NITROGEN (N) FERTILISER USE ON DAIRY PASTURES

BEST MANAGEMENT PRACTICES

These were developed to ensure maximum nitrogen use efficiency (NUE), while also minimising avoidable environmental losses. Remember, losses of N are wasted input costs.

General guidelines for N management

- **Apply N strategically, rather than by a fixed recipe.** Before each N application estimate the likely N response (i.e. experience, consultants) and compare the cost of the additional pasture produced to other purchased feed options.
- **Only apply N when pasture is actively growing and can utilise the N.** Ensure that soil moisture is adequate to sustain the regrowth, rainfall is likely 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 (see Fert$mart guidelines for other nutrient requirements).
- **Apply N at rates of 20 to 50 kg N/ha per application, no closer than 21 days apart at the lighter rates and preferably at least 28 days apart at high rates.** It can be useful to multiply the daily equivalent N rate by the interval between N applications (e.g. **1.5 kg N/ha per day by 21 days = 32 kg N/ha applied**). During the peak growth period, with good soil fertility and newer cultivars, it may be justified to increase the maximum rate to 60 kg N/ha for a single grazing rotation in spring.
- **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. Likewise over-grazing of pasture can lead to delayed response to N in the following grazing rotation.

Right Rate

- The most efficient pasture growth responses occur when N fertiliser is applied at rates of between 20-50 kg N/ha at any one time. This is because the steepest response to N occurs at these rates and drops off as rates increase.
- Do not apply above 50 kg N/ha in any single application and do not apply N closer than 21 days apart, as this will increase N losses exponentially and may risk animal health. The exception may be on highly productive pastures, through their peak growth period, with a newer cultivar, and where soil moisture is not limiting, then pastures may respond to rates of 60 kg N/ha per application for a single grazing rotation in spring.
- Applying less than 20 kg N/ha in any single application will often produce unpredictable N responses i.e. 20 kg N/ha on 2 ha may produce less than 40 kg N on 1 ha. Likewise, 80 kg N applied to 1 hectare (80 kg N/ha) is likely to produce less pasture than applying 80 kg N to 2 hectares (40 kg N/ha) due to decreasing N responses on the flat part of the curve.

Right Place

- Apply N to pastures with a high density of desirable species. Ryegrass and kikuyu pastures will respond better to N than other less desirable pasture types or weedy pastures.
- Apply N to pastures with a good ground cover. Gaps or bare areas in pastures will result in more N lost through leaching, denitrification, run-off and volatilisation.
- Apply N to pastures that have no limitations to major soil nutrients. Regularly soil testing will establish the nutrient status of the soil and if other major nutrients or pH are limiting growth, these can be addressed before or at the same time as the N application (see Fert$mart guidelines **fertsmart.dairyingfortomorrow.com.au/farm-advisors/soil-fertility-guidelines/** for other nutrient requirements).
- Do not apply N to pastures that are drought stressed, or water-logged (i.e. where water is running off the surface), or where they will be grazed at less than 2.5-leaf regrowth stage (or canopy closure) for temperate grasses (e.g. ryegrass) and 3-leaf stage for tropical grasses (e.g. kikuyu and paspalum).
- Consider applying less N to the front half of a paddock than the back, as cows transfer N towards the gate.
- Avoid applying N to animal hot spots (e.g. gateways, water troughs, shelter belts, stock camps) as these areas have high N loading already and are prime N loss areas on dairy farms.

