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DECIDE
How much superphosphate

By G. A. Robertson, Rural Economist, J. W. Bowden, Research Officer, and N. J. Halse, Chief, Plant Research Division

- A 400 per cent increase in the price of superphosphate has reduced the economic optimum rates of super for crops and pastures in 1975.
- Many factors, both biological and economic, must be taken into account in determining the rate of superphosphate to apply.
- DECIDE, a model developed by CSIRO and the Department of Agriculture, provides a formal system in which all these factors can be considered.
- DECIDE is based on the results of all research on superphosphate carried out in Western Australia. However, each farmer's own knowledge of his farm, the soils, crops and animals is used to adapt the experimental results to get the best, easily available estimate of how much super should be applied to give maximum returns on superphosphate expenditure.

The farmer supplies details of his farm to the district adviser of the Department of Agriculture. The information is forwarded to the computer, which produces a recommended rate of superphosphate for each paddock.

Information about DECIDE is available from all District Offices of the Department of Agriculture.

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Farmers don't need to be reminded that superphosphate prices have nearly quadrupled since mid 1974. These rises and the associated general decline in prices farmers receive have had large effects on the economics of fertiliser use.

**How much super should be used?**

Superphosphate should only be used when it is profitable to do so. A farmer should only apply superphosphate (or any other fertiliser) if the increased production gained pays for the cost of the fertiliser, plus an extra amount to cover risk and interest on the investment.

The response of crops and pastures to superphosphate is such that for every additional unit of superphosphate added, the increase in yield is less than that obtained from the previous unit of superphosphate. As more and more superphosphate is applied, so the benefits from the last unit of phosphate applied become less and less.

Figure 1A shows a typical response curve for a wheat crop in Western Australia on land where there is no native phosphate (phosphate present in virgin soil) or residual phosphate from previously applied dressings. Most wheat crops in Western Australia show this type of response to superphosphate if it is drilled at seeding, although if residual or native soil phosphorus is present some yield will be obtained without the addition of superphosphate.

Table 2 shows the yield, income, cost and financial return for a wheat crop with this type of response. On a virgin soil, at low superphosphate rates the return for each $3.00 (the cost of 50 kg) invested in super is high. For instance, increasing the superphosphate rate from 150 kg/ha to 200 kg/ha costs an extra $3.00 per hectare, but returns $8.16 worth of extra wheat.

Increasing the superphosphate rate from 300 kg/ha to 350 kg/ha still costs $3.00, but the extra return is only $1.02. Thus any farmer increasing his superphosphate rate to this level will lose money by doing so.

Table 2 shows that the maximum profit will be obtained by using about 250 kg/ha on a virgin soil. When superphosphate was around $18.00 a tonne (on farm) in early 1974, the maximum profit would have been obtained at an application rate of 350 kg/ha of super.

However, these rates are for a virgin soil. In practice paddocks on most established wheat and sheep farms would have a "super bank" or residual superphosphate equivalent to 150 kg/ha applied in the current year. Thus using the data in Table 2 the rate of superphosphate that would return most profit in 1975 would be about 100 kg/ha (250 minus 150) whereas in 1974 it would have been 200 kg/ha (350 minus 150).

In a similar way it is possible to show where the maximum profit will be for pasture production. Table 3 gives a comparison for a hypothetical new land pasture in a predominantly grazing area that is capable of carrying 12 sheep per hectare, returning a gross margin of $5.20 per sheep.

In 1974 when the price of super was $18.00 per tonne on farm, it can be seen that maximum profit would be obtained at the level of superphosphate that gave 96 per cent of maximum possible production. However, in 1975 with a superphosphate price of around $60 per tonne on farm, the maximum profit will be obtained at that level of superphosphate that gives about 89 per cent of maximum growth.
Thus, when either the return per animal falls, or the price of superphosphate rises, the amount of superphosphate required to give maximum profit is reduced. If the farmer uses more than this economic optimum level he will lose money by doing so.

The application rates of superphosphate for maximum profit shown in Table 3 are calculated assuming there was no native phosphate or residual super in the soil. In an established area capable of carrying 12 sheep per hectare the residual "super bank" may be equivalent to 250 kg/ha of superphosphate applied in the current year. On this basis the rate for maximum profit in 1974 would have been 150 kg/ha (400 minus 250), whereas in 1975 it would only be 20 kg/ha (270 minus 250).

