Strategic nitrogen use: viewing nitrogen as a feed supplement, not a fertiliser

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The traditional approach taken by most extensive graziers in Southern and Central West New South Wales is for productive legumes to provide the nitrogen needs of pastures. In systems with low stocking rates, the nitrogen generated from legumes is usually sufficient for the level of production required. However, as the stocking rate increases and more animal products are removed from the farm, pastures can quickly become nitrogen deficient at certain times of the year.

Plant available nitrogen in soils is present in the inorganic form (as ammonium or nitrate) and is usually less than 1% of the total soil nitrogen. Much of the plant available nitrogen comes from the breakdown or mineralisation, of the organic nitrogen by soil micro-organisms. The process of mineralisation, plant uptake rates and losses of nitrogen vary greatly, even from day to day.

Any factors limiting plant growth, such as temperature and moisture also restrict the ability of plants to respond to nitrogen. The soil temperature around plant roots generally has more impact on plant growth than air temperature.

These issues are critical when developing a fertiliser strategy, alongside whole farm issues such as production targets and the production capabilities of different paddocks. In many cases the landscape determines the productive potential of paddocks. For example, steeper hill country with more skeletal shallow soils and a lower nutrient status will be the first to dry out and hay off in late spring or early summer and will generally have a lower productive potential than the slopes and flats, which have deeper soils, better water holding capacity, and better inherent fertility.

These two issues (the potential of the land and the aspirations of the farmer) will greatly influence the targets set for soil fertility and any decision to lift productivity by using strategic nitrogen.

If the aim is a low risk, lower production system, perhaps based on native pastures and a responsive legume and an annual application of 125 kg of single superphosphate, then the target nutrient fertility will be different to that of the paddocks on the gentler slopes or flats with higher productive potential, where an intensive finishing operation may be an option.

Many farmers are more cautious about deciding to run a high output or high performance system.

Rather than taking a whole farm approach, one of the most successful ways to use strategic nitrogen is in small increments, on one or two paddocks with recently sown fescue or ryegrass pastures which can be more intensely managed.

This paper reviews current knowledge about the transformations and movement of nitrogen in the soil and how nitrogen fertilisers can be used with confidence to boost feed availability at critical times of the year when soil nitrogen from legumes is insufficient.

Boosting feed availability at these times can help improve animal performance and lift stocking rates, thus helping increase production per head and per hectare for the total year.

We recommend focusing on parts of the farm that have better moisture holding capacity and the ability to physically support greater stock numbers. Simply the greater grazing pressure required through the peak of spring growth would, in most cases, be inappropriate for the steeper parts of the landscape.

Legumes

Typically, nitrogen is added to the soil system through biological nitrogen fixation by legumes (see Figure 1). Legumes like white clover or sub-clover can fix between 0 and 250 kg N/ha per year. To achieve anywhere near this upper limit, clover would have to comprise at least 30% of the pasture and would require a warm wet winter and wet

