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Nitrogenous fertilisers for cereal production

M G. Mason

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Nitrogenous fertilisers for cereal production

Erratum
includes two pages of "Synthetic meat: is it a threat to our livestock industries?," Vol 16 No 4
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and should protect their animal industries from the vagaries of fluctuating feed prices.

The high soy bean prices in 1973 and the subsequent U.S. export embargo disrupted feed supply and has undoubtedly stimulated S.C.P. production in Western Europe and Japan. A plentiful supply of cheap local protein could increase meat production in these countries.

Textured vegetable protein will become an important competitor for meat in the next few years. It has been estimated for the USA that meat substitutes could penetrate to between 3.9 and 8.3 per cent of the red meat market by 1980 with a probable penetration of 6.4 per cent (Table 4).

The 6.4 per cent of red meat consumption is estimated to be equivalent to 91 per cent of the U.S. imports, four times the level of Australia’s exports to the U.S. Moreover, the replacement of meat substitutes in the other countries such as the EEC and Eastern Europe, could make them small exporters instead of importers (Table 4).

Although the impact of meat substitutes on total meat consumption may be small in the next few years, the effect may be significant on world trade.

Most of the replacement of meat by T.V.P. will occur in the manufactured meat market where the T.V.P. has many advantages. It is generally cheaper than meat and the food processor can be guaranteed a uniform product of stable price. Processing is also easier, with no waste. Moreover, the products are easily stored, usually without refrigeration.

However, all is not gloom for the meat industry. Some experts think that the use of meat substitutes could actually increase meat consumption by lowering the price of manufactured meat products. The resulting increase in consumption could compensate for the meat replaced.

Effect on Australia
It is unlikely that meat substitutes will affect the prime meat trade and exports of quality meat.

However, Australia relies heavily on exporting manufacturing grade meats, including cattle from the North and mutton and the costs of
Table 3—Efficiency of protein production

<table>
<thead>
<tr>
<th></th>
<th>Conversion ratio (feed to Liveweight gain)</th>
<th>Grams Protein per kg feed grain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef in feed lot</td>
<td>8:1</td>
<td>37.5</td>
</tr>
<tr>
<td>Pigs</td>
<td>3:5:1</td>
<td>85.7</td>
</tr>
<tr>
<td>Chicken</td>
<td>2:3:1</td>
<td>108.7</td>
</tr>
<tr>
<td>Myco protein (fungus)</td>
<td>2:1</td>
<td>200</td>
</tr>
<tr>
<td>Single cell protein</td>
<td>2:1</td>
<td>200</td>
</tr>
</tbody>
</table>

Manufacturing grades of meat put them at a disadvantage compared with T.V.P. Meat slaughtering and processing is very labour-intensive and costs are rapidly escalating. Estimates of the costs of getting boned mutton to the f.o.b. stage are given in Table 5.

If the cost of refrigerated transport to Japan for example, is added to this, the cost of the manufacturing mutton to the food processors overseas is a minimum of 84 c/kg (38c/lb), and this is without allowing for any price paid to the farmer. Also, the processor must store the meat for a considerable time under refrigeration and have facilities for thawing and preparing it. T.V.P. would be very competitive at these prices.

We have continually reassured ourselves that our long term market meat prospects are excellent, especially if the Asian countries become able to afford and to eat meat. However, these countries have relied for centuries on vegetable proteins (soy beans, pulses) and may accept processed vegetable protein rather than meat.

T.V.P. will be a lot easier to distribute in under-developed countries than meat because it does not require refrigeration.

**Weaknesses in meat marketing**

There is no doubt that the traditional meat industry will soon be seriously assaulted by meat substitutes. The industry must define its weaknesses and strengthen its position as soon as possible.

Some aspects of meat production and marketing which require action include:

- The type of animal being produced. Synthetic meat substitutes will have their biggest impact on manufacturing meat. Thus we should aim to produce animals of type and quality which will minimise the numbers destined for the boning floor. A move in this direction is to concentrate on producing the types of animal required for particular markets. Whether these are young sheep for the Middle East, lean beef for the United States or lean bacon for Japan, the industry must (determine) what is wanted, and then to produce it.

- Manufacturing meat is a low-value product, but the cost of slaughter, boning and preparation of the carcase is high. Research is urgently required to find cheaper ways of processing, handling and shipping manufactured meats.

- Manufacturing meat must be produced and sold in the most efficient manner. Perhaps the auction system and the various handling costs and commissions take too much of the value of a low priced carcase? A more efficient selling system for manufacturing meat is required.

- Wastage of manufacturing meat must be minimised. For instance, transporting horned cattle in the North causes very large losses from bruising.

- The meat industry must keep itself fully aware of the potential and capabilities of meat substitutes.

- Meat must be promoted at home and on export markets. New ways of packaging and presenting meat to consumers must be developed to keep meat an attractive proposition.

- Research into more efficient, cheaper ways of producing meat on farms must continue at high levels.

