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Nitrogen fertilisers for pasture production

By W. J. Cox* and K. Hawley†

At current prices nitrogen fertiliser is not an economic substitute for good clover pastures, but it can supplement the system by increasing nitrogen supply at peak growth periods. It can also provide useful increases in pasture production at critical feed times. Nitrogen usage for pasture production is still in the experimental stages and small areas should be tried before large-scale application.

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Although the use of nitrogenous fertilisers has long been accepted as an economic practice in cereal cropping, it has only recently been considered for pasture and fodder production. Use of nitrogen on pastures is generally confined to dairy farms where it is used to intensify production, to produce extra pasture to avoid purchase of fodder or concentrates, or to overcome seasonal feed shortages.

Nitrogen fertiliser is expensive, has a short-term effect and can affect the clover content of pastures. A close examination of the function of nitrogen in the soil and plant as well as the role of nitrogen in the farm system is therefore necessary.

The role of nitrogen in the plant

Nitrogen is one of the major essential elements for plant growth. Constituting from 1 to 5 per cent of the plant's dry matter (compared to 0.1 to 0.8 per cent for phosphorus) nitrogen is a major component of protein and of the compounds which direct and control metabolic activity. It fills essentially the same role in animals.

Although plants live in air that is 79 per cent nitrogen, their growth is limited by the availability of nitrogen in a form that they can
use. Plants can use atmosphere nitrogen through "fixation" by legumes such as clover and medics in which root nodule bacteria convert it to ammonia, which is readily used by the associated plants. A similar process takes place in the fertiliser factory, where nitrogen is chemically "fixed" in an operation involving large amounts of energy.

**Soil nitrogen**

Nitrogen reaches the soil direct from the root nodules, through decomposition of plant tissues, from decomposition of animal residues, or as fertiliser. As illustrated in Figure 1, nitrogen in the soil undergoes a number of reactions involving bacteria and other soil micro-organisms.

Some of these can be illustrated by following the fate of nitrogen applied to the soil as ammonium nitrate (Agran 34-0). The ammonium fraction, once it has moved into the soil through movement in rain water, is taken up by plants, becomes attached to clay and other soil particles or is converted to nitrate nitrogen by bacterial action. The nitrate component of the fertiliser, as well as the nitrate formed from the ammonium component, is very mobile in the soil and is either taken up by the plants or leached out of the root zone. In waterlogged surface and subsurface soils the nitrate is readily reduced to nitrogen gases, which move up into the atmosphere. This reaction completes the cycle outlined in Figure 1—the nitrogen cycle.

The process converting nitrate to nitrogen gas (denitrification) reduces the efficiency of fertilisers applied to soils subject to waterlogging even if the waterlogging lasts for only a few days. The visual effects of this process are quite evident in the wheatbelt in winter, where waterlogged sections of a paddock are distinctly yellow as a result of nitrogen deficiency. In South-West pastures the grass appears nitrogen deficient when the soil becomes partially waterlogged, and remains this way until mid-spring when the soil dries.

**Legumes versus fertiliser nitrogen**

The nitrogen required for plant growth can be derived directly or indirectly from legumes or from artificial fertilisers.

A pasture which produces 4000 kg of dry material per hectare containing 2.5 per cent nitrogen needs to take up 100 kg of nitrogen per hectare, equivalent to 300 kg of ammonium nitrate fertiliser. As the efficiency of nitrogen fertiliser is only about 50 per cent, due to losses from leaching and denitrification, 600 kg of Agran 34 costing about $40 would be needed on each hectare.

A grass/artificial nitrogen system would obviously not be economic. However, artificial nitrogen can profitably be used to supplement nitrogen produced by clover to increase grass production at times when soil nitrogen supply is inadequate for good pasture production.

**Nitrogen deficiency—where does it occur?**

Obviously pastures can be expected to become nitrogen deficient in situations where input of nitrogen from the clover is inadequate or where losses from the nitrogen cycle are high. This is likely to occur in pastures with a low clover content or in waterlogged soils. Cool temperatures in spring can accentuate the problem by reducing the rate at which nitrogen is released from soil organic matter.

