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Denitrification contributing to crop N deficiencies in 2012: analysis using 'NBudget' and soil test data

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Introduction

Managing nitrogen (N) supply for cereal and oilseed crops remains a challenge for growers, particularly when the weather conditions are extreme. In the 2012 winter season, many wheat crops in the northern NSW grains region were obviously N deficient prior to flowering with many more likely to be marginally N deficient. The upshot was that proteins of grain delivered to the receival depots were generally low, e.g. 60% of wheat delivered to depots in the Dubbo zone had proteins of 10.5% or less (Brill *et al.* 2013).

Brill *et al.* (2013) speculated that the low grain proteins were a result of low soil nitrate levels, in turn due to:

- high grain yields of preceding crops
- low N contributions from N_2-fixing pulses
- depletion of residual nitrate deep in the profile
- denitrification losses
- insufficient inputs of fertiliser N.

It is likely that all of the above contributed to the crop N deficiencies and low grain proteins during 2012. In this paper, we examine the possible role of denitrification in more detail. It is not possible to simply measure denitrification in the field. Rather, we used 'NBudget', the NSW DPI CropMate-based N decision tool, to predict soil nitrate levels at sowing in 2012 for a number of experimental sites in northern NSW, then compared the predictions with measured values. We would discount denitrification as a loss factor if the predicted and measured soil nitrates were similar. If the predicted values were substantially higher than the measured values, we could reasonably suspect denitrification losses.

Site details

2012

Location:	**Bithramere**
Co-operator:	**Gavin Hombsch, "Hyland"**
Location:	**Blackville**
Co-operator:	**Joe Fleming, "Parraweena"**
Location:	**Gurley**
Co-operator:	**Scott Carrigan, "Murray Cumummualah"**
Location:	**Moree**
Co-operator:	**Paul and Charles Tattam, "Bonniedoon"**
Location:	**Tamworth**
Co-operator:	**NSW DPI (TAI)**
Location:	**Walgett 1 and 2**
Co-operator:	**Dave Denyer, "Wattle Plains"**

Key findings

Widespread N deficiencies of cereal crops were evident in northern NSW during the 2012 winter season, culminating in receivals of large amounts of low protein grain.

We used 'NBudget', the NSW DPI CropMate-based decision-support tool, to predict sowing soil nitrate levels for a number of the 2012 experimental sites and compared with measured values.

Greatest differences between predicted and measured soil nitrates were at the sites that either had the highest fallow rainfall or were inundated with floodwater, suggesting denitrification losses of N may have been a contributing factor.

Due to the difficultly in predicting denitrification losses, growers are advised to consider deep coring for nitrate testing, particularly following saturating rainfall or flooding as was experienced during the 2011–12 fallow.

Treatments

Site	Paddock N status, histories of N fertiliser inputs (kg N/ha), grain yields (t/ha) and proteins (%)
Bithramere	Medium N fertility** 2010 barley, 50N 2011 durum, 80N, 4.5 t/ha @ 13.5%
Blackville	Medium N fertility 2010 barley, 60N 2011 wheat, 80N, 5 t/ha @ 10.0%
Gurley	Low-medium N fertility* 2010 barley, 60N 2011 faba beans, 0N, 2.2 t/ha
Moree	Low-medium N fertility 2010 wheat, 40N 2011 chickpeas, 0N, 3.5 t/ha
Tamworth – TAI	Medium N fertility 2010 wheat, 50–100N 2011 canola, 80N, 3.3 t/ha
Walgett 1	Medium N fertility 2010 wheat, 0N 2011 chickpeas, 0N, 0.9 t/ha
Walgett 2	Medium N fertility 2010, 0N 2011 wheat, 0N, 1.8 t/ha @ 12.5%

* Low-medium N fertility – long cropping history and low-moderate use of fertiliser N

** Medium N fertility – short cropping history and/or moderate-high use of fertiliser N

Results

- Not all the sites are available in Cropmate. Tamworth was used when simulating data for Bithramere; Quirindi was used for Blackville; Moree was used for Gurley.
- Predicted and measured sowing soil nitrates were similar for four of the sites (Figure 1)
- For the remaining three sites – Walgett 2, Moree and Tamworth – measured soil nitrates were much lower than predicted.
- Two of these sites had the highest fallow rainfall during the 2011–12 summer fallow (700+ mm), while the Walgett 2 site was inundated with flood water. Sites with the high fallow rainfall and/or flood water were likely to have experienced the highest levels of denitrification.
- There may have been some limited denitrification activity at the other sites (fallow rainfalls of 450 and 610 mm), which would explain the slightly higher predicted values.
- The Moree and Walgett 1 sites both came out of chickpeas in 2011 following wheat in 2010, so their post-fallow soil nitrate levels in April/May 2012 should have been similar.
- The big difference between the two profiles is that there was very little nitrate below 30 cm depth at the Moree site (Figure 2). It is likely that nitrate released from mineralisation was denitrified before it was leached into the lower part of the root zone. There could also have been denitrification at depth.