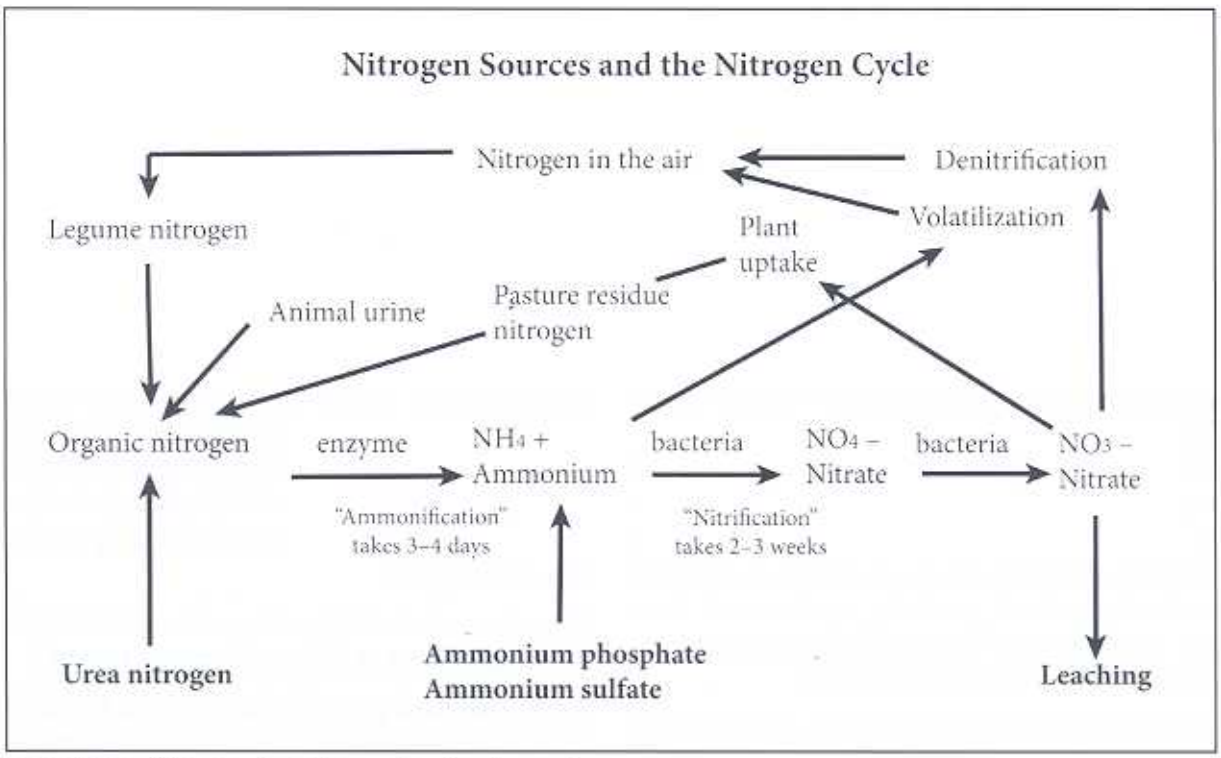


Figure 1: The nitrogen cycle in legume based pasture systems

spring/summer. Clovers are sensitive to a range of pests, low temperatures and soil fertility. Therefore most of Southern Australia's pastures are probably only fixing between 30 and 100 kg N/ha annually. (Eckard and Franks,1998)

Non symbiotic nitrogen fixation by free living or associative bacteria

Legume-fixed nitrogen is subject to a number of transformations. It can be consumed by animals, remain in standing pasture or be "leaked" to the soil. Most of the nitrogen consumed by animals is returned to the soil system either as urine or faeces. The rates of nitrogen in urine compared to faeces are typically season dependent and related to feed quality and water intake.

About 30% of the nitrogen consumed stays within the body of sheep grazing in the Mediterranean climate of Australia. Barrow and Lambourne (1962) concluded that sheep eating low nitrogen content feed (1.5%) excreted 45% of nitrogen in urine, while sheep eating high nitrogen content feed (3%) excreted and 80% of nitrogen in urine, with only 30 to 40% of this eventually taken up by plants. (Whitehead 1970) The effective nitrogen application rate within a urine patch can be between 600 and 1,600 kg N/ha in well-fertilised dairy pastures. (Eckard and Franks, 1998)

While urinary nitrogen is mainly in the form of urea, the spatial distribution of this nitrogen is such that a paddock is only fully covered in this manner at least once every 3 to 4 years.

Organic N

Plant residues and soil organic matter are subject to decomposition, producing ammonium nitrogen in the process of ammonification. Ammonium nitrogen is assimilated by soil micro-organisms (immobilisation) and nitrogen is retained in the microbial biomass before it is ammonified. A specialised group of micro-organisms (nitrifers) use ammonium nitrogen as an energy source and produce nitrate in the process known as nitrification.

Soil nitrogen from decaying roots and other organic matter can contribute as much as 100 to 250 kg/N /ha per year to the pasture. This process of mineralisation is affected by temperature, being much slower as soil temperatures drop below 10 degrees C.

Clover nitrogen fixation also becomes negligible at 10 degrees C. However, most of our temperate winter active grass species can continue to grow at soil temperatures down to around 2 to 3 degrees C. This means that most of our higher producing pastures will be deficient in nitrogen from

legume nitrogen fixation between May and early September.

Plants take up the majority of their nitrogen in the nitrate form.

Because of its increased mobility in soils, nitrate can also be displaced below the rooting depth of some pastures and crops as a result of percolation of rainwater or irrigation through the soil – the process of leaching.

