FERT$MART NITROGEN POCKET GUIDE

Prepared by the dairy research projects of the More Profit from Nitrogen Program

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1 Introduction

Nitrogen (N) is usually the most limiting nutrient for pastures on dairy farms. It is required in relatively large amounts and can have a big effect on supply and quality of feed on farm. Whilst soil reserves supply much of a pasture's requirement, N fertiliser is being used in greater amounts on-farm to boost pasture production. Used correctly, it is a very cost effective and efficient way to increase home grown feed. Used poorly, N fertiliser becomes expensive, as pasture responses can be low, animal health may be at risk and losses may cause unintended damage to the environment.

KEY POINTS FOR THE EFFICIENT USE OF N FERTILISERS ON DAIRY PASTURES

- Apply N strategically across the growing season according to conditions and likely response, rather than by a fixed recipe.
- Only apply N fertiliser when there is adequate soil moisture, the pasture is actively growing and can effectively utilise the N.
- Apply N fertilisers at rates of 20 to 50kg N/ha per application, no closer than 18 days apart at the lighter rates and preferably at least 28 days apart at high rates, equivalent to 1 to 1.75kg N/ha per day.
- Ensure that the extra pasture grown can be effectively utilised as poor utilisation increases the cost of the fertilised pasture.

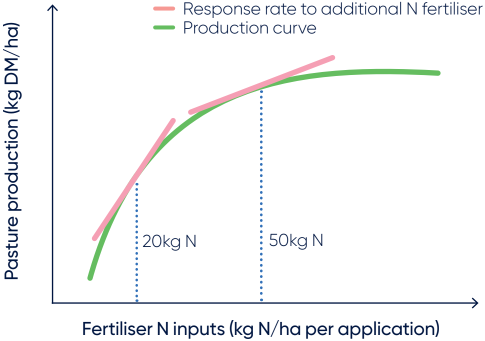
2 Pasture responses to N fertiliser – the DM production response curve

When soil moisture is not limiting plant growth, the growth or dry matter (DM) production response to applied N fertiliser will depend on the pasture's potential growth rate. This is primarily determined by temperature and the amount of sunlight being captured by the plants.

The N response (kg DM/kg N) to applied N fertiliser (response curve), is not constant (Figure 1):

- Responses vary between seasons (e.g. higher in spring, lower in winter), between locations (e.g. northern vs. southern dairy regions) and management (irrigated vs. rainfed).
- Highest responses occur at low rates of applied N, but can be unreliable at applications of less than 20kg N/ha.
- At high application rates (generally greater than 50kg N/ha), N response progressively declines to the point where there is minimal increase in pasture production with each additional kilogram of N applied.
- The most effective and efficient pasture responses generally occur at fertiliser rates of between 20 to 50kg N/ha. This is the steepest part of the response curve.

Figure 1 Stylised typical N response curve



- To produce more pasture, apply 40kg N to one hectare (40kg N/ha) rather than 40kg N to two hectares (20kg N/ha), due to unpredictable responses at the lower N rate.
- Likewise, apply 80kg N to two hectares (40kg N/ha) rather than 80kg N to one hectare (80kg N/ha) due to decreasing N responses with high N rates

3 Conditions for good pasture N responses

Applications of N fertiliser will only boost or enhance the growth rate of the pasture. Any factors or management that restricts pasture growth, will reduce the response to, and the economics of, N fertiliser applications.

Key factors driving pasture N responses:

- Temperature – is a primary driver of pasture growth rate and N fertiliser response.
- Soil water content:
  - If dry soils are restricting pasture growth, then N fertiliser responses will be reduced.
  - Waterlogged soils will reduce pasture growth rates, and together with increased N losses, will lower N fertiliser responses.
- Soil fertility – deficiencies of other essential nutrients such as phosphorous (P), potassium (K) and sulfur (S) and trace elements such as molybdenum (Mo) will reduce responses to applied N fertiliser.