Right Time

- Apply N as soon after grazing as possible, as this is when plants need access to N for maximum regrowth potential.
  - As a rule, for every day you delay applying N post-grazing, you can lose 1% of the potential N response.
- Avoid grazing until growth has reached at least the 2.5-leaf stage (or canopy closure) for temperate grasses (e.g. ryegrass), or the 3-leaf stage for tropical grasses (e.g. kikuyu, paspalum), to maximise the nitrogen use efficiency, the energy: protein ratio in the diet and therefore the amount of N excreted or lost.
- Temperate pasture grasses (e.g. ryegrass) generally respond to N fertiliser when soil temperatures (at 10 cm) are above 4°C, and subtropical pasture grasses (e.g. kikuyu) respond to N fertiliser when soil temperatures are above 10°C. Remember, this is the average soil temperature at 10 cm over the regrowth period, NOT just on the day of application.
- Autumn and summer N responses on dryland pastures are highly dependent on adequate soil moisture.
  - Don't apply N unless there is adequate soil moisture in the root zone from either irrigation or rainfall, plus there is a good prospect of irrigation or rainfall to follow through the regrowth period (e.g. summer and autumn in southern Australia).
  - In southern Australia, following a wet summer with active pasture growth, there will be little N left in the soil at the autumn break, meaning there will be a reasonable response to applied N when the rains start. In contrast, if the summer is dry there will substantial mineralisation of soil organic N, but little pasture growth to utilise this, meaning a dry soil profile with plenty of left-over N leading to a poor response to applied N at the break.
  - In sub-tropical east coast Australia, a lower N response should be expected in late summer/autumn due to high amounts of soil organic N mineralisation and N application frequency and rates can be reduced accordingly. N losses are likely to be lower in the late winter/spring so higher rates can be applied.
  - Irrigation at the start of the season should commence before the soil water content drops below the Readily Available Water (RAW) zone, as it is difficult to bring the soil water back into the RAW zone for optimum pasture growth rate, thereby limiting the potential response to N fertiliser.

Right source

- **Urea** is currently the cheapest pure source of N.
  - Assuming soil moisture is adequate for pasture growth, ammonia losses from urea fertiliser are usually not large enough to justify the price per unit N of other sources.
  - If applying N to waterlogged soils, an ammoniated source (e.g. urea, ammonium sulfate) is better than using a nitrate source (e.g. Urea Ammonium Nitrate).
  - While liquid sources of N are typically as effective as solid N sources, if applied at the same rate of N, foliar uptake of N alone is unlikely to meet the N requirements of pasture.
- As **inhibitor coated fertilisers** cost more per unit of N and seldom produce additional pasture, they are only cost-effective if the N rate applied is reduced by the expected reduction in N loss. Urease inhibitors are only required in situations where high ammonia loss is expected, such as autumn on dryland systems (see Managing ammonia losses).
- Other **inhibitor coated fertilisers** demonstrate variable effectiveness. Nitrification inhibitors (e.g. ENTEC®) have been shown to produce similar yield responses with 20% reduced application rates on heavier soils after prolonged use. Currently available slow-release urea products (e.g. polymers) are not cost effective on dairy pastures.
- **Other nutrients:** The response to N will be limited by the availability of other nutrients. Ensure adequacy of macro (P, K, S) and micro-nutrients (e.g. Molybdenum), based on regular soil and plant analysis.
- **Di-Ammonium Phosphate (DAP)** is a cost-effective source of N, if the P is needed at the same time.
  - When using DAP, calculate the P rate required first then consider 'topping up' with urea to ensure an adequate N fertiliser rate i.e. 100 kg of DAP/ha will only apply 18 kg N/ha, which may not produce a predictable N response.
  - When applying N and P fertiliser together, defer to the Fert$mart guidelines for minimising run-off losses of P.
- **Sulfur (S):** Low soil available S can reduce the response to N. Ammonium sulfate or S blends can be a useful source of both N and replacing soil S, particularly where single-superphosphate has not been applied for a few years.
  - Ammonium sulfate is an expensive form of N and it will acidify the soil rapidly with regular use.
  - Sulfate can also leach out from free draining soils during high rainfall or irrigation, so only apply the S when needed and at the recommended rate.
- **Lime:** 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 soil acidification.

Other factors to consider

Soil N mineralisation

- Around 1-2% of organic N will be mineralised from soil organic matter annually (approximately 150 to 250 kg N/ha), but mainly supplied in the warmer months.
- In southern Australia, soil N mineralised and not utilised by the pasture over a dry summer means there will be surplus N in the soil at the autumn break; thus only apply N later in autumn once deeper soil moisture is adequate and pasture growth has resumed. As mineralisation of organic N is low in winter, N fertiliser will be required to maximise pasture growth.
- In subtropical regions, dry periods (3-6 weeks) in spring (October) or summer (January) can cause pasture growth to cease while N mineralisation continues, building available N in the soil. However, profitable responses to applied N are still possible where rainfall events exceed 75-100 mm, especially for producing silage.