In waterlogged conditions, soil micro-organisms convert nitrate to gaseous forms such as nitrous oxide which are lost to the atmosphere.

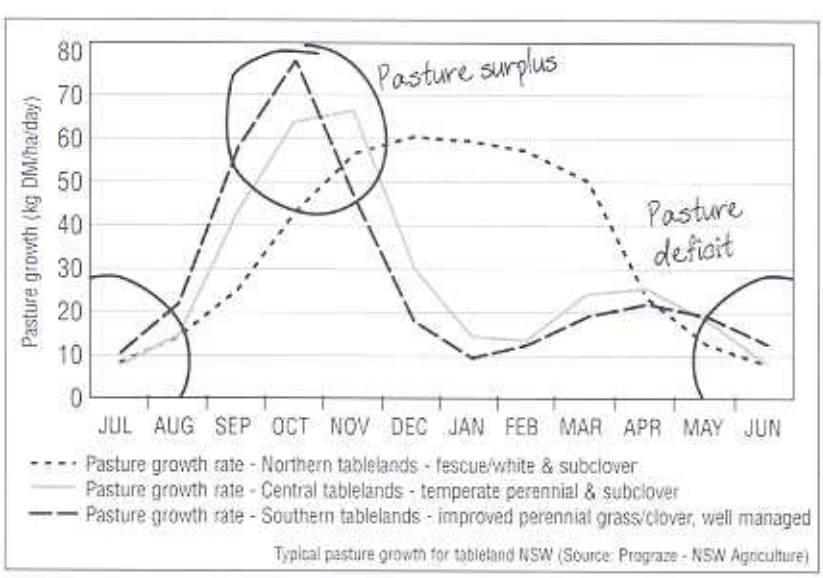
Volatilsation of ammonia (NH3) from the soil surface can cause the loss of nitrogen from applied urea and urine. Soil pH, urease activity, soil water content and the presence of surface trash all influence the rate ammonia loss.

The vast majority of pasture analysis suggests that pastures are overgrazed and under utilised. They are grazed too heavily in winter (particularly immediately after the break) and not heavily enough in spring (see Figure 2).

The average utilisation of improved pasture grown on beef and sheep properties has been estimated at about 30%. This low apparent number can be attributed to the natural spring bulge and a lack of confidence to take on more stock during the recent extended dry periods.

I am going to highlight some ideas for graziers considering increasing their productive potential from increasing pasture growth before the spring.

Figure 2. Increasing pasture consumed



Pasture planning does not have to be complicated.

Pasture planning is managing the feed supply to meet the target levels of beef/lamb/wool and the nutritional requirements of the herd or flock.

The biggest differences in productivity and income between extensive and intensive systems come from the level of production and the continuity of supply. It's about asking "how much is needed" and "when".

Feed planning can help graziers achieve maximum farm productivity and profits by balancing feed quality and quantity against production for the whole year. Pastures are the cheapest way to feed cattle and sheep for most graziers. To make better profits from a pasture-based farm, the pasture has to be managed with targets in mind.

Farm plans are personal long-term plans that set targets for pasture and animal production from the whole farm. They should consider herd size, calving /lambing patterns, market strategies, farm development opportunities, the current pasture and cropping base and opportunities for improvement.

Feed budgets are medium-term plans that examine management alternatives to overcome feed imbalances and make the best use of pastures, supplements and conserved feed.

Grazing plans are short term plans that maximise pasture production and use through various pasture and grazing management strategies.

Pasture allocations are carried out on a day to day basis to satisfy the herd or flocks needs and decide which gates to open and which to shut.

A useful guideline is to aim to grow more feed in autumn, not in the dead of winter.

This is defined as the seasonal response. It recognises that most of the natural sources of nitrogen will be limited from May, so planning a nitrogen application in April will improve cool season production.

The nitrogen response

Pasture responses to nitrogen fertiliser at this time of year

(i.e. applied in April) can range from 5 -12 kg of additional grass produced for every kilogram of nitrogen fertiliser applied. For example, 46 kilograms of nitrogen from fertiliser (100 kg of urea) applied to 1 hectare at a 10:1 response should yield an additional 460 kg DM/ha pasture growth.

To ensure a 10:1 response, graziers can use the following principles to target times of the year and paddocks that will give the best return.

