Multiple factors impacting nitrogen decisions

KATHERINE MAITLAND

Timing, rate, source and placement are all key factors when aiming for nitrogen efficiency.

According to Rob Norton, Regional Director Australia and New Zealand for the International Plant Nutrition Institute (IPNI), grain growers need to develop a flexible nitrogen management strategy to get the best results for their cropping systems.

There are, he explains, different dimensions of nutrient use efficiency (NUE) and farmers need to ask critical questions to achieve the most effective and efficient nitrogen uptake in crops.

"Because nitrogen use on grain crops has now become a tactical issue in response to seasonal conditions it is always a topic of conversation," Dr Norton said. "Some growers worry that they skimped and missed yield, while others may think that what they applied either did not work or gave only a small response. Others worry that there were big losses in what they applied so they wasted a lot of the nitrogen.

"These tactical issues need to be considered within the general approach of a soundly based and regularly reviewed nitrogen budget. Making and reviewing yield estimates is critical, as the yield potential will be a function of the nitrogen demand in rain-fed environments. The budget should include nitrogen obtained from the soil as well as fertiliser nitrogen and take account of the efficiency with which the nutrient gets to the crop.

"Knowing exactly how much nitrogen (N) is already in the ground and in the grain and what is taken out of the ground via production of a crop is vital for effective nitrogen management," he said.

DR NORTON, REGIONAL DIRECTOR FOR THE INTERNATIONAL PLANT NUTRITION INSTITUTE.

"System-level efficiency can be measured using a partial nutrient balance (N removed in grain/N applied) and partial factor productively (grain produced/N applied). The measurements are partial because they deal only with fertiliser input and nutrient removal in grain and do not consider other input pathways (nitrogen fixed by legumes, nitrate from rainfall, mineralised nitrogen from organic materials) or loss pathways (nitrification/denitrification, leaching, ammonia volatilisation, 'tie up' in organic materials).

Dr Norton says these factors are all important in the decision process of timing, rate, source and placement that will help farmers improve the effectiveness and efficiency of their N use.

TABLE 1. RESPONSES OF WHEAT (CV. YITPI, 2001, LONGERENONG) TO 20 KG N/HA APPLIED AT DIFFERENT CROP STAGES, RELATIVE TO NIL ADDED N.

RESPONSES		N APPLIED AT:				
	Nil N	GS31	GS42	GS65	GS72	LSD p>0.05
Yield (t/ha)	3.31	3.94	3.23	3.29	3.14	0.31
Protein (%)	8.6	9.4	10.4	9.8	8.9	0.4
N recovered (kg N/ha)	50	65	59	57	49	
% recovery		75%	44%	33%	-4%	

Timing

Applying N prior to seeding or early in the season is common practice but Dr Norton says this is not the best strategy because growers don't know how the growing season will develop.

"The earlier nitrogen is applied, the larger the yield increase. The later nitrogen is supplied, up until flowering, the larger the protein increase. Applied nitrogen will most affect the tissue that is actively growing at that time. Early nitrogen application stimulates shoots or tillers while later nitrogen application can increase stem growth. Once active stem growth slows, nitrogen can be used in grain filling but the contribution to yield is small.

"The other aspect is timing relative to rainfall. Most growers try to time application of urea ahead of rainfall so loss of nitrogen as volatilised urea is reduced."

Rate

The critical question is whether or not the crop is nitrogen limited, he said.

"Unless the crop is nitrogen limited there will be no response to N fertiliser and so a low efficiency," he said. "Reviewing nitrogen budgets with yield estimates from models such as Yield Prophet is useful to estimate demand, and supply from deeper in the soil or mineralised nitrogen is also important.

"The rate can be based on having adequate nitrogen in the crop by anthesis to match yield and protein targets. A 3.5 t/ha grain yield will probably come from a biomass at anthesis of 7 t/ha. To meet an 11% protein target a crop should have access to around 120 kg/ha of nitrogen. If post-anthesis growing conditions are better than expected the nitrogen in the system will be diluted by the extra growth and grain protein will decline. If conditions worsen during the growing season grain protein increases. The yield response will depend on the nitrogen rate closing the gap between the target demand and expected supply, neither of which we know in advance, so there is some luck involved in the outcome.