- The small amount of nitrate in the surface 30 cm at Moree may have been released during the latter part of the fallow, i.e. March–April, when normal weather conditions returned.
- Are the Walgett data typical of post-chickpeas, post-fallow soil nitrate levels?
- Data in Figure 3 are from the NSW DPI long-term farming systems experiments at North Star, NSW. There were two sites, which were sampled either in October 1989, 1990 or 1993 (harvest) or May 1990, 1991 or 1994 (sowing). Thus, each of the profile nitrates on the graph is the average of 32 sites × years × tillage × N fertility treatments.
- The sowing (post-fallow) profile is very similar to the one recorded for Walgett with 20–30 kg nitrate-N/ha in each of the 30 cm segments down the profile.
- The graph also shows the accumulation of nitrate during the fallow. Overall, it was 55 kg N/ha with most of it remaining in the top 60 cm. There was essentially no accumulation of nitrate-N below 90 cm depth.

Summary

Crop N deficiencies leading to widespread receivals of low protein grain in 2012 was likely due to a number of factors, including depletion of mineral N reserves, inadequate fertiliser N inputs and denitrification losses. To further examine the latter, we predicted soil nitrate levels at 7 NSW DPI experimental sites using 'NBudget', the CropMate-based decision-support tool and compared the predicted values with measured values. Differences between the two were greatest at sites that had the wettest pre-crop fallows or were inundated with floodwater, which could indicate denitrification losses. Because such losses are difficult to predict, growers would be advised to deep core for nitrate, particularly following saturating rainfall such as experienced during the 2011–12 summer.

Acknowledgements

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References

Brill R, Gardner M, Graham R, Fetttell N (2013). Will low protein become the new norm? In GRDC Grains Research Update, Coonabarrabran, In Press.

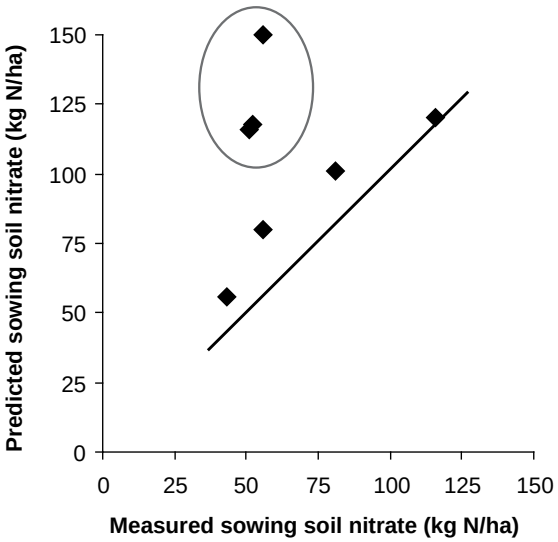

Figure 1: *Measured and NBudget-predicted sowing soil nitrates at the 7 experimental sites. The drawn line is the 1:1 line.*

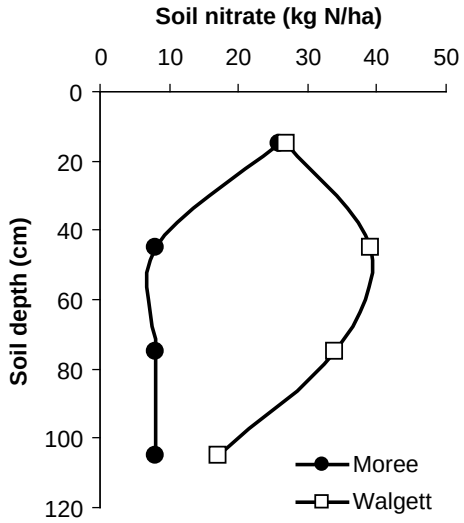

Figure 2: *Measured sowing soil nitrate levels in the root zone at the Moree and Walgett sites pre-sowing 2012.*

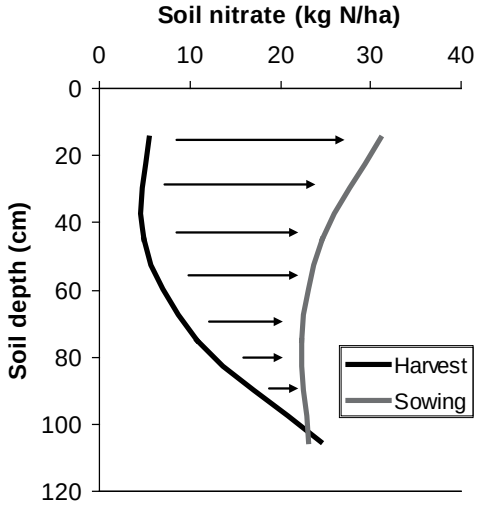

Figure 3: *Typical patterns of soil nitrate accumulation during the summer fallow following chickpeas. Data are from the NSW DPI farming systems trials at North Star during 1989–1994.*