Table 5—Costs per head of 18 kg carcases yielding 9-2 kg boned meat*

<table>
<thead>
<tr>
<th></th>
<th>Killing</th>
<th>Slaughter levy</th>
<th>Boning</th>
<th>Packing</th>
<th>Freezing</th>
<th>Costs to f. o. b.</th>
<th>Export levy</th>
<th>Wholesalers overheads and margins</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$1 990</td>
<td>$0.25</td>
<td>$1.60</td>
<td>$0.35</td>
<td>$0.50</td>
<td>$0.11</td>
<td>$0.21</td>
<td>$0.80</td>
</tr>
</tbody>
</table>

*From Darawa Market Insight, July 18, 1975.

Table 4—Hypothetical impact of meat-like production on projected 1980 demand and trade balances for red meats, assuming three different degrees of market penetration*

<table>
<thead>
<tr>
<th>Market</th>
<th>Total red meat</th>
<th>Low assumption</th>
<th>Medium assumption</th>
<th>High assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1980 Projected demand</td>
<td>1980 projected trade balance '000 t</td>
<td>Meat replaced '000 t</td>
<td>Percent. of trade balance</td>
</tr>
<tr>
<td>E.E.C.</td>
<td>16 404</td>
<td>+1 419</td>
<td>164.0</td>
<td>11.6</td>
</tr>
<tr>
<td>Other Western Europe</td>
<td>4 929</td>
<td>+646</td>
<td>49.3</td>
<td>7.6</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>6 620</td>
<td>—348</td>
<td>66.2</td>
<td>19.8</td>
</tr>
<tr>
<td>U.S.S.R.</td>
<td>12 784</td>
<td>+831</td>
<td>127.8</td>
<td>15.4</td>
</tr>
<tr>
<td>Israel</td>
<td>101</td>
<td>+63</td>
<td>1.0</td>
<td>1.6</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>20 640</td>
<td>—1 446</td>
<td>810.1</td>
<td>56.0</td>
</tr>
</tbody>
</table>

* After D. M. Beloglavce


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Nitrogenous fertilisers for cereal production

By M. G. Mason, Research Officer, Plant Research Division

Because fertilisers have substantially increased in price since 1968*, it has become increasingly important to understand those factors affecting the response to fertilisers by crops.

Among the many factors influencing crop response to nitrogen applications, the most important are the season, soil type, paddock history, time of application and source of nitrogen. Before deciding whether to use nitrogen on a cereal crop, which source to use and at what rate, the farmer needs some understanding of how these factors work.

Greatest responses to nitrogen fertilisers can be expected in areas with a relatively long growing season. In such areas light soils with a low nitrogen status give the best prospects for nitrogen fertilisers—provided adequate moisture is available.

Response also depends on the recommended variety being sown at the best time, on a weed and disease-free crop, and the correct timing of the fertiliser application.

This article, based on the results of more than 900 Department of Agriculture trials over many seasons, in many districts and on a wide range of soil types, provides the background on which farmers can base decisions. As local considerations are also very important, the man best equipped to interpret these recommendations for an individual property is the Department's district agricultural adviser.

Factors affecting response to nitrogen

Nitrogen is essential for plant growth and is needed by plants in relatively large quantities. Symptoms of nitrogen deficiency depend on the degree of deficiency but plants low in nitrogen generally have a pale colour.

If the deficiency is severe, lower (or oldest) leaves become yellow and often die prematurely because the nitrogen in them is mobilised and transported to younger, actively growing tissues.

Weather and climate

Sufficient soil moisture is essential for the crop to make full use of nitrogen fertilisers; rainfall thus causes great variations in response.

The chance of obtaining a profitable response usually diminishes as the average rainfall decreases and in cereal growing areas the chances of nitrogen being profitable decrease with increasing distance from the coast. High nitrogen rates may be profitable for cropping in wetter areas, provided the soil does not become waterlogged.

Rainfall distribution is even more important than total rainfall. Rainfall during the growing season is all-important and summer rains do not usually affect the response to nitrogen. For example, Wongan Hills' annual rainfall is only about 25 mm more than that of Salmon Gums, but with 76 mm more rain during the growing season Wongan Hills would be more likely to have a profitable response to nitrogen.

Under most conditions, nitrogen application results in a greater leaf area per hectare. This creates an increased demand for soil moisture and if the supply of soil moisture is low it is used up much more quickly than with a thinner crop. Lack of moisture then causes "burning-off" of the crop, so reducing yields.

Only when finishing rains are sufficient to maintain soil moisture can the full potential of the crop be realised.

Finishing rains are especially important because they keep up the level of soil moisture while the grain is being formed. If the level of soil moisture becomes very low at this stage, nitrogen fertiliser applied earlier in the season may not give profitable yield increases and in severe cases will actually cause yield reductions.

Rainfall also affects nitrogen supply in the soil and heavy rain will cause soluble nitrate to be leached out of the root zone on coarse textured soils.