- Pasture species and composition – a good density of well-managed, improved pasture species such as perennial ryegrass will give higher responses to applied N than older, degraded pastures.
- Grazing management – grazing pastures according to best management practices (BMPs) for the pasture type, will improve pasture N fertiliser responses.
- Mineralisation of soil N – plant available N is released (mineralised) from soil organic matter at higher rates in the spring and summer (section 7).
- If the pastures current growth rate is slow (e.g. winter in southern Australia), then response to N will also be low. Likewise, if growth rates are high (e.g. spring), the response rate to N will be greater (Table 1).

Temperate and sub-tropical pasture grasses have quite different optimum soil temperature requirements for good N fertiliser responses:

- Apply N fertiliser to temperate pasture grasses, such as perennial ryegrass, when soil temperatures (at 10cm depth) are above 4°C.
- Apply N fertiliser to subtropical grasses, such as kikuyu and paspalum, when soil temperatures (10cm) are above 10°C.
- These soil temperatures need to be the average over the regrowth period, not just on the day of application.

Table 1 Estimated pasture response to N based on existing growth rates

Pasture growth rate	**Pasture growth** (kg DM/ha/day)	**Response** (kg DM/kg N)	**Pasture quality**	**Climate**
Slow	10	5–8	Poor/open sward/high weed content	Cold/moisture limited/ waterlogged
Moderate	20–40	10–15	Ryegrass pasture	Typical late winter/early spring
Fast	50–70	15–20	Well managed ryegrass pasture	Typical mid spring

4 Rates and timing of N fertiliser applications

The rate of N fertiliser to apply in any one application will depend on a combination of factors including the likely response (sections 2 and 3), the economic value of the additional pasture grown (section 5) and the length of the grazing rotation.

- The most efficient pasture growth responses occur when N fertiliser is applied at rates of between 20–50kg N/ha at any one time (section 2).
- A reliable guide is to apply between 1 and 1.75kg N/ha per day during the effective growing season of the pasture.
- As a rule of thumb, this means that the grazing rotation length (days) can be multiplied by 1 to 1.75 (kg N/ha per day) to calculate the total kilograms of N to be applied after each grazing. For example, a 30 day grazing rotation at 1kg N/ha per day requires an application of 30 x 1 = 30kg N/ha

- With some of the newer pasture cultivars, there may be some justification to increase the upper rate to 2kg N/ha per day during peak growth periods.
- Higher rates (e.g. 60kg N/ha) may be justified when building up pasture cover for silage or hay conservation.
- Paddocks with very low soil N (e.g. farms being converted to dairying) may require multiple applications of N before a pasture response is seen. Much of the N applied is being immobilised into the organic matter pool and not available for pasture production.
- Ideally N fertiliser should be applied as soon after grazing as possible (Figure 2).

These above-mentioned N fertiliser application guidelines should be used with caution at certain times of the year:

- In dryland southern Australian pastures, a combination of sub-optimal soil moisture, often with large amounts of N in the soil from spring/summer mineralisation, can result in poor fertiliser N responses for a number of weeks after the autumn break.
- Similarly, in the subtropics, soil mineralisation can supply adequate plant available N over the late summer/autumn period so responses to N fertiliser may be poor.
- N fertiliser rates may be reduced at these times of the year to take advantage of the already available soil N from mineralisation.

Figure 2 Nitrogen fertiliser application timeline

5 Assessing the economics of N fertiliser applications

Used effectively and efficiently, N fertiliser boosted pasture can usually be a cost effective method of producing additional forage supplies on dairy farms. As such it can be considered as an alternate feed source alongside purchased hay, silage and grain in the farm's feed budget.

A number of factors need to be taken into account and considered when assessing the economic value of N fertiliser applications to pastures. These include:

- The cost per kilogram of N. This should be an 'as applied' cost, including freight and spreading costs.
- The likely pasture N response (kg DM/kg N) for the pasture and the time of the year (sections 2 and 3).
- The utilisation of the additional pasture grown. Under ideal conditions and good grazing management, close to 100% can be utilised. Under less ideal conditions, such as grazing wet soils, utilisation can be much lower, increasing the effective cost of pasture consumed ($/kg DM consumed).
- If the pasture is conserved, harvest costs and wastage should also be taken into account.
- The cost of the additional pasture ($/kg DM consumed) should then be compared with the alternative purchased feed ($/kg DM consumed), allowing for differences in feed quality (refer to section 13).
- The cost effectiveness of using N fertiliser is quite sensitive to the combined effects of both N response (kg DM/kg N) and utilisation (%) (Table 2).

