorus there is in the seed, the better the potential yield irrespective of whether fertilizer phosphorus is applied to the soil or not.

This article discusses the influence of phosphorus concentration in the seed of annual crop and pasture species on subsequent production. It also explains the difference between phosphorus concentration and phosphorus content in the seed (Table 1).

The role of seed phosphorus

Phosphorus is an essential plant nutrient. It is a component of genetic material in plant cells. It also plays a crucial role in providing energy for chemical reactions within these cells.

Plants need phosphorus from the earliest stages of growth, and any deficiency during this time can reduce subsequent plant yield potentials.

Effect of seed phosphorus on early plant growth

The embryo in seeds of plants needs phosphorus to grow and develop. Before the embryo has developed a root system, its only source of phosphorus is provided by the seed.

The amount of phosphorus in seeds of annual plants can vary: from about 0.15 to 0.60 per cent in seed of wheat, oats, barley and lupins and from 0.30 to 1.10 per cent in seed of subterranean clover and annual medic.

Dry matter production of seedlings of annual plants appears to increase as the phosphorus concentration in the seed increases (Table 2). The yield increases from seed with higher phosphorus concentration occurs irrespective of whether phosphorus fertilizer is applied to the soil or not. However, the proportional increase in yield from seed with higher phosphorus usually decreases as more phosphorus fertilizer is applied (Tables 2 and 3).

Once the seedling’s roots have developed sufficiently to be able to take up substantial phosphorus from the soil, thereafter all of the subsequent phosphorus requirements of the plant are provided from the soil. Less than one per cent of the phosphorus measured in mature plants is derived from the seed.

Table 1. Phosphorus concentration\(^1\), seed weight, and phosphorus content\(^2\) in seed of subterranean clover, wheat and lupins

<table>
<thead>
<tr>
<th>Species</th>
<th>Phosphorus concentration in seed(^1) (per cent phosphorus)</th>
<th>Seed weight (mg per seed)</th>
<th>Phosphorus content in seed(^2) (mg phosphorus per seed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junee sub.clover</td>
<td>0.35</td>
<td>5</td>
<td>0.0175</td>
</tr>
<tr>
<td>Aroona wheat</td>
<td>0.35</td>
<td>35</td>
<td>0.1225</td>
</tr>
<tr>
<td>Gungurru lupins</td>
<td>0.35</td>
<td>153</td>
<td>0.5355</td>
</tr>
</tbody>
</table>

\(^1\) Phosphorus concentration is the amount of phosphorus per unit of seed, expressed as a percentage of the phosphorus present in the seed on a dry weight basis.

\(^2\) Phosphorus content is the total amount of phosphorus in the seed, which is the phosphorus concentration multiplied by the weight of the seed.
Thus seed phosphorus has its greatest direct effect on plant yields during the very early stages of plant growth. As the plant ages, the proportional increase in dry matter production of plant tops due to seed phosphorus tends to decrease (Table 4).

**Effect of seed phosphorus on subsequent grain production**

The effect of phosphorus concentration in the sown seed on final plant yields would be expected to be minimal. Nonetheless increases in seed and grain yields due to higher seed phosphorus levels in the sown seed have been measured in experiments (Table 3). (Note that in Table 3 proportional yield increases due to seed phosphorus tended to decrease as more fertilizer phosphorus was applied).

Seeds with higher phosphorus levels produce larger seedlings. These seedlings may develop deeper roots more rapidly and may take up water and nutrients from the soil earlier. Should there be any stress from drought, diseases and pests during the growing season then the larger seedlings may eventually produce more grain or seed. Thus the higher phosphorus levels in sown seed may indirectly affect final yields of annual plants grown from that seed, depending on seasonal conditions, diseases or pests.

**Serena burr medic (Medicago polymorpha) about one month after sowing in a glasshouse experiment.**

The same amount of powdered superphosphate was applied to the soil of both boxes, the same-sized seed (3.3 mg/seed) was sown, but the seed in the left hand box contained 0.38 per cent phosphorus, and the other seed 0.54 per cent.

Dry matter herbage yield was 43 per cent greater for the high phosphorus seed.