Managing ammonia losses

- Ammonia loss is highest under hot, dry, windy conditions. Ammonia losses from urea are also highest during the first 48 hours after application, while the urea granule is breaking down to ammonia (called hydrolysis).
- As a general principle, ammonia volatilisation losses from urea should be small, if best practice is followed i.e. do not apply urea where soil moisture is limiting, especially on hot and windy days.
- Between the cooler, wetter months (May to November in southern Australia), or under irrigation in the sub-tropical annual ryegrass season, ammonia volatilisation losses from urea fertiliser are too small to justify switching to higher-cost N fertiliser sources. During this period, urea does not need to be watered into the soil – assuming there is enough soil moisture, rainfall or irrigation to justify the N, as urea will be able to absorb enough moisture to dissolve.
- Ammonia volatilisation losses in summer average around 10 to 15% under dryland conditions, which still does not economically justify switching to other more expensive sources of N. Avoid applying urea fertiliser the day after a rainfall event during periods when potential evaporation is high (e.g. hot, dry and windy), as this may increase volatilisation losses above 30%. Under these conditions, irrigating after urea application will greatly reduce ammonia loss.
- If urea fertiliser is applied in drier periods without irrigation (November to March in southern Australia) you can apply the urea 2 to 3 days prior to grazing to minimise wind speed at ground level and reduce ammonia volatilisation during the critical loss period (first 48 hours). Care must be taken to avoid cows ingesting lumps of fertiliser as this could lead to ammonia toxicity.

Managing ammonia losses – spray irrigated pastures

- Apply N fertiliser within 24 hours prior to spray irrigation.
- In summer, where evaporation is high, avoid applying urea fertiliser after irrigation as this is likely to increase volatilisation losses.

Managing ammonia losses - flood irrigation

- Urea is best applied just before irrigation but minimise run off into drains, as this will carry dissolved urea. In some cases, not fertilising the last few metres of the irrigation bay can capture the urea dissolved in the irrigation head water.
- If urea fertiliser is applied after flood irrigation, soil moisture should be adequate to dissolve the urea and minimise volatilisation, but avoid wheel damage to the wet soils.

Minimising nitrate leaching and denitrification

- Avoid applying N fertiliser to warm (>10°C), waterlogged soils, as this increases the risk of N loss through denitrification.
- If applying N to cold (<10°C), wet soils use urea or ammonium based fertilisers and avoid nitrate based fertilisers (e.g. UAN).
- Avoid applying N fertiliser near streams/riparian zones and over drainage lines within a paddock.
- If irrigating, take care to avoid overwatering, as this may result in nitrate leaching and run-off of dissolved urea, as well as inefficient water use.
- Avoid applying high rates of N fertiliser to free draining soils during periods of high leaching potential (e.g. high rainfall).
- Use of nitrification inhibitors may be warranted in high drainage or waterlogged sites to prevent N losses to the environment (nitrate leaching, gaseous loss by denitrification).

Minimising surface runoff losses

- The volume of water lost as runoff determines the N lost in runoff – avoid overwatering and surface runoff.
  - Use a weather forecast to minimise runoff after N application. When soils are saturated, wait at least 2 days after rainfall for excess run-off water to drain, before applying N.
  - Where possible, re-use drainage water.
- Do not apply N fertiliser near drains, channels, dams, lakes or riparian areas. In a hump and hollow, avoiding applying N to the hollow as this is likely to receive N through surface movement anyway.

Dung and urine management

- Minimise the time that cows spend in the laneways and ensure that runoff from laneways, feedpads, sacrifice paddocks or other standoff areas drain to pastures and not directly into waterways.
- Effluent should be viewed as a valuable fertiliser resource, and nutrient testing should be used to ensure that no more than 50 kg N/ha is applied to a pasture at a time.
- High stocking density will result in high losses of N from hot spots in the farm.

Animal health and nitrogen

- Avoid high rates of N fertiliser on annual ryegrass and kikuyu, as these can accumulate potentially toxic levels of nitrate. Perennial ryegrass, fescue, cocksfoot and white clover are not known to accumulate toxic levels of nitrate.
- If nitrate toxicity is of concern, do not graze pastures 7 to 14 days after N fertilisation or if water-limited as nitrate levels increase in water-stressed plants. Likewise, do not graze pastures 14 to 18 days after N fertilisation if pastures are high in crude protein (e.g. spring or autumn with high N fertiliser rates) and animals are not receiving an energy supplement or lower quality hay or silage to counterbalance the high N in the pastures.
- Do not apply more than 60 kg N/ha in a single application, particularly with higher pasture growth in autumn and spring.
- Avoid subjecting cows to rapid diet change e.g. from low to high quality pasture, or to pasture with 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.