Upper North Farming Systems

Stubble Management Guidelines

Crop nutrition

Heavy stubble loads can result in nitrogen tie-up, impacting on early crop growth, yield and grain quality. Photo: UNFS

Key facts

- Heavy stubble loads can tie up nitrogen (N), but stubble retention is unlikely to affect the availability of other nutrients, such as phosphorus (P).
- Additional nitrogen at sowing can be beneficial in paddocks with heavy stubble loads, particularly on lighter, low-organic-carbon soils.
- Stubble retention only has a minimal impact on maintaining soil organic carbon (C) levels in low-rainfall farming systems.
- Deep soil sampling and soil moisture probes can provide useful information to support nitrogen fertiliser decisions.

In the lower-rainfall areas of the Upper North growers traditionally apply low levels of nitrogen fertiliser due to the area's lower yield potential, inherent medium-to-high soil fertility and the use of legume-based pastures in crop rotations.

With increased cropping intensity, and some poor seasons, the legume content of pastures has declined on many farms, lowering soil nitrogen levels. As a result, during recent years nitrogen fertiliser application in the Upper North has increased.

The Upper North contains a small proportion of highly-productive loamy sand and sandy loam soils (about 10 per cent or 25,000 hectares) with low organic carbon levels (<0.5 per cent). With improved agronomy and management, heavy stubble loads (>5t/ha) are becoming more frequent on these soils and resulting in nitrogen 'tie-up', and subsequent nitrogen deficiency during early crop growth, lower grain yields and reduced grain quality.

Impact of stubble on soil nitrogen

Lighter-textured soils with low organic carbon levels pose a particular management challenge when dealing with high stubble loads. As soil microbes break down stubble, they extract available nitrogen from the soil as a source of energy to fuel the stubble decomposition process. This temporary 'tie-up' of nitrogen limits the amount available to growing crops, often resulting in nitrogen deficiency.

Project information

This *Crop nutrition* guideline has been developed for the Upper North Farming Systems Group (UNFS) as part of the Maintaining Profitable Farming Systems with Retained Stubble Initiative, funded by the Grains Research and Development Corporation (GRDC UNF00002).

The Stubble Initiative involves farming systems groups in Victoria, South Australia and southern and central New South Wales, collaborating with research organisations and agribusiness, to address challenges associated with stubble retention.

The GRDC, on behalf of growers and the Australian Government, is investing $17.5 million in the initiative that has been instigated by the GRDC Southern Regional Panel and the four Regional Cropping Solutions Networks that support the panel.


Standing stubble (left) immobilises less nitrogen than incorporated stubble (right). Photos: UNFS

The type of stubble, in addition to the amount of stubble (stubble load), also influences the extent and duration of nitrogen tie-up.

The carbon:nitrogen (C:N) ratio of decomposing stubble is the main factor determining whether nitrogen is immobilised (made unavailable to the crop) or mineralised (made available to the crop). Crop residues with a large C:N ratio (more than 22:1) will result in immobilisation, while lower ratios will result in mineralisation.

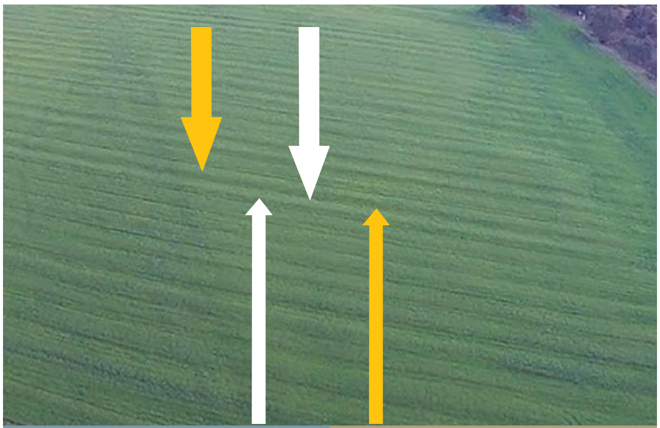
Wheat stubbles tend to have C:N ratios of around 85:1, whereas legume stubbles are more commonly around 35:1. Nitrogen in stubble will continue to be immobilised until the C:N ratio drops sufficiently as the stubble decomposes, returning crop-available nitrogen to the system.

Stubble treatment

Stubble treatment is another factor affecting the rate of nitrogen immobilisation and mineralisation.

Incorporated wheat stubble can immobilise 5–13kg/ha of nitrogen for each tonne of stubble. However, where stubble remains standing, immobilisation figures are significantly lower (<5kg/ha N/t stubble) due to the slower rate of stubble decomposition.

Significant yield penalties may occur if insufficient nitrogen is applied when sowing into heavy cereal stubbles that have been incorporated into the soil.



The white arrow indicates low nitrogen availability and reduced crop growth

Yellow arrow indicates high soil nitrogen availability and increased crop growth

Visible nitrogen tie-up 'strips' in an oat crop in the Upper North following a 5t/ha barley crop. These low-nitrogen strips are the result of high surface stubble loads being spread unevenly by the harvester in the previous season. Photo: Matt Foulis

Burning heavy stubble loads can reduce nitrogen tie-up, but burning increases the risk of wind erosion, lowers soil fertility and can exacerbate moisture loss through increased soil evaporation. While burning will make some nitrogen immediately available for plant uptake, up to 80 per cent of the total nitrogen and a significant amount of carbon, sulphur (S), phosphorus and potassium (K) contained in the stubble is lost as a result of the burn.