It is possible to calculate similar tables for all paddocks on a farm, and for all the products being produced in each paddock. However, as this must be recalculated every year, a farmer might spend all his time calculating super rates and never actually get around to farming!

In an attempt to simplify the calculations of superphosphate rates, scientists in CSIRO1 and the Department of Agriculture2 have developed DECIDE, a mathematical model that can be used to predict the superphosphate rates that are most likely to give maximum profit for any enterprise, in any year, on any soil type.

J. W. Bowden

Moreover, DECIDE is able to take into account more factors than those accounted for in the calculations shown in Tables 1 and 2. For instance, superphosphate added to old land this year will still be worth half this year's value to the "super bank" next year. This residual value effectively reduces the cost of superphosphate applied in any one year, with the result that it is profitable to use more superphosphate than would be used if superphosphate had no residual value.

Similarly, most farmers would require a reasonable return on money invested in superphosphate. DECIDE allows each farmer to nominate the rate of return on his investment in superphosphate that he expects in his farm management programme.

Table 1—Changes in superphosphate prices 1973-75

<table>
<thead>
<tr>
<th>Month</th>
<th>Price received by manufacturer $/tonne</th>
<th>Subsidy $/tonne</th>
<th>Price to farmer</th>
<th>Price to farmer as % 1974 price</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 1974—January 1975</td>
<td>45.71</td>
<td>11.81</td>
<td>33.90</td>
<td>231</td>
</tr>
<tr>
<td>January 1975—July 1975</td>
<td>56.25</td>
<td>0</td>
<td>56.25</td>
<td>383</td>
</tr>
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</table>

Table 2—Relationship between yield of wheat, rate of superphosphate, and profit for a typical Western Australian virgin soil.

<table>
<thead>
<tr>
<th>Total Amount of super applied (kg/ha)</th>
<th>Percentage of maximum yield</th>
<th>Yield of wheat obtained (tonnes/ha)</th>
<th>Increase in yield obtained by last 50 kg/ha super (tonnes/ha)</th>
<th>Value of increased wheat produced at $85/tonne ($/ha)</th>
<th>Cost of last 50 kg/ha super at $60/tonne ($/ha)</th>
<th>Margin ($/ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>46</td>
<td>1.55</td>
<td>0.52</td>
<td>22.44</td>
<td>3.00</td>
<td>43.92</td>
</tr>
<tr>
<td>100</td>
<td>68</td>
<td>1.81</td>
<td>0.24</td>
<td>12.00</td>
<td>3.00</td>
<td>63.36</td>
</tr>
<tr>
<td>150</td>
<td>82</td>
<td>1.98</td>
<td>0.16</td>
<td>11.68</td>
<td>3.00</td>
<td>74.64</td>
</tr>
<tr>
<td>200</td>
<td>90</td>
<td>1.08</td>
<td>0.09</td>
<td>8.16</td>
<td>3.00</td>
<td>79.80</td>
</tr>
<tr>
<td>250</td>
<td>95</td>
<td>1.14</td>
<td>0.06</td>
<td>5.10</td>
<td>3.00</td>
<td>81.90*</td>
</tr>
<tr>
<td>300</td>
<td>97</td>
<td>1.64</td>
<td>0.02</td>
<td>2.04</td>
<td>3.00</td>
<td>80.94</td>
</tr>
<tr>
<td>350</td>
<td>98</td>
<td>1.76</td>
<td>0.01</td>
<td>1.02</td>
<td>3.00</td>
<td>78.96</td>
</tr>
<tr>
<td>400</td>
<td>98.5</td>
<td>1.82</td>
<td>0.06</td>
<td>0.51</td>
<td>3.00</td>
<td>76.53</td>
</tr>
</tbody>
</table>

* maximum profit

(The margin per hectare is the return from the wheat less the cost of superphosphate. For true profit other costs must be subtracted, such as cost of seeding, sprays, harvesting, etc.)