Table 2 Variation in cost of additional pasture consumed*

N pasture response (kg DM/kg N)	**Utilisation** (%)	**Cost** ($/t DM)
High response 20:1	100	76
	75	100
Average response 10:1	100	150
	75	200
Low response 5:1	100	305
	75	405
Very low response 3:1	100	506
	75	675

**When urea is $700 per tonne as spread. Utilisation column assumes this is the utilisation of the extra pasture produced.*

6 Types of N fertilisers

A range of N fertilisers are available for use on Australian dairy pastures (section 13). These fertilisers vary in their N content, the chemical form of the N and the cost per kilogram of the N. They can also contain other essential nutrients for pastures such as phosphorus (P) and sulfur (S).

- Urea is usually the cheapest ($/kg N) and most commonly used N fertiliser on dairy pastures.
- Some of the N applied in urea can be lost through ammonia volatilisation, especially during the critical first 48 hours after application.
- In southern Australia, provided there is adequate soil moisture for pasture growth, ammonia losses are usually not large enough to justify using other more expensive N fertilisers less prone to these losses.
- Ammonium sulfate (also known as sulfate of ammonia; SoA) is a more expensive form of N that also contains 24% S in the plant available sulfate form. As such SoA can be a useful N fertiliser alone or in blends to address S deficiencies such as during winter. SoA can however have a greater soil acidifying effect (section 11) than other N fertilisers.
- If P is also required, N-P fertilisers such as di-ammonium phosphate (DAP) is usually the cheapest form of N. Due to the relatively low N content in DAP, it may have to be blended with other N fertilisers to boost N application rates.
- Nitrate containing N fertilisers such as UAN (urea ammonium nitrate) and CAN (calcium ammonium nitrate) can be less effective in wet soil conditions, due to the increased risk of the nitrate leaching, compared to ammonium based fertilisers.
- Organic fertilisers (e.g. manures), while advantageous in supplying other nutrients, can have the disadvantage of often being low and variable in N content, difficult to apply, bulky and expensive to transport, together with the N content taking some time to become plant available.
- Foliar application of N is unlikely to meet total N requirements of pasture, due to low uptake through the leaf. Foliar N usage also may be limited due to risks associated with leaf burning.

7 The N cycle

Nitrogen exists in many different forms in the soil, air and water. It is a very dynamic element as it cycles from the soil to pasture, to the animal and back to the soil in the N cycle with various losses and off-farm inputs (Figure 3) including:

Inputs N fertiliser applications, brought in feed (e.g. hay and grain), N fixation from legumes (e.g. clovers). Rain and lightning contributes very little N.

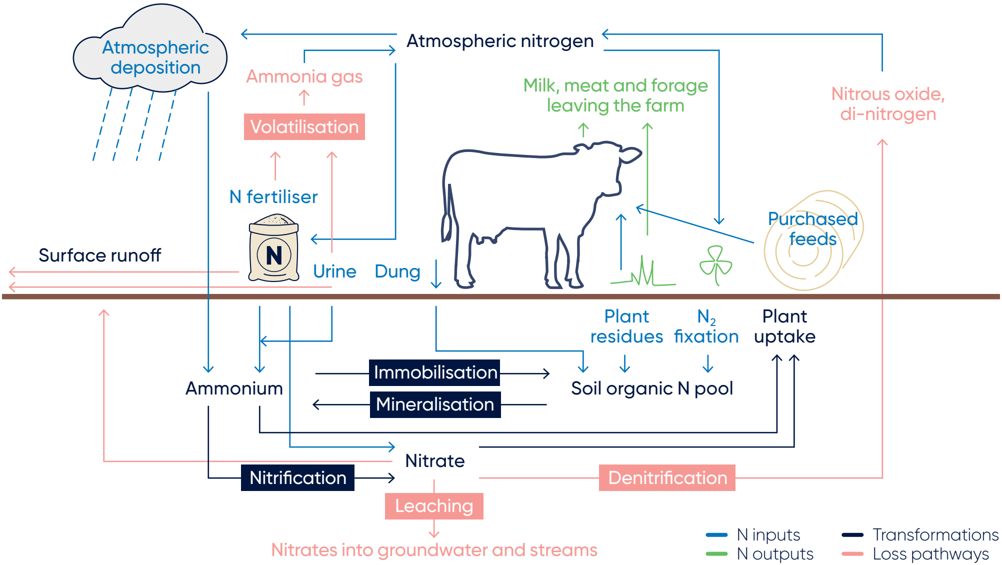
Outputs milk, animals and fodder taken off the farm.

