Seasonal nitrogen use (7-11)

Introduction
This Farmfact explains good practice N fertiliser use on a seasonal basis. For more information about optimising N fertiliser use, see Farmfact 7-10 Nitrogen fertiliser. For more information about mitigation strategies to reduce N losses from farms, see Farmfact 7-23 Minimising nitrogen loss.

What influences the response rate to nitrogen?
The amount of pasture grown in kg DM/ha per kg N/ha applied is the “response rate”. For example where 30 kg N/ha is applied and an additional 300 kg DM/ha of pasture is grown the response rate is 10 kg DM/kg N fertiliser applied. The response rate is dependent on:
1. Amount of available N in the soil – the greater the deficit, the higher the response
2. Soil temperature – the warmer the soil, the greater and more immediate the response
3. Plant growth – the faster the growth, the greater and more immediate the response
4. Moisture – too much or too little water will lower the response
5. Rate of N applied per application – there is a diminishing response at high application rates

Table 1 shows that the best response to N fertiliser occurs on fast growing pasture, when other factors such as moisture and soil temperature are not limiting growth.

Table 1 Impact of pasture growth rate on response rates to N fertiliser (N applied at optimum rates)

<table>
<thead>
<tr>
<th>Pasture growth rate</th>
<th>Pasture growth (kg DM/ha/day)</th>
<th>Response (kg DM/ kg N)</th>
<th>Time for full response (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow</td>
<td>10</td>
<td>5</td>
<td>10 - 14</td>
</tr>
<tr>
<td>Moderate</td>
<td>20 – 40</td>
<td>10</td>
<td>6 – 8</td>
</tr>
<tr>
<td>Fast</td>
<td>50 - 70</td>
<td>15</td>
<td>5 - 6</td>
</tr>
<tr>
<td>Rapid</td>
<td>80</td>
<td>20</td>
<td>3 – 4</td>
</tr>
</tbody>
</table>

Response rate variation also depends on the season and on N application rate as illustrated in Figure 2. At the same application rate, responses are lower and slower in winter than in spring. The response rate also declines for the same amount of N applied over 20-40 kg N/ha.

For example, if 25 kg N/ha is applied in the spring the expected response is 12 kg DM/kg N compared to an expected response of only 7 kg DM/kg N at the same application rate in the winter. If the spring application rate is increased to 100 kg N/ha, then the expected response rate falls to 7 kg DM/kg N.
Timing of nitrogen fertiliser application

The profitability of applying N is dependent on the extra feed being utilised. Therefore N needs to either be applied to fill genuine feed deficits, or any surplus feed identified and harvested to make quality supplement. As the response rate to N occurs over 3-14 weeks (refer Table 1) N needs to be applied in anticipation of a feed deficit. This requires feed budgeting and monitoring actual pasture cover against target cover to ensure N is applied early enough to fill a feed deficit. A summary of the response to N over 40 days from about 400 trials was 4, 9 and 15 kg DM/kg N for winter, early spring and late spring applied N.

Late Winter/early Spring

Good milk production responses can be achieved from late winter/early spring applications of 30-50 kg N/ha to pastures with a cover of 1200-2200 kg DM/ha where there is a genuine feed deficit (applied 70-30 days before balance date i.e. when feed demand = feed supply).

Good responses in late winter/early spring are due to plants being N deficient as:
- Nitrate has been leached from the soil over the late autumn/winter
- The rate of N fixation by the clover is low because of low soil temperatures (at 5-10°C nitrogen fixation is very slow)
- The rate of N mineralisation from soil organic matter is slow because of low soil temperatures

Figure 2    Effect of season on response rate (adapted from Cameron et al, 2005)

Spring

In spring, when pastures are growing rapidly, the response rate to N is high and applications of 40-60 kg N/ha can be used. However, the profitability of applying N at this time is often questionable unless pre-grazing covers are kept at target and cows graze to a consistent, even height (refer Farmfact 1-2). This requires early identification of pasture surpluses and harvesting high quality silage that can be used to fill a genuine feed deficit later in the season. The profitability of this practice will depend on the response to the supplement when fed out at a later date and the cost of conservation.
Summer

On summer dry farms, N can be applied in late November/early December at 40-50 kg N/ha to increase pasture cover going into dry summer. N needs to be applied before moisture is limiting growth.

Where N is used to increase grazing residuals (leaving paddocks clumpy) and promote seedhead production the returns will be negative due to loss of pasture quality over the whole farm.

Summer – irrigated farms

When moisture is not limiting, pasture responses are similar to those in spring where soil temperatures are less than 16°C i.e. good responses with up to 40-60 kg N/ha. Where soil temperatures are above 16°C, responses can be lower (6-8 kg DM/kg N) as there is increased available N in the soil from greater mineralisation, reducing the responsiveness to add N.

To reduce volatilisation losses, apply N near to the time the paddock will be irrigated.

Autumn

Autumn applications of 20-40 kg N/ha can be used to build up pasture cover to increase days in milk at the end of the season, or to achieve pasture cover targets. N fertiliser should be applied before soil temperature drops below 7°C in order to ensure plant uptake occurs.

Winter

Winter applications are least effective and most prone to direct N leaching losses. Nitrogen converts to ammonium in 1-3 days and then to nitrate within about 10-70 days.
Therefore slow growth and drainage can result in nitrate leaching directly from fertiliser, before plant uptake occurs. A trial in the Waikato measured N responses of 6, 9, and 11 kg DM/kg N for May, June and August applications and related to the direct leaching measured in May and June (Ledgard et al 1998).

**Application rates**

Research has shown that a single application of N fertiliser is most efficient when applied between 30 to 50 kg N/ha (giving a pasture production response of about 12 kg DM/kg of N applied). Application rates above 40 kg N/ha gave a smaller increase in kg DM/kg N applied and at 100 kg N/ha responses of only 7 kg DM/kg N were measured. As shown in Figure 2, these values were generally higher in warm springs and lower in cold winters.

Ruakura farmlet studies showed that response efficiency expressed as kg milksolids per kg N differed between application rates. A response efficiency of 0.8 kg milksolids/kg N occurred when N was applied at 200 kg N/ha/year, compared to 0.6 kg milksolids per kg N applied at 400 kg N/ha/year. An economic analysis of the study showed marginal profitability for the 400 kg N/ha/year farmlet due to the large amount of silage harvested in the spring and fed out in the autumn and extra costs for harvesting and labour. The profitability was dependent on the milk price, costs of N fertiliser and whether stocking rate was increased to harvest the extra feed grown.

Farm system trials around the country have found that as the amount of N applied per year increases so does the amount of N leached, and that there are large increases in N leached at rates above about 200 kg N/ha. Based on the studies discussed the following applications rates are recommended:

- 20-40kg N/ha in a single application is most efficient
- Rates can be increased up to 60kg N/ha in rapid growth periods (spring)
- Annual rates no greater than 150-200kg N/ha are recommended to achieve economic efficiency and limit leaching losses and environmental effects
- Check with the local regional authority for any maximum N loading rules and regulations e.g. nil or limited N fertiliser on effluent areas

**Post-application grazing**

- Grazing within 4 days after application has no effect on pasture response
- Grazing between 4 and 14 days post-application can reduce responses because rapid N uptake has had insufficient time to convert to increased growth and will be lost
- Graze N-boosted pastures in the normal rotation to avoid a decrease in herbage quality

**References:**