Moisture is also needed for the soil's mineralisation and nitrification processes, during which organic matter is broken down and nitrogen is released and changed to forms readily available to plants. In waterlogged soils nitrogen can be lost to the atmosphere as gases by a process of denitrification.

Results from using nitrogen fertilisers on crops thus vary considerably from season to season, depending on weather conditions, particularly rainfall, which cannot be forecast with much accuracy.

Temperature can also affect the response to nitrogen. High temperatures during the growing season increase the crop's growth rate and bring about the uptake of more applied nitrogen; but they can also increase the loss of moisture, which

* A previous article with this title was published in the W.A. Journal of Agriculture in May, 1968.
could partly offset the effect of the better growth rate.

On the other hand, very low temperatures can stop crop growth or at least slow the rate of growth severely. This greatly reduces the rate of uptake of nitrogen from the soil, allowing additional nitrogen to be lost by leaching or denitrification.

**Soil type**

Soil type greatly affects the profitability of nitrogenous fertilisers. Heavier soils are usually more fertile and less prone to leaching than lighter soils and do not often give profitable response to nitrogen fertilisers unless they have been continuously cropped. Some nitrogen may also be lost by denitrification when heavy soils are waterlogged.

The soils referred to as “heavy” in this article are the heavy clays and clay loams which normally support salmon gum or gimlet vegetation, but in Zone A (see map) would include such soils as the “kopis” and “kumaris” soils around Salmon Gums. The kopis is light grey or greyish-brown calcareous, “powdery”, sandy loam over clay, with lime nodules at depth. Kumaris soils are brown to red-brown clay-loams to sandy loams.

The “light” soils in this article include all the light-surfaced soils, and the medium-textured soils which normally carry York gum vegetation, often associated with “jam” (Acacia acuminata) or white gum and sometimes mallees. These include soils in the Chapman and Avon Valleys, the white gum and jam soils in the Great Southern, and the red-brown loams and clay loams carrying York gum around Three Springs and Minganew.

The “moort” soils, such as those around Pingrup and Ravensthorpe, are quite responsive to nitrogen. Recommendations and yield responses for these soils are about 75 per cent of those for light soils.

Successful crops, even on heavy land, gradually reduce the nitrogen supply until a profitable response to nitrogen may be obtained.

In drier years, heavy soils have less favourable moisture relations than lighter soils and this limits response to nitrogen.

Lighter soils generally are a better prospect for the use of nitrogen fertilisers. Such soils have usually been subject to a great deal of leaching and have a low nitrogen status. Furthermore, soil moisture is more available to the plant in light than in heavy soils.

However, some light soils, such as the coarse, deep, white and grey sands, cannot grow a profitable crop even with the addition of nitrogen.

**Recent history of the paddock**

Paddock history has a large effect on the response obtained to additional nitrogen—even on two otherwise similar paddocks.

If the area to be cropped is new land, the response to nitrogen will generally be different on fallowed land from that obtained on similar but non-fallowed land. On land fallowed the previous year, “ploughed in” organic matter is partly broken down by soil micro-organisms. The breakdown releases nitrogen from the organic matter, allowing it to be used by the crop.

If an area is ploughed for the first time in the cropping year, nitrogen in the organic matter will not be available to the plant. At the same time, the soil micro-organisms use some of the soil's available nitrogen during the early stage of the breakdown process, leaving little available nitrogen for the crop. In this situation a higher rate of applied nitrogen is needed.

In drier areas, on some soils, following may also lead to conservation of moisture from the previous season. This would tend to increase the chance of a profitable response to nitrogen.

An area of old land which has not grown a good legume pasture could be expected to give a greater response to nitrogen than an area which has grown such a pasture.

A good stand of legumes causes a large build up of soil nitrogen and fertility and the first cereal crop obtains much of its nitrogen requirement from the soil. This supply is gradually used up by successive crops however and nitrogen fertilisers thus become more profitable. The rate of application can also be increased with successive crops.

**Treatment of stubble from previous crops**

When a heavy cereal stubble is ploughed in it can tie up much of the available soil nitrogen and make it temporarily unavailable to the crop being grown. A little more nitrogen is therefore needed when the stubble is ploughed in, compared with a situation where it is burnt.

The stubble material has a high carbon to nitrogen ratio and the micro-organisms which break it down need to use nitrogen from the soil to complete the breakdown process.

**Time of seeding**

Time of seeding has a great effect on the response to nitrogenous fertilisers in areas with a short growing season. In such areas the crop should be sown as early as possible. If seeding is delayed the season may “cut out” before the grain has properly developed, so reducing the potential for a profitable response to nitrogen fertiliser.

**Other nutrients**

A deficiency of other essential nutrients must not be allowed to limit crop growth if maximum benefit from nitrogen fertilisers is to be obtained.

For instance, if the phosphate level is too low the response to nitrogen can be severely reduced. In some trials, even when as much as 224 kg/ha of urea was applied, no wheat was obtained until superphosphate was added. The same can apply if nutrients such as copper and zinc are severely deficient.