Losses to the environment Ammonia volatilisation, nitrous oxide and di-nitrogen gas losses by denitrification to the atmosphere, nitrate leaching down through the soil or in surface runoff.

SOIL N MINERALISATION

- Most (about 98%) of the N present in soil is locked up in organic matter.
- Plants generally only take up N in an inorganic form (as either ammonium or nitrate).
- Synthetic fertilisers supply N in these inorganic forms, which are readily taken up by plants.
- Organic forms of N need to undergo the process of **mineralisation** by soil microbes to be converted into the inorganic forms.
- Around 1–2% of the soil organic N will be mineralised each year (approx. 150–250kg N/ha in dairy pastures), mainly in spring and summer.
- Ammonium and nitrate forms can also be **immobilised** back into organic forms by soil microbes and plants.

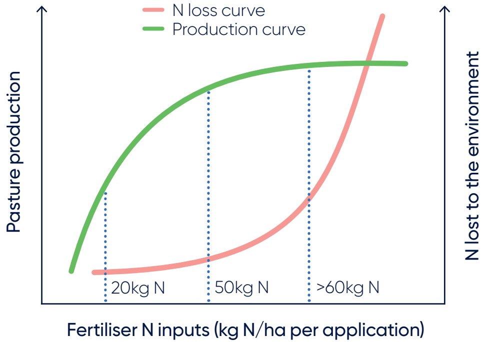
Figure 3 Simplified N cycle of a grazed dairy pasture



8 Reducing N losses to the environment

With increasing N fertiliser application rates, the rate of increase in pasture production declines and plateaus out, while N lost to the environment increases exponentially (Figure 4). Therefore, by restricting N fertiliser application rates to the recommended optimum levels, excessively high N losses to the environment can be avoided.

Figure 4 Schematic diagram of losses of N



Loss pathways

Volatilisation

- N can be lost to the atmosphere as ammonia gas from urine patches and from the application of ammonium-based N fertilisers, or ones that quickly break down to ammonium (e.g. urea).
- Ammonia losses are highest during the first two days after the application of urea fertiliser, while the granules are breaking down (hydrolysis).
- Ammonia volatilisation losses from urea fertiliser applications to pasture in summer under dryland pasture conditions are typically 10–15% of the N applied.
- However, under hot, dry, windy conditions when pasture cover is low, losses can be as high as 30% of applied N.
- If N fertiliser is applied during drier and warmer periods, it can be applied 2–3 days prior to grazing to minimise losses. Care needs to be taken in respect to animal health (section 10).

- At the start and end of the dryland growing season, when soil moisture is becoming limiting and follow up rain is not certain, the use of urease inhibitor coated urea (e.g. Green Urea™; section 9) may be warranted to reduce the risk of high volatilisation loss.

Denitrification

- When soils become saturated (low oxygen levels/anaerobic), usually following heavy rainfall, flood irrigation or waterlogging due to poor drainage, soil N in the nitrate form can be denitrified.
- During denitrification, the soil nitrate is converted to and lost to the environment as nitrous oxide (a potent greenhouse gas), and as di-nitrogen gas.
- Avoid applying N fertiliser to warm (>10°C) waterlogged soils, as this increases the rate of denitrification.
- If N fertiliser applications to saturated soils are necessary, avoid nitrate containing types such as UAN (urea ammonium nitrate) and CAN (calcium ammonium nitrate). Apply ammonium based types instead.
- Nitrification inhibitors (section 9) can reduce denitrification losses, especially on warm and waterlogged soils.

