Nitrogen decisions for winter cereals 2022

Take-home messages

- Knowing the potential responsiveness of paddocks is the key to making the most of N. High responsiveness = lower risk, and best returns
- Standard N budget rate is likely to be similar to rates calculated, taking into account the N higher price to grain price ratio in high responsiveness paddocks for 2022 but as responsiveness reduces, the rate of discount of budgeted N rates increases.
- Just focusing on the economic maximum rate of N in the longer term may negatively impact the productivity of cropping systems based on soils with plant available water capacity >75 mm.

The challenge:

With more than doubling of urea price recently, the importance of driving plant productivity with manufactured fertiliser nitrogen has and will continue to come under closer scrutiny. Although, to some extent, increased urea prices may have been buffered by the favourable winter crop yields and commodity prices in 2021. The more significant issue for 2022, and maybe beyond, will be the ability to purchase fertiliser supply as required, making sure the available product is applied to areas where it will have the highest positive impact on profitability and without compromising longer-term productivity.

Where soil nitrogen is in short supply relative to plant available water in cereal and oilseed crops, yield and grain quality deficits reduce profitability. Conversely, where nitrogen supply exceeds the requirement to achieve a water-limited yield, the return on nitrogen investment can quickly become small or even negative. Therefore, matching nitrogen availability and water supply is critical in cropping. This means every kilogram of product needs to be applied where and when it will generate the best return. However, strict economic rationalism, i.e. using N at less than replacement rates because the economic maximum rate of N (EMRN) is lower than replacement, may not be a good choice in soils with greater than 75 mm of plant available water capacity (PAWC) if supply and price conditions continue. Running down the soil N bank in soils with higher PAWC and generally higher mineral N retentions is a self-defeating strategy in the long term, particularly in soil with limited soil organic N reserves and a low frequency of legumes, a low level of mineral N and continuously cropped.

What changes are needed when calculating an N budget rate with the higher N cost in 2022?

The standard N budget was created in the late 1990s to work within a defined set of conditions that were prevalent at the time. Significant variation from the previous standard conditions such as

- decreased contribution from the soil organic N pool to mineralisable-N
- change crop residue C/N ratio in rotation crop species
- more significant seasonal swings in the soil mineral N pool at sowing
- N application tactics
- increase in continuous cropping and decrease on pasture leys
- N price to grain price ratio

all have the potential to significantly change the relevance of the simple "rules of thumb" N budget to calculate N requirements. The use of 50 % NUE in N budgets is a case in point.

Changes to soil pool size and contribution to crop uptake vary by up to 100 % in circumstances that are becoming more frequent. This possibly explains some of the more frequent poor alignment between budget rate and crop performance experienced recently (Table 1). Using more appropriate NUEs in more extreme soil pool conditions can improve N allocation across the farm and help save costs when the N price/grain price (Np/Gp) ratio is high. In the past 10 years, the N price to grain price ratio has been in a band between about 2.5 and 5 /1. At the time of writing, the prospects for 2022 were that this ratio would be in the range of 8 to 10/1, i.e. it would take 8 -10 kg of grain to pay for 1 kg of N.

Table 1 – Four scenarios showing the effect of the contribution of the four main soil N pools to total crop pant uptake (as determined by pools size and its uptake efficiency) on the NUE used in standard N budgets.

	Nitrogen source								
	Soil organic N		**Plant residue organic N**		**Mineral N**		**Fertiliser N**		**Average NUE**
Scenario	% of total pool	% efficiency	% of total pool	% efficiency	% of total pool	% efficiency	% of total pool	% efficiency	%
Standard	20%	70%	5%	70%	40%	60%	35%	30%	**52%**
High mineral N good distribution	20%	70%	10%	70%	60%	60%	10%	30%	**60%**
High SON (new soil)	50%	70%	10%	70%	30%	60%	10%	30%	**63%**
Exhausetd soil	5%	70%	5%	70%	15%	60%	75%	20%	**31%**

This means that the margin for error in fertiliser N use in 2022 is smaller. The most productivity and lowest risk application will be associated with paddocks with the highest responsiveness to N. Closer scrutiny of the NUE number used in the N budget equation is a start to ensuring fertiliser N is applied at rates in closer alignment to the prevailing soil N pool conditions.

How do I know how responsive my paddocks are?

Firstly, look at the grain protein achievement in cereal crops last for 2021 harvest. Low protein in 2021 (<10.5 % for wheat) suggests that if the soil profile is full at crop establishment in 2022 and we receive at least average GSR in 2022, these paddocks are highly likely to be very N responsive (>20 kg grain/ kg N uptake from fertiliser). Grain protein between 10.5 and 12.5 % are likely to be moderately responsive and above 12.5 % low or no response. Of course, soil residual available N at harvest (as indicated by high grain protein) may not necessarily mean soil N will be available at sowing in 2022, particularly after a waterlogging or weedy summer fallow.

A second approach to identifying the most responsive areas is to calculate the soil available N (soil mineral N + in season mineralisation) to seasonal plant available water (PAW) ratio. This ratio has been found quite robust in describing N adequacy relative to seasonal plant available water (fallow stored + GSR) (Sadras et al. 2016, Dalal et al. 1997 and French and Schultz 1984). The more responsive paddocks cab broadly be described as those having more than twice as much crop available water than soil available N (Table 2).

Table 2 – N response classes as determined by soil N/PAW ratio.