**Nitrogen is not a substitute for other deficient nutrients. They must also be applied.**

**The relative prices of fertiliser and cereal grain**

Pricing for fertiliser and cereal grains greatly affects the net cash return from the increased cereal yields. The cost of various nitrogen fertilisers and the prices received for various grains are constantly changing and therefore the most profitable rates vary with them.

Expected yield increases should cover cost of fertiliser and cost of application, and still leave a margin for profit. As the cost of fertiliser decreases, or the price received for grain increases, the chance of making a profit from the application will increase.

**Which cereal?**

Because of the lower return per tonne, nitrogen added to oats and barley must effect greater yield in-
creases than when added to wheat to give the same profit. Where as a 130 kg/ha increase in wheat yield may be profitable when 50 kg/ha of urea is applied, yield increases of 175 kg/ha of barley or 210 kg/ha of oats will be needed to show the same profit.

For the best result the recommended variety should be sown at the correct time. In areas with a short growing season an early maturing variety is necessary and should be sown as early as possible; where the growing season is longer, later maturing varieties can be used if sown early. If seeding is delayed in areas with a relatively long growing season early maturing varieties should be used. Where the wrong variety is used the response to nitrogen may be limited. Also, in areas with a longer growing season, if an early maturing wheat variety is sown early it may come into ear while the conditions are warm but still moist. Such conditions favour septoria, which could further reduce yields and response to nitrogen.

The response to nitrogen is also reduced if weeds are not properly controlled, and if serious outbreaks of diseases such as rust, septoria and root rots occur. Insect pests and vermin can also lower yields and limit response.

Rates of application
The agricultural areas of Western Australia can be divided into three zones (see map) in which nitrogen fertilisers give different responses. Lines separating the zones are based on a combination of annual rainfall and growing season. ZONE A includes the drier areas from approximately the 330 mm rainfall isohyet of the outer limit of the cereal growing areas. ZONE C includes cereal growing areas with over 460 mm annual rainfall. ZONE B receives about 330 to 460 mm annual rainfall.

General recommendations for Zones A, B, and C are set out in Table 1. Because of the lower rainfall in Zone A the chance of obtaining a profitable response to nitrogen fertiliser is lower than in the other two zones. Obviously the response to nitrogen changes gradually through the zones and there is no sharp difference in response on either side of the dividing lines. The lines are drawn to simplify the process of making recommendations. The rates set out in Table 1 will not be the best in every season. In a good season higher rates could be profitable and in a poor season lower rates might be better. The rates recommended are considered to offer the greatest profit in an average season and some profit in most seasons.

Table 2 gives the present prices of currently available nitrogenous fertilisers.

Procedure for determining nitrogen fertiliser rates
STEP 1: Select the type of nitrogen fertiliser you will use and determine its price per tonne of nitrogen (Table 2). You can now select the appropriate (nearest
### TABLE I.—NITROGEN RECOMMENDATIONS FOR CEREALS (kg nitrogen/ha)

**ZONE A—up to 330 mm annual rainfall**

<table>
<thead>
<tr>
<th>Situation</th>
<th>Nitrogen (N) $300/tonne</th>
<th>Nitrogen (N) $350/tonne</th>
<th>Nitrogen (N) $400/tonne</th>
<th>Nitrogen (N) $450/tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grain $45/t</td>
<td>Grain $70/t</td>
<td>Grain $90/t</td>
<td>Grain $110/t</td>
</tr>
<tr>
<td>Heavy land</td>
<td>0 0 0 0</td>
<td>0 0 0 0</td>
<td>0 0 0 0</td>
<td>0 0 0 0</td>
</tr>
<tr>
<td>Light land (LL) first crop—New land—fallow</td>
<td>11.5 26 34.5 40</td>
<td>11.5 20 30 35</td>
<td>11.5 18 25 32</td>
<td>8 12 20 28</td>
</tr>
<tr>
<td>LL—first crop new land—non-fallow</td>
<td>14 25 30 35</td>
<td>11.5 21 28 32</td>
<td>11.5 18 25 29</td>
<td>8 14 21 26</td>
</tr>
<tr>
<td>LL—second and subsequent crops—new land</td>
<td>18 26 30 35</td>
<td>14 24 28 30</td>
<td>11.5 21 25 28</td>
<td>8 19 24 27</td>
</tr>
<tr>
<td>LL—first crop on old clover land</td>
<td>0 14 21 26</td>
<td>0 9 16 21</td>
<td>0 6 14 19</td>
<td>0 0 9 15</td>
</tr>
<tr>
<td>LL—second crop on old clover land</td>
<td>0 19 28 35</td>
<td>0 12 23 31</td>
<td>0 6 18 27</td>
<td>0 0 12 21</td>
</tr>
<tr>
<td>LL—third and subsequent crops on old clover land</td>
<td>0 19 28 35</td>
<td>0 12 23 31</td>
<td>0 6 18 27</td>
<td>0 0 12 21</td>
</tr>
<tr>
<td>LL—first crop on old land—non-clover</td>
<td>9 25 34.5 41</td>
<td>0 18 28 35</td>
<td>0 8 23 33</td>
<td>0 0 18 27</td>
</tr>
<tr>
<td>LL—second and subsequent crops on old land—non-clover</td>
<td>18 25 32 37</td>
<td>11.5 21 28 31</td>
<td>11.5 19 25 29</td>
<td>0 14 21 26</td>
</tr>
</tbody>
</table>