Impact of stubble on other nutrients

Retaining stubble is unlikely to have a major effect on the availability of other nutrients (phosphorus, sulphur, potassium etc.) in the short term, with a positive effect in the longer term as these stubbles decompose. These nutrients will generally become available at the same rate at which the stubble decomposes.

Organic carbon levels can act as an indicator of the amount of nutrients, particularly nitrogen, available to be mineralised. Although stubble retention is unlikely to lead to instant increases in soil organic carbon levels (research indicates this may take decades in a lower-rainfall environment), there is often an immediate increase in microbial biomass carbon. This increase in microbial carbon aids in biological fertility of the soil, influencing the rate at which microbes cycle nutrients.

! Soil sampling and analysis

When sampling soil for testing, collect samples according to soil type rather than on a whole-paddock basis. Avoid headlands, waterways and stock camps.

1. **Standard 0–10 cm samples** — A standard 0–10cm sample is appropriate when testing for phosphorus, organic carbon, pH, and trace elements.

   In paddocks where you plan to inter-row sow, take soil samples in the inter-row space rather than randomly across the paddock, as the fertility in the inter-row may be lower.
2. **Deep soil testing (0–60cm) pre-sowing** — Carry out deep soil testing to measure nitrogen, sulphur and stored soil moisture levels at the start of the season.
3. **Deep soil testing (0–60cm) in-crop** — An increasing number of samples are now collected in-crop to take into account soil mineralisation following harvest, nitrogen tie-up and sowing-applied nitrogen. This approach is likely to be a more reliable tool than pre-sowing testing for post-sowing applications. Take care when handling moist soil samples to avoid poor results. Keep samples cool and express post them to an accredited laboratory for quick analysis.

The deep soil nitrogen level can be used in a range of nitrogen decision models to help determine if additional nitrogen may be required to achieve target yields and grain quality.

Note: Use an ASPAC-or NATA accredited laboratory for all soil tests to take advantage of the quality control this accreditation represents.

Timing of nitrogen applications

Pre-sowing or at sowing

The amount of nitrogen applied at sowing may be increased where:

- the crop is following a non-legume (e.g. cereal or canola)
- soil organic carbon levels are low (<0.8 per cent)
- stored soil moisture is above average
- stubble loads are high (>3t/ha)
- the target yield is high.

Post-sowing (in-crop)

Delaying nitrogen fertiliser application for as long as possible is an effective risk management strategy in lower-rainfall areas, however the longer it is delayed the greater the risk of poor nitrogen use efficiency.

Applications at late tillering to early stem elongation (GS30–31) tend to give the best results in low-rainfall areas, with increased yield and a low risk of higher screenings. Later applications tend to increase protein without boosting grain yield.

Split application (pre-sowing and post-sowing)

Splitting applications is perhaps the most common and sensible technique. This involves an application of 30–70 per cent of nitrogen at sowing, followed by an in-crop 'top-dress' of 30–70 per cent. This technique allows the option to increase or decrease the in-crop nitrogen rate based on seasonal conditions, without compromising plant health in the early growth stages.

During late winter to early spring — when crop growth is greatest — a plant's daily nitrogen demand can be four to five times the rate of soil nitrogen mineralisation. Peak mineralisation is 1kgN/ha/day for an average loam soil with one per cent organic carbon and lower for sandy soils. A fast-growing crop may require 4–5kgN/ha/day during this time.

! Variable rate nitrogen applications

Aside from carefully choosing the timing, the efficiency of fertiliser applications may also be improved through variable rate applications. Soil variation within a field can sometimes make blanket nitrogen applications difficult. Improvements in precision agriculture technology have given growers the option to segregate fields into different production/management zones. This technique has been widely adopted for varying phosphate fertilisers at sowing, and can similarly be used to vary nitrogen rates either at sowing, in-crop or both.

Nitrogen fertiliser decision tools

There is a range of different nitrogen fertiliser decision tools available. The Upper North Farming Systems (UNFS) group has been using Yield Prophet® for a number of seasons with growers generally reporting success after using it as a nitrogen fertiliser decision tool.

An increasing number of growers have installed soil moisture probes during recent years as they become more affordable and reliable. Stored soil moisture levels can be used to estimate yield potential and nitrogen demand to help better understand plant available water and root growth. This information can be used to improve Yield Prophet® results.

There is a range of other nitrogen budgeting tools that growers, agronomists and advisers use to aid nitrogen fertiliser management, such as the CSIRO-developed 'Yield and N Calculator' (also referred to as the Mallee Calculator) or the Better Fertiliser Decisions for Cropping tool (**www.bfdc.com.au/interrogator/frontpage.vm**).

Nitrogen supply and demand is relatively complex. Seek professional advice for your individual situation.