Leaching and surface runoff

- Leaching is the movement and loss of soil N in the nitrate form down through the soil beyond the root zone of the pasture.
- Leached nitrate can cause environmental concerns, contaminating ground water and sometimes re-entering surface waterways.
- Rainfall, soil N loading and soil type are the key drivers of nitrate leaching risk.
- Nitrate leaching risk is higher on light sandy, free-draining soil types or where there is artificial sub-surface drainage, compared to heavier textured soils.
- Avoid applying high rates of N fertiliser to these higher risk soil types during periods of high leaching potential.
- The build-up of high soil N levels in autumn and early winter, through N fertilisation and urine deposition (high stocking rates), is a major contributor to spring nitrate leaching losses.

- If irrigating, take care not to over water as this may cause leaching.
- Ammonium-based N fertilisers are less likely leach than nitrate-based fertilisers.
- Most types of N fertiliser are readily soluble and dissolve in surface water runoff (e.g. dissolved urea). Soil also will release some N to runoff water as it moves across the soil surface.
- Do not apply N fertiliser to areas of pasture where water is running off – the more runoff, the more surface-N will be lost.
- Do not apply N fertiliser near drains, channels, dams, lakes or riparian areas. In 'hump and hollow' surface drainage systems, avoid applying N in the hollows as they will most likely receive N through surface movement (runoff) anyway.
- The use of nitrification inhibitors (section 9) can reduce nitrate leaching losses in some situations by keeping more of the soil mineral N in the ammonium form.

REDUCING N LOSS TO THE ENVIRONMENT

- Apply N fertiliser at recommended optimum rates to reduce N losses to the environment.
- At most times of the year, volatilisation losses are not high enough to justify switching to more expensive N fertilisers that are less prone to volatilisation.
- In summer, irrigate the pasture **after** the urea application, rather than before, to reduce ammonia volatilisation.
- To reduce the risk of denitrification losses when N fertiliser applications to wet soils are necessary, avoid using nitrate-containing types.
- Apply ammonium-based N fertilisers, rather than nitrate-based fertilisers, when there is a higher risk of leaching.
- When soils are saturated, wait at least two days after rainfall for excess water to drain before applying N to reduce leaching and surface runoff losses.

9 Urease and nitrification inhibitors

A number of chemical compounds, called inhibitors, can be coated onto N fertilisers or applied directly to soils, to manipulate different steps in the N cycle (Figure 5). Such inhibitors can potentially reduce N losses and improve N availability in certain situations. Inhibitors also increase the cost of the N fertiliser. Therefore, inhibitors are only likely to be cost-effective if the rate of fertiliser applied can be reduced by the expected reductions in N loss.