Table 3—Relationship between superphosphate rate, yield of pasture and profit for a clover pasture on a heavy loamy soil

<table>
<thead>
<tr>
<th>Pasture % of maximum</th>
<th>Super Rate required</th>
<th>Sheep carried animal/ha</th>
<th>Return $/ha</th>
<th>Cost $/ha</th>
<th>Profit $/ha</th>
<th>Return $/ha</th>
<th>Cost $/ha</th>
<th>Profit $/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>88</td>
<td>6-0</td>
<td>31-20</td>
<td>1-58</td>
<td>29-62</td>
<td>31-20</td>
<td>5-28</td>
<td>25-92</td>
</tr>
<tr>
<td>60</td>
<td>117</td>
<td>7-2</td>
<td>37-44</td>
<td>2-11</td>
<td>35-33</td>
<td>37-44</td>
<td>7-02</td>
<td>30-42</td>
</tr>
<tr>
<td>70</td>
<td>152</td>
<td>8-4</td>
<td>43-68</td>
<td>2-74</td>
<td>40-94</td>
<td>43-68</td>
<td>9-12</td>
<td>34-56</td>
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<tr>
<td>80</td>
<td>207</td>
<td>9-6</td>
<td>49-92</td>
<td>3-73</td>
<td>46-19</td>
<td>49-92</td>
<td>12-42</td>
<td>37-50</td>
</tr>
<tr>
<td>89</td>
<td>270</td>
<td>10-7</td>
<td>55-64</td>
<td>4-86</td>
<td>50-64</td>
<td>55-64</td>
<td>16-20</td>
<td>39-44*</td>
</tr>
<tr>
<td>90</td>
<td>288</td>
<td>10-8</td>
<td>56-16</td>
<td>5-18</td>
<td>50-98</td>
<td>56-16</td>
<td>17-28</td>
<td>38-88</td>
</tr>
<tr>
<td>96</td>
<td>400</td>
<td>11-5</td>
<td>59-80</td>
<td>7-20</td>
<td>52-60*</td>
<td>59-80</td>
<td>24-00</td>
<td>35-80</td>
</tr>
<tr>
<td>99-5</td>
<td>600</td>
<td>12-0</td>
<td>62-40</td>
<td>10-80</td>
<td>51-60</td>
<td>62-40</td>
<td>36-00</td>
<td>26-40</td>
</tr>
</tbody>
</table>

* maximum profit

1 D. Bennett, P. G. Ozanne
2 J. W. Bowden
What is DECIDE?

Results from all experimental trials involving superphosphate conducted in Western Australia were analysed and it was found that most trials showed a response to superphosphate that could be related to a specific type of response curve known as the Mitscherlich curve.

In Figure 1 the curve A is an example of a Mitscherlich response curve for wheat, while B is a Mitscherlich curve for a clover pasture on a loamy soil type.

DECIDE is the process of taking these general curves, adapting them for the peculiarities of any individual paddock, making allowance for past super applications and determining the most profitable rate of superphosphate application under prevailing economic conditions.

How DECIDE is adapted for the individual paddock

DECIDE takes the following factors into account:

- **The types of plants grown** (wheat, lupins, pasture, etc.). This affects both the gross profit and the shape of the response curve. For instance, lupins, wheat and clover all respond differently to superphosphate.

- **The yield** that the crop or pasture is likely to give. This affects the gross profit. The higher the yield the higher the rate of superphosphate that can profitably be applied.

- **The soil type** of the paddock. This can affect the shape of the response curve, as different soils may have different effects on the applied superphosphate. Some soils, such as the salmon gum soils, have a basic level of native phosphorus; this affects the yield that can be obtained with zero super.

- **The method of application** of superphosphate. For instance, drilled superphosphate is about twice as efficient as topdressed superphosphate.

- **Time of application** of superphosphate. Superphosphate becomes less available the longer it is in contact with the soil. Thus the earlier super is applied before the break of the season the less efficient it is. The most efficient time to apply superphosphate is at the break of the season.

- **The type of enterprise**. It pays to apply more superphosphate to a paddock producing high value animal products than to a paddock producing low value products. Similarly the higher the price being received for a crop, the more superphosphate should be used.

- **The cost of the fertiliser**. As superphosphate prices rise relative to the price of the product, so the rate of super that will give the best economic return is reduced. Similarly, if the price falls relative to the price of the product, more super can be profitably used.

- **The 'super history' of the paddock**. Superphosphate applied in previous years contributes phosphate to the crop or pasture this year. Generally, on old land, for each 100 kg of superphosphate applied in any one year 50 kg will still be available for the following years. In effect the size of the residual 'super bank' can be used to calculate how much additional superphosphate must be applied to bring the total available superphosphate up to the economic optimum.