N Response	Soil N/PAW (kg N/mm)
High	< 0.5 (10.7 % GP)
Moderate	0.5 – 0.7
Low	> 0.7 (14 % GP)

For example
Stored soil water at sowing = 60 mm
GSR = 300 mm
Seasonal PAW = 360 mm
Highly response if seasonal soil N supply < 180 kg/ha
Low response if seasonal soil N supply > 250 kg/ha
Water limited yield potential (F&S) ~ 5 t/ha

What are some fundamental N management options?

There is a range of broad options to put together an N strategy for 2022, but making it real will depend on factors that can only be determined by an enterprise owner. Available funding, long term soil goals, attitude to risk are all factors that need to be considered together with the options to calculate N application rate and application tactics. Some of the options include:

- Continue as usual – use the standard N budget to guide how much N is applied to paddocks.
- Continue as usual – use N budget to guide where and how much N is applied to paddocks, but lean more on potential soil N mineralisation capacity where not usually included in N budget to guide fertiliser rate reduction.
- Use the N pools contribution budget approach.
- Calculate EMRN (economic maximum rate of N) and apply the suggested rate
- Calculate EMRN but use replacement rate where EMRN< long term average N replacement
- Apply at long term average N removal rate
- Variable-rate N using one of the above to guide calculation rates or use proximal or remote sensed data fed into N rate algorithms.
- Change crop species balance to favour species that don't require N, require less N or have a more favourable N price/ grain price ratio.
- Change the enterprise cropping/ livestock balance if livestock prices are attractive.

What effect does a higher N price/grain price ratio (Np/Gp) have on fertiliser N budget application rates?

For at least the last 20 years, the Np/Gp ratio for most cereal crops has varied from 2.5 to 5/1. In a recent exercise, I compared N budgeted rates vs the economic maximum rate for scenarios with Np/Gp at 3.7 (representative of 2021) and 9.3

(possible outcome for 2022). Also considered were High, Moderate and Low crop N response scenarios (Figure 1) to understand how the significantly higher Np/Gp ratio might impact N recommendation for a "representative" situation. Starting soil N varied from 60-120 kg/ha across response scenarios, and the maximum site yield was about 3.5 t/ha. Responsiveness scenarios were characterised as

Low = 6 kg grain/kg N applied

Moderate = 12 kg grain/kg N applied

High = 15 kg grain/kg N applied

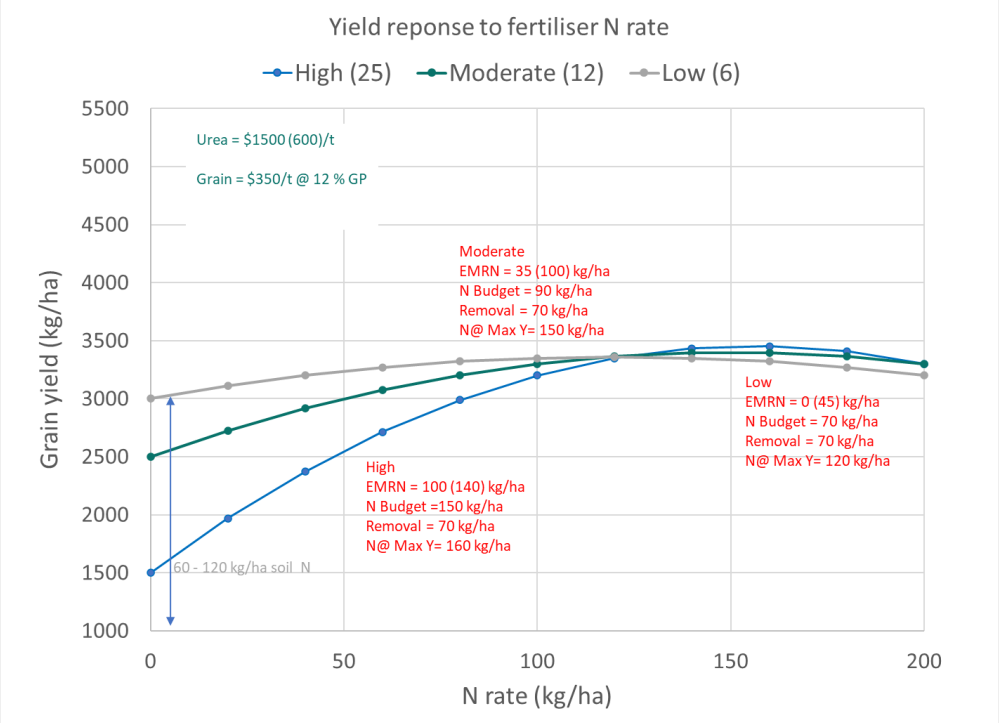

Figure 1 – comparison of N application rate based on different methods of calculation for three nitrogen responsiveness scenarios

The broad take-home messages were

- There was reasonable alignment between the calculated N Budget rate and the EMRN when the NP/GP ratio was in the range 2.5 - 5/1 (urea price and EMRN in brackets) for the high and moderate responsiveness scenarios. The N budget rate was more related to N removal than EMRN in the low responsiveness scenario.

- Where the Np/Gp ratio was 9.3, there was a larger difference between the N budgeted rate and EMRN; the variance increased with reducing responsiveness.
- In the High response scenario, the N Budget rate needed to be reduced by about 30 % to reflect the high Np/Gp ratio. In contrast, the N Budget rate was reduced by 65 % in the Moderate scenario. For the Low scenario, no rate of N was economic.