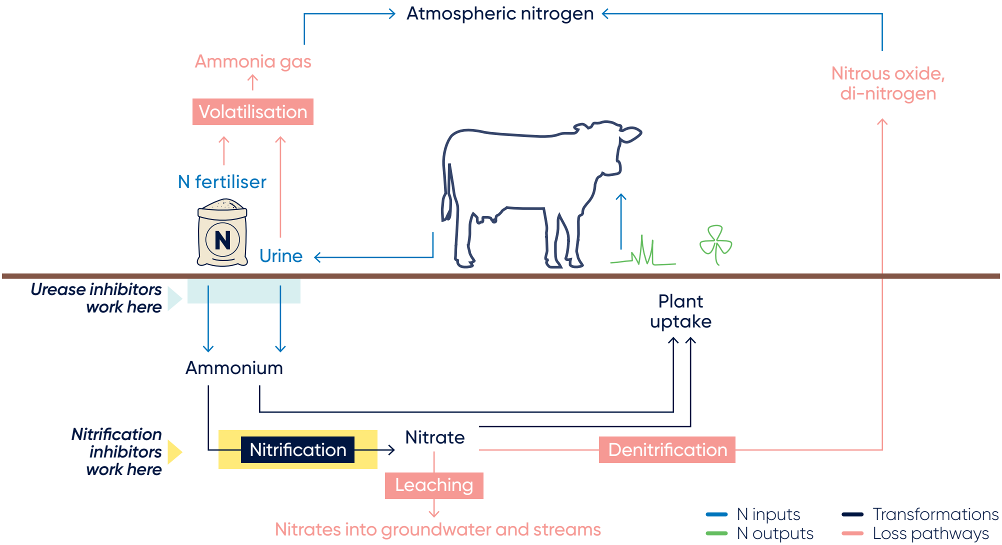
Urease inhibitors

- When urea fertiliser is applied to soils, urease enzymes convert urea to ammonium through hydrolysis. Ammonium can be volatilised and lost as ammonia gas.
- Urease inhibitors slow down the rate at which urea is hydrolysed for around 2 weeks, allowing the urea to dissolve out of the granule and enter the soil (Figure 5).
- Urease inhibitors may be warranted in situations when ammonia losses are expected to be high (i.e. hot, windy conditions).
- Examples include Green Urea™ and can reduce ammonia volatilisation for up to 14 days.

Nitrification inhibitors

- In the soil, ammonium N is converted into nitrate N by soil microbes.
- Nitrate N has a higher risk of being lost to groundwater and surface water through leaching/runoff or undergoing denitrification and being converted into nitrous oxide (a potent greenhouse gas) and di-nitrogen gas.
- Nitrification inhibitors slow down this conversion of soil ammonium into nitrate (Figure 5).
- Nitrification inhibitors have been found to more consistently reduce nitrate leaching on free draining soils, than denitrification losses on waterlogged soils.
- The effectiveness of the nitrification inhibitor is temperature and soil-moisture dependent. Examples include Entec® and N-Protect™.

Figure 5 Simplified dairy N cycle showing where urease and nitrification inhibitors act to reduce N loss to the environment



10 Animal health and production

Application of N fertilisers to pastures can increase the risk of a number of animal health conditions in grazing livestock. These include nitrate toxicity, ammonia-induced bloat, clinical and sub-clinical ammonia toxicity as well as reduced production effects caused by excess N in the cow's diet.

These risks can be reduced by:

- Avoiding high rates of N fertiliser on annual ryegrass, kikuyu and some broad-leaf weeds such as capeweed, as these can accumulate potentially toxic levels of nitrate. Perennial ryegrass, tall fescue, white clover and cocksfoot are **not** known to accumulate toxic levels of nitrate.
- Do not graze pastures for the first 14 days after the application of N fertiliser as nitrate levels are at their highest at this time, especially pastures that are water-stressed.
- Likewise, continue to avoid grazing pastures for 14–21 days post fertilising if the pastures are high in crude protein and animals are not receiving an energy supplement or lower quality hay or silage to counterbalance the high N in the pasture.
- Do not apply more than 60kg N/ha in a single application to annual ryegrass or kikuyu, particularly at the beginning of peak growth periods in autumn and spring or following a long dry period.
- Avoid subjecting cows to a rapid change in diet, e.g. from low to high quality pasture, or to pasture containing capeweed or volunteer brassicas, especially dry cows or heifers. Likewise, never give starved, unadapted or dry cows unrestricted access to highly N fertilised pastures.
- Cows that are suffering as a result of excess N in their diet tend to select for lower quality roughage. A bale of low quality 'bedding' hay in the corner of the paddock can be used as an indicator of protein or nitrate stress.
- At times of the year when cows are fed a high proportion of pasture with crude protein levels in excess of the cow's requirements (16–18% crude protein), feeding a higher proportion of high energy supplements (e.g. grain) will assist in balancing the N content of the overall diet.

11 Soil acidification

One of the long term effects of regular N fertiliser applications to pastures can be a gradual acidification of the soil.

- Both biologically fixed N from clovers and N applied in artificial fertilisers have an acidifying effect on the soil.
- N fertilisers vary in their acidifying effect on the soil with ammonium sulfate (SoA) being the most acidifying (Table 3).
- Well buffered, heavier textured soils are relatively resistant to acidification. However, regular applications of N fertilisers will cause the soil pH to gradually decline with poorly buffered, light textured sandy soils.
- Where N fertiliser is applied regularly and at high rates, depending on soil type, a proactive strategy of soil testing and liming may be required to prevent undesirable soil acidification.