In the cereal growing areas the nitrogen status of a crop, and therefore its nitrogen fertiliser requirement, depends very much on the clover content during the previous pasture phase. Similarly the nitrogen status of pasture grasses depends on the well-being of the associated clover plants.

For example, where potassium deficiency leads to poor clover growth and reduces the quantity of nitrogen fixed, this in turn may cause nitrogen deficiency in the associated grass. In such a case fertilising with potash overcomes the potassium deficiency in clover and, after a time lag, the nitrogen deficiency in the grass.

It is generally easy to identify nitrogen deficiency in pastures through symptoms or tissue testing. It is almost impossible, however, to predict the future occurrence of de-
ficiency through soil testing or any other means.

The symptoms of nitrogen deficiency are quite clear. Generally the young leaves on affected grass plants are healthy while the older leaves turn yellow and die back from the tips. In very deficient plants even the younger leaves are yellow. The symptoms can sometimes be confused with those of sulphur deficiency.

Deficient grasses generally contain less than 2 per cent nitrogen. Existence of a deficiency can be confirmed by a tissue test.* Tissue testing is particularly valuable where the deficiency symptoms are not clear or are complicated by other nutrient deficiencies, or in cases of sub-clinical deficiency where there are no grass symptoms but where the addition of nitrogen will result in yield increases.

Soil testing for nitrogen is of little value as the amount of soil nitrogen available for plant growth depends on climatic factors which cannot be predicted.

Potential uses of nitrogen in the farm system

Nitrogen fertilisers can be used in the dairy or beef farm system in a variety of ways. These include:

• Autumn application on established pastures to increase early green feed. This is often combined with sowing of Wimmera or Tama ryegrass at heavy seeding rates.
• Autumn or spring application to cereals sown for early green feed, hay or silage.
• Late winter to early spring application on hay paddocks to improve the quantity of hay cut.
• Application to summer-irrigated pasture and summer fodder crops.

Only autumn application and the use of nitrogen on irrigated pastures are considered here in detail.

The use of nitrogen application on spring-sown cereals or grasses has some immediate value in areas affected by clover scorch (Kabatiella caulivora). In pastures badly affected by this fungal disease early in the season it is possible to sow oats with nitrogen in spring to produce appreciable quantities of feed, thereby partially alleviating the problem.

Nitrogen for autumn application

Autumn application of nitrogen has the specific aim of increasing the quantity of good quality feed available at the break of the season. This may be used as a substitute for concentrates and hay or in combination with these traditional feeds.

In situations were nitrogen might be applied economically a number of requirements should be met to obtain the best results.

• Grass-dominant pastures should be selected. Alternatively extra grass seed—preferably Wimmera or Tama ryegrass which respond rapidly—should be drilled into the pasture. The common silver and winter grasses are not very responsive.
• The maximum response is obtained if nitrogen is applied when the pasture is about 5 cm high. Earlier applications are largely wasted because the pasture is not capable of using the applied nitrogen.
• The rate of nitrogen to use depends on the cost of fertiliser as well as the value placed on the extra feed produced. Use of from 75 to 150 kg of Agran 34-0 per hectare, depending on the grass content of the pasture, appears to be warranted.
• Other deficiencies should be overcome before a maximum response to nitrogen can be obtained. Because of the greater demands of the pasture, higher rates of superphosphate and potash may be needed.
• The pasture should not be grazed for two weeks after application. It should then be grazed heavily and later grazed as part of the farm rotation. Longer deferment at the break of the season can lead to serious degeneration in pasture composition.

Changes in pasture composition can be particularly evident when grazing is deferred for six weeks after nitrogen application, as is common practice. In one trial near Margaret River the clover content of the pasture declined markedly when grazing was delayed for four weeks (Fig. 3).

This effect appears to be due to competition for light between the

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* For further information on tissue testing see Carroll.
grass and clover components of the pasture. When fertiliser nitrogen is supplied, grass production increases greatly and the long grass appears to shade out the clover.

As the use of nitrogen for autumn pastures is backed by relatively little experience and little experimental evidence it is important to realise the problems associated with nitrogen usage before it is adopted on a large scale. Further information is being collected from a number of trials now in progress, in which emphasis is placed on obtaining answers to the questions of length of deferment and time of application.