Soil temperature

- Ryegrass and introduced improved grass pastures respond to nitrogen as long as soil temperatures are above 4 degrees C.
- White and sub clover effectively stop growing and fixing nitrogen below 10 degrees C.
- Avoid nitrogen application during extreme temperatures and during times of moisture stress.

Soil moisture

- If the pasture is moisture stressed, the nitrogen fertiliser response will be restricted. Likewise, prolonged waterlogging can reduce pasture response.

Soil fertility

- If other soil nutrients are limiting growth then the response to nitrogen will be limited.

Pasture species

- Annual, short rotation and perennial ryegrass and the latest fescues respond most efficiently to nitrogen.

Grazing management

Response to nitrogen is lower after "hard grazing"

- (< 1300 kg/DM/ha on offer). Nitrogen is most efficiently applied soon after grazing as long as the pasture has some green leaf (i.e. 1300-1500 kg Dry matter per hectare, typically 4-5 cm height).
- Do not allow pastures to become rank. Rank pastures are inefficient at utilising nitrogen.

Nitrogen fertiliser response

To assess the economics of applying nitrogen, the figures in Table 1 can be taken as a guide. All will vary according to seasonal and price fluctuations. For example, at current prices for urea, nitrogen costs approximately $1 kg. Applying 1 kg of nitrogen will produce 15-20 kg DM pasture in a ryegrass fescue at Moss Vale on the Southern Highlands in Autumn or Spring. This extra pasture can be said to cost between 5 and 7 cents.

The value of this additional feed can only be realised if efficiently converted to beef or lamb.

Cost comparisons with other feed supplements shows that creating extra pasture growth with nitrogen is often the most economical option.

Percentage return on investment in nitrogen fertiliser

See Table 2. Yield responses are highest in spring and autumn and lowest from applications made in winter. On the South Coast of New South Wales and also in the high cold production areas of Mossvale /Bowral and the Tablelands, perennial ryegrass yields are at a maximum in the 5 to 6 weeks after applications made in autumn and winter. Yields

Table 1. Nitrogen fertiliser response (c/kg N)

	5 kg DM/ha	10 kg DM/ha	15 kg DM/ha	20 kg DM/ha
$1.00/kg N	20	10	7	5
$1.20 kg N	24	12	8	6
$1.40 kg N	28	14	9	7

Table 2. Percentage return on investment in nitrogen fertiliser

	5 kg DM/ha	10 kg DM/ha	15 kg DM/ha	20 kg DM/ha
$0.60/kg N	67%	233%	400%	567%
$0.80/kg N	25%	150%	275%	400%
$1.00/kg N	0	100%	200%	300%
$1.20/kg N	-17%	67%	150%	233%

Always target a 10-20 kg/ha response to nitrogen applied

increase 57% when the grazing interval is increased from three weeks to four and 171% when it is increased from three weeks to five weeks. (Getting value from your fertiliser 1994. Sth Coast Harry Kemp. Sth Coast District Agronomist)

The Italian ryegrass, Concord, is still very popular and yield responses obtained in 1989 were similar. Increasing the grazing interval from three to four weeks increased yield by 86% and from three to five weeks 239%.

Late autumn, winter and early spring is the period of the year when "natural" sources of nitrogen are most limiting, yet the grass component of the pasture can grow. Pasture responses to nitrogen fertiliser at this time of the year range between 5 and 12 kg of additional grass produced for every 1 kg of nitrogen fertiliser applied.

Graziers who learn how to improve the response to strategic nitrogen have the potential to fill feed deficits that occur in their animal enterprise.

High levels of utilised pasture begin with managing the pasture and soil resource to get the best results.

Pasture management issues like maintenance of soil fertility, control of pests and diseases and choice of species will control what the pasture will produce. Grazing management and fodder conservation control how much of that pasture is utilised.

This strategic nitrogen approach allows graziers to reduce costs and increase profits by:

- Reducing feed shortages and avoiding the underfeeding of animals.
- Maximising the use of surplus feed, normally in the spring.
- Increasing pasture production by using a paddock by paddock approach.
- Optimising the use of pastures and supplements that complement the feed base.
- Using feed tests to critically assess the value of your home grown forage.
- Using CRAFT (Choice, Rate, Application, Frequency and Timing) on fertilisers, recognising that every paddock on the farm is different, recording paddock performance and maintaining your production potential.

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Further Reading

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