**ZONE B—330 up to 460 mm annual rainfall**

<table>
<thead>
<tr>
<th>Situation</th>
<th>Nitrogen (N) $300/tonne</th>
<th>Nitrogen (N) $350/tonne</th>
<th>Nitrogen (N) $400/tonne</th>
<th>Nitrogen (N) $450/tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grain $45/t</td>
<td>Grain $70/t</td>
<td>Grain $90/t</td>
<td>Grain $110/t</td>
</tr>
<tr>
<td>Heavy land</td>
<td>0 14 21 26</td>
<td>0 7 16 21</td>
<td>0 0 14 19</td>
<td>0 0 7 15</td>
</tr>
<tr>
<td>Light land (LL) first crop—New land—fallow</td>
<td>30 41 46 49</td>
<td>28 37 44 46</td>
<td>25 35 40 45</td>
<td>21 32 37 43</td>
</tr>
<tr>
<td>LL—first crop new land—non-fallow</td>
<td>34.5 39 44 47</td>
<td>30 37 41 43</td>
<td>28 36 39 41</td>
<td>25 34 37 39</td>
</tr>
<tr>
<td>LL—second and subsequent crops—new land</td>
<td>34.5 39 44 48</td>
<td>30 38 41 43</td>
<td>28 36 39 41</td>
<td>25 34 38 40</td>
</tr>
<tr>
<td>LL—first crop on old clover land</td>
<td>0 19 28 35</td>
<td>0 12 22 30</td>
<td>0 0 17 26</td>
<td>0 0 12 21</td>
</tr>
<tr>
<td>LL—second crop on old clover land</td>
<td>28 40 45 48</td>
<td>21 38 41 44</td>
<td>16 33 39 43</td>
<td>11.5 31 38 41</td>
</tr>
<tr>
<td>LL—third and subsequent crops on old clover land</td>
<td>32 39 44 47</td>
<td>29 38 41 43</td>
<td>26 36 39 41</td>
<td>24 35 38 40</td>
</tr>
<tr>
<td>LL—first crop on old land—non-clover</td>
<td>25 39 44 49</td>
<td>19.5 36 41 44</td>
<td>17 33 38 42</td>
<td>16 30 36 40</td>
</tr>
<tr>
<td>LL—second and subsequent crops on old land—non-clover</td>
<td>25 39 44 49</td>
<td>19.5 36 41 44</td>
<td>17 33 38 42</td>
<td>16 30 36 40</td>
</tr>
</tbody>
</table>
TABLE I—NITROGEN RECOMMENDATIONS FOR CEREALS (kg nitrogen/ha)—continued

ZONE C—over 460 mm annual rainfall

<table>
<thead>
<tr>
<th>Situation</th>
<th>Nitrogen (N) $300/tonne</th>
<th>Nitrogen (N) $350/tonne</th>
<th>Nitrogen (N) $400/tonne</th>
<th>Nitrogen (N) $450/tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy land</td>
<td>0 10 16 20</td>
<td>0 14 16 20</td>
<td>0 17 19 21</td>
<td>0 19 21 23</td>
</tr>
<tr>
<td>Light land (LL) first crop—New land</td>
<td>30 47 55 60</td>
<td>18 41 51 57</td>
<td>16 36 46 53</td>
<td>11.5 29 41 49</td>
</tr>
<tr>
<td>Light land (LL) first crop —fallow</td>
<td>41 47 53</td>
<td>37 47 51 53</td>
<td>34.5 46 48 52</td>
<td>32 43 47 49</td>
</tr>
<tr>
<td>Light land (LL) first crop on old land—non-clover</td>
<td>37 49 53 56</td>
<td>30 46 51 54</td>
<td>28 42 48 51</td>
<td>23 40 46 50</td>
</tr>
<tr>
<td>Light land (LL) first crop on old land</td>
<td>0 11 20 26</td>
<td>0 14 21</td>
<td>0 17 20</td>
<td>0 0 7 12</td>
</tr>
<tr>
<td>Light land (LL) second and subsequent crops—new land</td>
<td>30 49 55 60</td>
<td>23 44 51 57</td>
<td>14 38 46 54</td>
<td>7 34 44 50</td>
</tr>
<tr>
<td>Light land (LL) second and subsequent crops on old clover land</td>
<td>30 48 55 60</td>
<td>18 43 51 56</td>
<td>14 37 46 52</td>
<td>7 33 43 49</td>
</tr>
<tr>
<td>Light land (LL) third and subsequent crops on old clover land</td>
<td>30 48 55 60</td>
<td>18 43 51 56</td>
<td>14 37 46 52</td>
<td>7 33 43 49</td>
</tr>
<tr>
<td>Light land (LL) first crop on old land—non-clover</td>
<td>30 48 55 60</td>
<td>18 43 51 56</td>
<td>14 37 46 52</td>
<td>7 33 43 49</td>
</tr>
<tr>
<td>Light land (LL) second and subsequent crops on old land</td>
<td>30 48 55 60</td>
<td>18 43 51 56</td>
<td>14 37 46 52</td>
<td>7 33 43 49</td>
</tr>
</tbody>
</table>