DECIDE adapts the general response curves to individual paddocks and determines the most profitable rate of superphosphate.
rate as shown in Table 2 or Table 3, for any specific paddock.

The return the farmer requires from his investment in superphosphate. This includes the interest charged on money used to buy superphosphate and also an allowance for risk. Although money may be available at 10 per cent a farmer may believe he needs 20 per cent to cover the risk of a crop failure.

How to use DECIDE

DECIDE attempts to take into account all the major factors that may affect the rate of superphosphate a farmer should use on any particular paddock. Consequently the mathematics involved can become complicated. However, once the routine is understood the calculations can be made comparatively easily.

Department of Agriculture advisers in all district offices are familiar with DECIDE and are able to demonstrate, to individuals or to groups, the use of the DECIDE ready reckoner or DECIDE handbooks.

A much more simple method both for the farmer and the adviser, is to use the Department's computer service. The computer takes the worries and the mathematical errors out of DECIDE calculations.

The procedure is that the farmer supplies details of his farm to the adviser in the Department of Agriculture's District Office. The adviser arranges for these details to be forwarded to the Department's head office at South Perth by Telex, if it is available in the country town, or by mail.

At South Perth the details are fed into a small computer which produces a recommended rate of superphosphate for each paddock. An additional facility provided by the computer is that it is able to calculate the superphosphate rates that will give the best return when the farmer does not have enough finance available to buy enough super to apply it at the rates that will give the optimum return. The farmer is given the recommended rates that will allow him to obtain the maximum return for his limited expenditure on superphosphate.

The results from the computer are returned to the country office by Telex. The time taken for the whole operation should be less than 24 hours.

An example

Department of Agriculture advisers have been using the DECIDE computer service with farmers on a trial basis this season.

One result which has worried farmers is that for many paddocks the recommendation for 1975 has been to apply no superphosphate at all. This result should not be surprising because farmers who have been topdressing near or a little above optimum rates in the past are now faced with lower income per hectare and a much higher superphosphate price. Both these factors reduce the economic optimum rate. Therefore applications in the past have been too high for the new situation and a nil super application is recommended for 1975. Table 4 gives an example of a typical paddock in this situation.

Farmers find it difficult to accept a recommendation to apply no super, believing intuitively that it is impossible to farm without super. In fact if economic conditions remained the same, the recommended rate would rise as the residual value of past applications was reduced.

The example in Table 4 shows recommended rates for a particular paddock for the next five years and it can be seen that the recommended rate increases towards an equilibrium rate of 60 kg/ha.

This rate will remain constant until economic conditions change, that is, either the superphosphate price changes or the prices of the products vary. The nil super recommendation in fact only applies for the first year, 1975 in this instance.

Reliability

DECIDE is the most accurate method we have for estimating the best rate of superphosphate to apply to crops and pastures.

However, the DECIDE recommendation is not perfect. It is possible that soil testing combined with DECIDE would give more accuracy but it is unlikely that the resulting improvements in accuracy would be worth the cost of soil testing individual paddocks.

DECIDE is an evolving model and in 1975 numerous trials are being conducted throughout the State to further test DECIDE and provide information that will improve the accuracy of future recommendations.

Acknowledgments

The initial concept of DECIDE was developed by Dr. David Bennett and Mr. Peter Ozanne, of CSIRO. Although many other people have contributed to its progress, the current form of DECIDE is principally due to the combined efforts of Dr. David Bennett and Dr. J. W. (Bill) Bowden, of the Department of Agriculture.

<table>
<thead>
<tr>
<th>Year</th>
<th>Residual value of super bank kg/ha</th>
<th>Optimum rate to be applied kg/ha</th>
<th>Pasture yield % maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974 (old price)</td>
<td>290</td>
<td>150</td>
<td>95</td>
</tr>
<tr>
<td>1975 (new prices)</td>
<td>305</td>
<td>0</td>
<td>91</td>
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<tr>
<td>1976 (new prices)</td>
<td>240</td>
<td>30</td>
<td>88</td>
</tr>
<tr>
<td>1977 (new prices)</td>
<td>225</td>
<td>45</td>
<td>88</td>
</tr>
<tr>
<td>1978 (new prices)</td>
<td>210</td>
<td>60</td>
<td>88</td>
</tr>
<tr>
<td>1979 (new prices)</td>
<td>210</td>
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