Nitrogen for irrigated pastures

As most irrigated pastures are grazed by cows producing “quota” milk, the economics of using nitrogen fertiliser on irrigated pasture are influenced by the need to maintain milk production at quota levels and to maintain the quality of the milk above the legal minimum.

The pasture generally consists of *Paspalum dilatatum*, kikuyu and perennial ryegrass, with variable amounts of white clover.

Langdon* showed that under these conditions large economic responses can be obtained from the use of nitrogen fertiliser. He suggested a spring topdressing and demonstrated additional benefits from subsequent applications.

The recommended rates depend on the need for additional feed. If feed is likely to be scarce, 50 kg of nitrogen per hectare in late Spring (Sept.-Oct.) should be followed by another dose in mid-December, and possibly again in early March if the quality is poor.

If the stocking rate is inadequate for the amount of feed grown no economic benefit can be expected from the use of nitrogen and the clover content might be seriously depressed. This is illustrated by the results of a trial at Wokalup Research Station in 1973/74, in which 75 kg/ha of nitrogen was applied to the pasture in late October, December and February. The nitrogen-treated plots yielded 2,000 kg/ha more dry matter than the no-nitrogen plots but produced no significant increase in production per animal. This was apparently due to gross under-stocking even at 3.3 cows per hectare.

Under irrigation the application of nitrogen can be used to manipulate the amount of feed grown to fit in with stocking rate and milk quota requirements.

The use of nitrogen on irrigated pasture can also be profitable in beef production. In one trial at Wokalup Research Station Hereford heifers with an average initial liveweight of 322 kg gained 0.7 kg per day per animal on nitrogen-treated pasture compared with 0.5 kg per day for animals grazing untreated areas. This difference in growth rate was economic.

Sources of nitrogen

The main considerations in deciding which nitrogen fertiliser to use are the cost, relative effectiveness and certain physical differences which influence convenience and time of application.

The main nitrogen fertilisers available are described in Table 1. At present, there is little difference in the cost per kilogram of nitrogen. Other nitrogen fertilisers available are calcium ammonium nitrate (CAN) (20.5 per cent nitrogen), nitrate of soda (16 per cent nitrogen) and the compound fertilisers 28 : 14 and 24 : 24.

**Sulphate of ammonia** has a low nitrogen content (20.5 per cent nitrogen). Although of comparable cost to the other sources, it has the major disadvantage of having an acid-forming effect on the soil. This could harm clover nodulation and in some soils may induce high levels of available aluminium or manganese, to which clover is very susceptible. Sulphate of ammonia should not be used on acid soils. One advantage is that it can be mixed with super. It is the ideal source for coastal calcareous sands.

**Urea** has a high nitrogen content, containing 46 per cent nitrogen, and is quick-acting. It cannot be mixed with superphosphate. The major problem with this source is loss through volatilisation (ammonia gas is released) when the urea particles are topdressed on dry surfaces and exposed to high temperatures—particularly on neutral and alkaline soils. When top-dressed on moist, slightly acid soils it is just as effective as the other sources.

**Ammonium nitrate** is an easy-to-handle fertiliser containing 34 per cent nitrogen. It appears to be the best source for the slightly acid sands and sandy loams common in the South-West.

**Compound fertilisers** are easy to handle and allow nitrogen and phosphorus to be applied in the one application. Nitrogen is present as ammonium nitrate in Agran 28 : 14 and 24 : 24. The nitrogen source in “Agras” 18 : 18 is sulphate of ammonia.

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Table 1—Nitrogen content and relative cost of the main nitrogen sources (March, 1974)

<table>
<thead>
<tr>
<th>Source</th>
<th>% N</th>
<th>Cost (Bunbury) / tonne</th>
<th>Cost/100 kg N</th>
<th>Cost/kg N</th>
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</thead>
<tbody>
<tr>
<td>Sulphate of ammonia</td>
<td>21</td>
<td>$46.40</td>
<td>$22.09</td>
<td>$0.22</td>
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<tr>
<td>Urea</td>
<td>46</td>
<td>$91.30</td>
<td>$19.85</td>
<td>$0.20</td>
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<tr>
<td>Ammonium nitrate</td>
<td>34</td>
<td>$70.80</td>
<td>$20.82</td>
<td>$0.21</td>
</tr>
</tbody>
</table>