Source

Numerous trials and comparisons have found little difference between different sources of applied nitrogen including urea and UAN.

"For surface-applied nitrogen, two experiments showed losses to ammonification from urea (23%), urea/ammonium nitrate (12%) and sulphate of ammonia (12%) for nine days between application and light rainfall on an alkaline vertosol," he said. "A similar earlier experiment showed that the loss of nitrogen applied as urea can be reduced from 10% to 1% through the use of a urease inhibitor, although the efficiency of this reduction was reduced at higher temperature and higher soil organic carbon content.

"In a trial at Birchip, in 2013 nitrogen uptake from UAN (applied using streaming nozzles), urea solution (flat fan nozzles) and dry urea (top-dressed) was similar 10 days after application at GS31 but by anthesis the UAN and dry urea treatments had more nitrogen in the crop than those that received the urea solution. By maturity there were no yield differences but the UAN and dry urea crops had higher grain protein contents than where the urea solution was used.

"In my opinion there would need to be compelling circumstances pointing to expected high losses to justify moving away from top-dressing urea as the season unfolds.

"Applying nitrogen in crop isolates it from losses due to ammonification, denitrification and leaching, so if the crop really needs nitrogen it can access it with minimal loss. Putting all the nitrogen on up front seems efficient but this is when seasonal conditions are least known and demand is still being formed, so the only rate decision can be adjust up, not down. It is also important to be aware that nitrogen fertiliser, especially urea, placed in the seed-row can result in poor establishment due to damage to germinating seeds, particularly where growers are using wide rows and narrow points in dry conditions on light soils."

Placement

In-crop application will determine the effectiveness of the source of nitrogen, Dr Norton said.

"Inter-row banding pre-crop or side-banding in-crop are attractive options because they bury the nitrogen, but the technologies around this require more refinement.

TAKE HOME MESSAGES

- Top-dressed urea as the season unfolds will usually be the most efficient way to apply nitrogen fertiliser.
- Use N-rich strips to assess the likelihood of responses to nitrogen fertiliser.
- Early N is generally used more efficiently, but the N source, rate, timing and placement all affect the efficiency with which a crop can access N.
- A system-level assessment of nutrient use efficiency (NUE) can be made using a partial nutrient balance (N removed in grain/N applied) and partial factor productivity (grain produced/N applied).

"Most fertilisers applied in crop are applied over the top of the crop and most dry fertiliser applied in this way will end up on the soil, where urea will become ammonia, which can be lost, or plant-available ammonium or nitrate. Leaves can absorb inorganic and organic nitrogen sources, with small pores within leaf cuticles able to take up urea, ammonium and nitrate. These pores are lined with negatively charged molecules so they take up cations such as ammonium ions faster than anions such as nitrate ions. The uptake of small, uncharged molecules like urea can also be fast. Urea is commonly used for foliar fertilisation because it is uncharged, has high solubility and can be rapidly and efficiently absorbed by leaves.

"With fluid fertilisers such as urea or urea and ammonium nitrate solutions, some of the material will be intercepted by the crop canopy and some will hit the soil. Once on the soil the loss processes are the same as for dry fertilisers. Nitrogen on the canopy can be taken up through the leaves."

Foliar-applied nitrogen has been proposed as the most efficient method to present nitrogen and urea is rapidly and effectively taken up directly through leaf surfaces.

"Good coverage will maximise efficiency but crops are susceptible to damage from the urea itself and the salt effect of the solution. This urea toxicity will dictate the upper level for effective nitrogen uptake, which is probably around 10-15 kg N/ha depending on crop cover, ambient conditions and how it is applied. Streaming noz zles rarely place fluids on the inter-row rather the canopy, and while they can reduce canopy damage, they expose the material to soil surface losses under the canopy."

Dr Norton says N-rich strips are an effective way to monitor nitrogen levels in crop during the growing season.

"The first step in ensuring nitrogen is used efficiently and effectively is to ensure that other issues such as sodicity, salinity, acidity, other nutrients, pests, weeds or diseases are not the limitation. A simple way to do this is to use an N-rich strip in a paddock. This will serve as a reference for later in the season and give an early indication of whether additional nitrogen is giving a response and if further nitrogen could provide extra benefit."