TABLE 4—A COMPARISON OF COSTS OF AGRAS 18:18 PLUS AND ALTERNATIVE SOURCES (7/11/75)

<table>
<thead>
<tr>
<th>Rate of AGRAS 18:18 plus (kg/ha)</th>
<th>Cost of AGRAS (bags)</th>
<th>Cost of AGRAS (bulk)</th>
<th>Equivalent rates of superphosphate + ammonium nitrate (kg/ha)</th>
<th>Cost of (4)</th>
<th>Equivalent rates of superphosphate + sulphate of ammonia (kg/ha)</th>
<th>Cost of (6)</th>
<th>Cost of Urea (kg/ha)</th>
<th>Cost of (8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>7.35</td>
<td>6.90</td>
<td>A.N. 26-5 + super 41</td>
<td>8.29</td>
<td>S/A 43 + super 41</td>
<td>8.39</td>
<td>Urea 19-5 + super 41</td>
<td>7.32</td>
</tr>
<tr>
<td>100</td>
<td>14.70</td>
<td>13.80</td>
<td>A.N. 53 + super 82</td>
<td>15.08</td>
<td>S/A 86 + super 82</td>
<td>15.28</td>
<td>Urea 39 + super 82</td>
<td>13.14</td>
</tr>
<tr>
<td>150</td>
<td>22.05</td>
<td>20.70</td>
<td>A.N. 79-5 + super 123</td>
<td>21.86</td>
<td>S/A 129 + super 123</td>
<td>22.15</td>
<td>Urea 58-5 + super 123</td>
<td>18.95</td>
</tr>
<tr>
<td>200</td>
<td>29.40</td>
<td>27.60</td>
<td>A.N. 106 + super 164</td>
<td>28.64</td>
<td>S/A 172 + super 164</td>
<td>29.04</td>
<td>Urea 78 + super 164</td>
<td>24.78</td>
</tr>
<tr>
<td>250</td>
<td>36.75</td>
<td>34.50</td>
<td>A.N. 132-5 + super 205</td>
<td>35.43</td>
<td>S/A 215 + super 205</td>
<td>35.93</td>
<td>Urea 97-5 + super 205</td>
<td>30.60</td>
</tr>
<tr>
<td>300</td>
<td>44.10</td>
<td>41.40</td>
<td>A.N. 159 + super 246</td>
<td>42.22</td>
<td>S/A 258 + super 246</td>
<td>42.82</td>
<td>Urea 117 + super 246</td>
<td>36.43</td>
</tr>
<tr>
<td>350</td>
<td>51.45</td>
<td>48.30</td>
<td>A.N. 185-5 + super 287</td>
<td>49.00</td>
<td>S/A 301 + super 287</td>
<td>49.70</td>
<td>Urea 136-5 + super 287</td>
<td>42.24</td>
</tr>
</tbody>
</table>

(Prices including freight)
AGRAS 18:18 plus—$147 (bags) $138 (bulk) tonne
Sulphate of Ammonia—$86/tonne
Urea $135/tonne
Ammonium nitrate—$135-80/tonne
Superphosphate (bags)—$77-75 (Using bulk super—each 50 kg would cost 45 cents less)
value) “Nitrogen Cost Column” from Table 1.

STEP 2: From Table 1 select the Table for your rainfall zone, then under the column with the appropriate expected price for grain, select your land situation and find the N recommendation (kgN/ha).

STEP 3: You now have a figure to refer to Table 3 and select the column for the nitrogen fertiliser type selected earlier.

The rates recommended in Table 1 are only a guide and are based on the results of many trials over many seasons. They will be revised as more results are obtained.

Because there are differences between sources in the price per unit of nitrogen, with the cheaper sources (urea at present) it is profitable to use a higher rate than when using sources costing more per unit of nitrogen.

**Which nitrogenous fertiliser?**

Results of Department of Agriculture trials indicate that overall, the currently available commercial sources of nitrogen fertilisers are equally effective for cereal growing. In general, high analysis fertilisers such as urea and ammonium nitrate have the advantage that lower amounts are needed to supply the required nitrogen.