Table 3 Lime requirement to neutralise the potential acidifying effect of N fertiliser

Form of N fertiliser	Amount of lime (kg lime/ha) needed to neutralise each 30kg N/ha applied
Ammonium sulfate (SoA)	160
Di-ammonium phosphate (DAP)	110
Urea	50

Source: Dairy Soils and Fertiliser manual in section 16: Further resources

12 The 4Rs of N fertiliser use on dairy pastures

The 4Rs are a nutrient stewardship framework: use the **right** fertiliser source, at the **right** rate, at the **right** time, and in the **right** place.

- **Urea is currently the cheapest pure SOURCE of N**. If P fertiliser is also needed at the same time, di-ammonium phosphate (DAP) is a cost-effective source of N. Assuming soil moisture is adequate for pasture growth, N losses from urea applications, via volatilisation, are usually not large enough to justify using other N sources.
- **Apply N at RATES of 20 to 50kg N/ha per application, no closer than 21 to 28 days apart**. It can also be useful to combine the daily equivalent rate by the interval between N applications (e.g. 1.5kg N/ha per day by 21 days = 32kg N/ha applied). During the peak growth period, with good soil fertility and newer cultivars, it may be justified to increase the rate to 2kg N/ha per day, limited to a maximum of 60kg N/ha in a single application.
- **TIME N applications for when pastures are actively growing and can utilise the N**. Ensure that soil moisture is adequate to sustain the regrowth, rainfall is likely or irrigation is available in the regrowth period, temperatures are conducive to good pasture growth, there is a good species composition and other major soil nutrients are non-limiting. All these factors will assist in reducing N losses to the environment. In addition, before each application, estimate the likely N response and compare the cost of the additional pasture produced to other purchased feed options.
- **PLACE N application where there is a high density of actively growing and desirable (i.e. sown) species**. Avoid areas where N responses are unlikely (near gateways, water troughs, shelter belts).
- **Ensure that the extra pasture grown is utilised either through grazing or as harvested forage, as utilisation has a big impact on the economics of using N.** If you feed the grass, your cows need to eat the grass!

13 Reference tables

Table 4 Nutrient content of commonly used N fertilisers

	Nutrient analysis (%)			
Type of fertiliser	**N**	**P**	**K**	**S**
Urea	46	0	0	0
Ammonium sulfate (SoA)	21	0	0	24
Di-ammonium phosphate (DAP)	18	20	0	0
Mono-ammonium phosphate (MAP)	10	22	0	0
Calcium ammonium nitrate (CAN)	27	0	0	0
Urea ammonium nitrate solution (UAN)	42.5(w/v)	0	0	0
Dairy effluent* (kg/ML)	150–500	50–150	200–600	50–300
Chicken shed litter*	3–6	1–2	1–2	<1

**N content can be highly variable, beyond these ranges especially for effluent, so test to ascertain nutrient content prior to applying to pastures and crops.*

Tips for using Table 4

- To convert kg product to kg of nutrient, need to multiply by the nutrient % as a decimal. For example, 100kg urea is 46kg N (i.e. 100 x 0.46), 100kg DAP is 18kg N (i.e. 100 x 0.18).
- To convert kg of nutrient to kg of product, need to divide by the nutrient % as a decimal. For example, 50kg N is 109kg urea (i.e. 50 ÷ 0.46), 50kg N is 278kg DAP (i.e. 50 ÷ 0.18).
- Remember the kg of product (urea, DAP etc) will always be greater than the kg of nutrient (N, P, K or S).

Break-even response to N fertiliser

The use of N fertiliser on pastures is one of a number of different options for providing additional feed on dairy farms. Other examples include hay/silage, grain/concentrates, fodder crops or by-products. It is important to estimate the cost of growing pasture with N fertiliser inputs, compared to the cost of alternative feeds.

Estimating the break-even response to N fertiliser is a relatively simple and effective way to make a more informed decision. This can be calculated from the price of the input (N fertiliser) divided by the price of the output (alternative supplementary feed) to determine how much extra pasture needs to be produced to cover the extra N fertiliser cost.

If urea costs $600/tonne applied and the price of an alternative supplementary feed was $250/t DM (25¢/kg DM) as fed, then a response of at least 5kg DM/kg N is required for urea to be the more cost-effective option (Table 5). An N fertiliser response rate less than 5kg DM/kg N makes supplementary feeding a cheaper option, assuming the supplementary feed has a similar feed quality (energy and crude protein) to fertilised pastures. As supplementary feed prices increase, the N response rate required diminishes.