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**Table 2. Yield responses of Cranbrook wheat to phosphorus concentration in seed and the level of superphosphate drilled with the seed measured 26 days after sowing in a 1987 field experiment at Medina**

<table>
<thead>
<tr>
<th>Superphosphate drilled with the seed (kg/ha)</th>
<th>Phosphorus concentration in the sown seed (per cent phosphorus)</th>
<th>Yield (mg/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.14</td>
<td>10.6 (100%)</td>
</tr>
<tr>
<td>255</td>
<td>0.14</td>
<td>13.6 (100%)</td>
</tr>
<tr>
<td>505</td>
<td>0.14</td>
<td>15.4 (100%)</td>
</tr>
</tbody>
</table>

**Table 3. Yield responses of plants to seed phosphorus and fertilizer phosphorus measured in 1988 field experiments: (a) Seed yield of Circle Valley medic (Medicago polymorpha) grown at Dale; (b) Seed yield of Danja lupins (Lupinus angustifolius) grown at Medina**

<table>
<thead>
<tr>
<th>Superphosphate drilled with the seed (kg/ha)</th>
<th>Phosphorus concentration in the sown seed (per cent phosphorus)</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circle Valley medic (186 days after sowing)</td>
<td>55</td>
<td>0.40</td>
</tr>
<tr>
<td>220</td>
<td>0.64</td>
<td>501 (244%)</td>
</tr>
<tr>
<td>440</td>
<td>0.64</td>
<td>681 (113%)</td>
</tr>
<tr>
<td>Danja lupins (170 days after sowing)</td>
<td>55</td>
<td>0.20</td>
</tr>
<tr>
<td>220</td>
<td>0.28</td>
<td>497 (149%)</td>
</tr>
<tr>
<td>440</td>
<td>0.20</td>
<td>606 (100%)</td>
</tr>
<tr>
<td>660</td>
<td>0.28</td>
<td>618 (100%)</td>
</tr>
</tbody>
</table>

**Table 4. Increase in yield measured for Serena burr medic (Medicago polymorpha) in a glasshouse experiment when seed containing 0.36 or 0.70 per cent phosphorus (P) was sown†**

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Days after sowing</th>
<th>Per cent increase in yield of high seed P over low P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried herbage</td>
<td>21</td>
<td>30</td>
</tr>
<tr>
<td>Dried herbage</td>
<td>52</td>
<td>20</td>
</tr>
<tr>
<td>Dried herbage</td>
<td>103</td>
<td>10</td>
</tr>
<tr>
<td>Seed</td>
<td>103</td>
<td>10</td>
</tr>
</tbody>
</table>

† Before sowing, 17 g or 165 g of powdered superphosphate was added and mixed through the soil (13.5 kg of soil collected near North Bannister was used for each pot). Mean data are shown for both superphosphate levels.
The two arrowed plots were sown with similar sized seed (157 mg/seed) of Danja lupins (Lupinus angustifolius) and 55 kg of superphosphate per hectare drilled with the seed on both plots.

Seed in the foreground plot contained 0.20 per cent phosphorus, the other seed contained 0.28 per cent phosphorus.

There was a 40 per cent difference in yield of dried tops and grain between the two plots.

Practical implications of seed phosphorus

To date, we have limited data on the effect of seed phosphorus on subsequent plant yields. Here are some possible practical implications of the amount of phosphorus in the seed.

Crops

The effect of seed phosphorus on plant production is only of economic significance if it increases grain yields.

Unlike self-regenerating pastures, crops are sown each year. Farmers can take advantage of potentially larger grain yields from seed with higher concentration of phosphorus by sowing seed with higher phosphorus concentration. Farmers should harvest seed for the next year’s crop from paddocks that have received large applications of superphosphate in previous years, and/or increase superphosphate applications to the crop they intend to keep for their seed.

Annual pastures

The implications of the amount of seed phosphorus for pasture production are less obvious because pasture stands regenerate from whatever viable seed happens to be left from the previous year or years.

Higher phosphorus concentration in pasture seed may be important for providing paddock-grown stock feed during autumn when feed is scarce and of poor quality. During autumn, paddock feed comprises dried plant remains from last season and small, germinating seedlings. The effect of seed phosphorus on plant production is most pronounced during autumn, which is during the early growth stages of annual plants. Therefore higher seed phosphorus could well lead to more production at a critical period of the year.

The recommended rates of applied phosphorus fertilizer for pastures are estimated from results of field experiments mainly with permanent or semi-permanent pasture. These experiments have determined the response of pasture to superphosphate applications, both in the year the fertilizer was applied and for fertilizer applied in previous years (residual value).

The effects of seed phosphorus on subsequent pasture yields for permanent pastures or ley pastures that are cropped infrequently would have been taken into account in these experiments.

The Department of Agriculture has conducted few experiments on a pasture’s need for phosphorus in rotations shorter than one year crop: three years pasture. Because the amount of phosphorus in the seed could influence pasture production, applications of superphosphate to pastures may be more important for pasture regeneration and early growth than we previously realized.

The many questions raised by our discovery of the influence of phosphorus concentration in the seed on plant production are being investigated in projects partially funded by the Wheat Research Committee of Western Australia, and by the Grain Legumes Research Council.