However, all sources have advantages and disadvantages. These are:

**Urea**

Urea’s main advantage is that it is now the cheapest source per unit of nitrogen. However, it cannot be mixed with superphosphate because the product becomes very sticky, and when sown close to the seed it can adversely affect germination. As urea must be applied separately from superphosphate an extra cultural operation may be involved.

Urea is very soluble and much can be lost by leaching. It can also have an acidifying effect on the soil, although this is not a serious problem.

Nitrogen may be lost in gaseous form from urea broadcast on sandy soils. This loss, as ammonia gas, is greatest where the urea is topdressed on to a moist soil surface and left uncovered, with no following rain, for some time. The ammonia gas is a product of the breakdown of urea and its loss is greatly reduced or eliminated altogether if the urea is incorporated into the soil or washed in by rains soon after application. In this situation the gas is absorbed by soil moisture and retained in the soil.

**Ammonium nitrate (Agran 34-0)**

Ammonium nitrate has a lower nitrogen content (34 per cent) than urea (46 per cent), which means that a higher rate is needed to give the same amount of nitrogen.

The nitrogen is supplied in both the nitrate form, which is readily available and easily leached, and in the ammonium form, which is also readily available but not generally leached. In the soil the ammonium form is quickly converted to nitrate.
but there are no gaseous losses after application except on highly calcareous soils.

It is safe to drill up to 100 kg/ha ammonium nitrate in contact with cereal seeds but higher rates can cause reduced germination if placed in contact with the seed. This source also has an acidifying effect on the soil, similar to that with urea, but again this is not a serious problem. Ammonium nitrate cannot be mixed with superphosphate.

**Sulphate of ammonia**

Sulphate of ammonia has a lower nitrogen content (21 per cent) than ammonium nitrate, but it has the advantage that it can be mixed with superphosphate and drilled in one operation. There may be a slight reduction in germination, but this is unlikely to be important at rates of 120 kg/ha or less.

Sulphate of ammonia is quite strongly acid forming in the soil but this effect may sometimes be an advantage. In soils deficient in manganese the local acidifying effect around the seed can make any manganese present more readily available. The acidifying effect may become quite harmful if high rates are used repeatedly on any one area.

**Agras 18:18 plus**

Agras 18:18 has a low nitrogen content (18 per cent) but being a compound fertiliser has the advantage of supplying both nitrogen and phosphorus drilled with the seed, thus avoiding the problem of handling two separate fertilisers. It also has a sulphur content of 16 per cent. It can be handled in bulk as well as in bags.

A disadvantage is that the nitrogen and phosphorus are present in a fixed ratio, which will not be ideal for many situations. However, where the ratio is correct it is a very convenient source although tending to have an acidifying effect on the soil.

Table 4 compares the cost of using Agras 18:18 and other nitrogen sources.

**Sodium nitrate**

Sodium nitrate is very expensive per unit of nitrogen but has the advantage that its nitrogen is in the nitrate form, which is easily taken up by plants. It is quick-acting but very soluble and prone to rapid leaching. Sodium nitrate has no acidifying effect on the soil.

**Calcium ammonium nitrate**

Nitrogen in calcium ammonium nitrate is present half as ammonium nitrogen and half as nitrate nitrogen. The nitrate form is readily taken up by plants while the ammonium form is also freely available but less readily leached.

Because of its content of calcium, calcium ammonium nitrate does not increase soil acidity. It can be mixed with superphosphate but should be used soon after mixing.

Calcium ammonium nitrate is more costly per unit of nitrogen than either urea or sulphate of ammonia. It is not recommended in preference to these sources.

**Time of application**

The response to nitrogen fertilisers varies considerably according to the time of application. Application should be made when the crop can make best use of the applied nitrogen, which depends on:

**Length of growing season**

Where the growing season is very short (Zone A) nitrogen should be applied very early in the season. This allows the crop to make maximum use of the nitrogen in the short time available.

**The incidence of heavy rainfall**

If the application of an easily-leached fertiliser is followed by heavy rain the fertiliser may be lost from the root zone before the plant can make much use of it. If a very dry period follows application, the fertiliser may remain on top of the ground for some time before it is washed down to the root zone and taken up by plants. These are circumstances which cannot be foreseen but which cause results to vary from one season to the next.

**The source of nitrogen**

Agras 18:18 plus will always be drilled with the seed but other solid fertilisers may be applied at some other time. Application at seeding requires only one operation but at other times the cost of an extra operation is involved.

Early application stimulates growth and tillering before the cold winter period. These effects are lost if the fertiliser is applied too late. Results of trials using urea and other nitrogen fertilisers have led to the following conclusions:

- An application made more than one week before seeding gives poor results. This may be a result of losses of nitrogen following leaching by heavy rains soon after application and before the crop has developed its root system, or of losses to the atmosphere when rain starts the breakdown of urea to ammonia but is not heavy enough to wash the urea into the soil.

- In areas with a short growing season the nitrogen should be applied as close to germination as possible.