Table 5 Response rate required to break even

		Supplementary feed price ($/t dry matter)			
Fertiliser price		100	250	350	500
Urea ($/t)	**$/kg N**	**Response required to break-even** (kg DM/kg N*)			
400	0.87	9	3	2	2
600	1.30	13	5	4	3
800	1.74	17	7	5	3
1,000	2.17	22	9	6	4

**$1.30/kg N fertiliser divided by $250/t DM and multiply by 1000 (converts $/t DM to $/kg DM) gives a break-even response rate of 5.2kg DM/kg N.*

14 Glossary

4Rs a nutrient stewardship framework: the right fertiliser source, at the right rate, at the right time, and in the right place.

ammonia volatilisation a chemical process that occurs at the soil surface when ammonium from an ammonium-containing fertiliser, or one that breaks down to ammonium (e.g. urea), is converted into ammonia gas and lost to the environment.

ammonium a positive charged inorganic chemical (NH_4^+) found in N fertilisers (e.g. ammonium sulfate) and is converted into nitrate by soil microbes (see nitrification).

best management practices (BMPs) a range of management practices to achieve the best outcome, such as optimising pasture production or minimising nutrient loss (see 4Rs).

denitrification breakdown of nitrate (NO_3^-) into nitrous oxide (N_2O) and di-nitrogen (N_2).

enhanced efficiency fertilisers (EEFs) fertiliser product that can reduce nutrient losses to the environment while increasing nutrient availability for the plant or crop. These products can either slow the release of nutrients for uptake or alter the conversion of nutrients to other forms that may be less susceptible to losses.

hydrolysis chemical decomposition by which a compound is converted into other compounds by taking up the elements of water (hydrogen and oxygen).

immobilisation of N conversion of inorganic forms of N (such as ammonium and nitrate) into organic forms of N by microbes in the soil or plants, by which the N unavailable to plants (opposite to mineralisation).

mineralisation of N release of plant available N from soil organic matter into inorganic forms of N by soil microbes (opposite to immobilisation).

nitrate chemical (NO_3^-), nitrifying bacteria in the soil convert ammonium into nitrate as part of the N cycle.

nitrate leaching movement of nitrate beyond the pasture rootzone in drainage water.

nitrification the breakdown of ammonium into nitrite and then nitrate in the soil.

nitrification inhibitors chemical products which can reduce the rate of conversion of ammonium to nitrate, potentially reducing leaching and denitrification losses. Examples include 3,4-dimethylpyrazole phosphate (DMPP; Entec®), dicyandiamide (DCD; N-Protect™).

nitrogen response amount of additional herbage DM production as a proportion of applied N fertiliser inputs (kg DM/kg N).

nitrogen use efficiency NUE; a measure of conversion response of N inputs (fertiliser, supplementary feed, N fixation) into N outputs (milk, meat, manure). NUE can be estimated at a range of scales. Feed NUE: N excreted in milk as proportion of N consumed. Pastures NUE: amount of additional DM production grown as a proportion of additional N inputs (kg DM/kg N). Whole-farm NUE: amount of N exported off farm as a proportion of N imported onto farm.

soil acidification process where the soil pH decreases (becomes more acidic) over time.

surface runoff movement of water flowing over the land surface taking N, other nutrients and soil particulates

urease inhibitor chemical that temporarily reduces the activity of enzymes, slowing down the rate at which urea is hydrolysed, potentially reducing ammonia volatilisation. Examples include N- (n-butyl) thiophosphoric triamide (NBPT; Green Urea™).

15 Further resources

Dairy Australia's Fert$mart home page
fertsmart.dairyingfortomorrow.com.au

Fert$mart Dairy Soils and Fertiliser Manual
fertsmart.dairyingfortomorrow.com.au/dairy-soils-and-fertiliser-manual

NSW DPI Soils website contains a range of factsheets, booklets and videos on fertilisers, amendments and testing
dpi.nsw.gov.au/agriculture/soils/improvement

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