- In heavier rainfall areas (Zone C) the nitrogen application should be delayed for three to four weeks after seeding, to minimise leaching.

- In intermediate rainfall regions (Zone B), application is generally recommended with seeding, but in many cases better yields are obtained if the application is delayed for up to three weeks. Results have varied in this zone from year to year, favouring application at seeding in some seasons and delayed application in others. However, the with-seeding application saves the cost of a second operation and is recommended unless leaching is likely to be severe in a particular situation, such as on deep sandy soils.

- Applications should not be made later than six weeks after seeding. Very late applications do not increase yield although they may increase the grain protein content. Nitrogen applied after the period of heavy winter rains may take some time to be washed down to the root zone, further delaying the effect of application.

Although applications made at times other than the optimum give a less profitable return, they may still be profitable. For example, in Zones A and B, while maximum return is usually obtained from application at seeding time, profitable responses can often be obtained up to six or eight weeks after sowing. Profitable responses have been obtained in trials with even later
application where the crop has been very yellow and suffering from nitrogen deficiency.

Recommendations—time of application

ZONE A: Apply at seeding if the crop is sown after the break of the season, or at germination if the crop is sown dry.

ZONE B: Apply at seeding in most situations. Application can be delayed up to three weeks after seeding on very light soils more prone to leaching.

ZONE C: Apply three to four weeks after seeding unless the land is generally too wet to make an application at this time. In this case application should be made at seeding.

Soil type

Very light soil is more prone to leaching than heavy soil. Therefore, in areas of intermediate rainfall (Zone B), applications on very light soils should be delayed for about three weeks after seeding. In high rainfall areas (Zone C) application should be three to four weeks after seeding.

In areas prone to waterlogging where machinery may bog, nitrogen must be applied at seeding unless aerial application is practical.

Early sowing of a crop may allow a good root system to develop before the advent of heavy winter rains. In intermediate or heavy rainfall areas applications at seeding of early-sown crops may therefore be safer than they would be with later sowing.

Method of application

- Mixed with other fertilisers at seeding

Superphosphate cannot be mixed with urea or ammonium nitrate because the result is a sticky mess. Low rates of urea mixed with high rates of superphosphate will flow through a drill but the mixture can still cause trouble in damp weather.

Sulphate of ammonia can be mixed with superphosphate and drilled with the seed but if the mixture is kept for a long period it tends to cake (although the lumps are soft and readily broken up).

- Mixed with the seed at seeding

Trials with urea have indicated that mixing nitrogen fertiliser with the seed at seeding has serious effects on germination. At low rates it delays germination and gives lower yields than urea top-dressed; at high rates plant numbers are severely reduced.

Sulphate of ammonia and ammonium nitrate can also have a harmful effect on germination if drilled with the seed. The effects are greatest if the fertilisers are drilled with the grain under moist conditions and a dry period follows seeding.

- Top-dressed at seeding but separated from the seed

If an extra fertiliser box is fitted to the seeding machine, the nitrogen fertiliser can be dropped just in front of the seeding tyne or discs and turning in during seeding. Alternatively the fertiliser can be dropped just behind the seeding tyne and left on the surface.

Nitrogen can also be dropped from an extra combine or drill towed either just in front or just behind the seeding machine. If the extra machine is towed in front the fertiliser is turned in by the seeding machine. When urea is used, the thin covering of soil reduces loss of nitrogen to the atmosphere.

- Top-dressed in an operation separate from seeding

Separate application of nitrogenous fertilisers can be made by dropper type applicators including combines or drills, broadcasters or spinner machines, or by aircraft. Dropper types are generally preferred because they give a more even distribution than spinner type machines. Aerial application is expensive but may be used when the land is too wet for ground vehicles.

Spraying

Nitrogen fertilisers are very soluble in water but highly concentrated sprays may cause some crop damage. In one ground spraying operation however, an application 80 kg of urea dissolved in 455 l of water left white deposits of urea on the leaves but caused no important damage. Although heavy rates of urea have been applied to wheat from the air without damage, spraying from an aircraft requires low volumes and concentrated solutions which allow large losses of nitrogen into the atmosphere.

Generally, spray application has no advantage over other application methods.

or ammonium nitrate would be by way of an extra fertiliser box or an extra combine, although these fertilisers often cannot be applied at night or in other damp conditions while seeding is being carried on. Areas missed should be marked and the fertiliser applied separately at a later date.

Agras 18:18 is designed to be drilled with the seed.

Residual effect

Nitrogen is a very mobile nutrient and under Western Australian conditions there is little chance of any residual effect at commercial rates. Only very high nitrogen rates or very late applications may provide some residual benefit.

Local information

For information about local nitrogen trials, or specific recommendations for agricultural areas, farmers should contact district agricultural advisers at the nearest Department of Agriculture office.

Acknowledgments

The conclusions drawn in this article are based on the results of many trials, some carried out by other officers of the Department of Agriculture.

Further reading