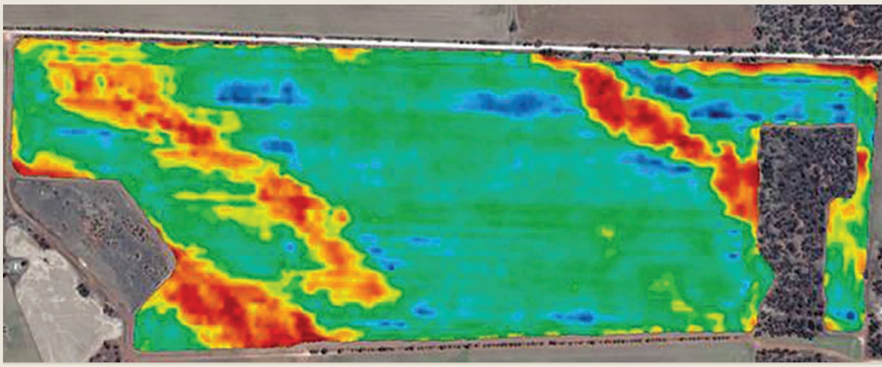
Growers have access to a wide range of support tools that can help guide nitrogen fertiliser decisions. Photo: UNFS

Variable rate technology offers economic advantage

David Kumnick, Booleroo Whim

David farms in the Booleroo and Willowie area of the Upper North, with soils ranging from deep sands to medium clays. There is often a big variation in wheat yields from the different soil types and the potential to manage these soil types differently to reduce risk and improve profitability.

During 2014 the Upper North Farming Systems (UNFS) group established a large-scale demonstration on one of David's highly-variable paddocks to evaluate the use of a variable rate nitrogen application approach.



2013 yield map of David Kumnick's paddock

The previous wheat crop yielded an average of 3t/ha across the paddock, with stubble loads of 3–3.5t/ha at sowing the following season. Four production zones (sand, sandy loam, clay loam and clay) were developed using a combination of EM38 and yield maps. Each of the production zones was soil tested to 60cm with low nitrate and sulphur recorded in the deep sand. Both the clay loam and clay soils had moderate salinity levels and high levels of boron at depth, which can limit yield, particularly in dry seasons. Three nitrogen rates (0, 50 and 100kg/ha urea) were applied in strips across the four production zones.

TABLE 1. Whole field benefit if optimal treatment applied over each soil zone

Soil zone	Optimal treatment (kg/ha)	Area (ha)	Benefit ($/ha)	Total benefit ($/ha)
(Sand) 40.7	100	14.85	92.60	1,375.11
(Sandy loam) 72.9	100	27.68	138.60	3,836.45
(Clay loam)103.8	50*	24.38	–	–
(Clay)145.3	50*	14.34	–	–

**No benefit gained for 50kg/ha treatment as this is considered standard application rate.*

The results indicated an economic benefit in varying the nitrogen application rate across these zones. The sand and sandy loam soils were most profitable at the 100kg/ha urea rate, whereas the clay loam and clay soils were most profitable at the 50kg/ha urea rate (Table 1).

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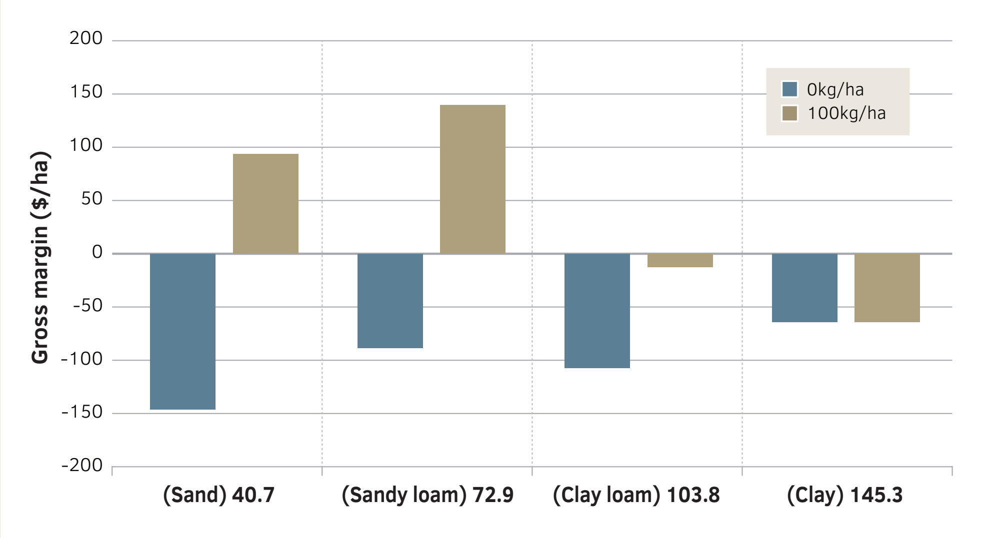
Variable rate technology offers economic advantage (continued)

The most economical nitrogen rate will vary from season to season, however results from this trial suggest sandy soils are likely to respond to higher rates of nitrogen in most seasons.

David is yet to adopt a variable rate fertiliser program over his entire farm due to the apparent lack of significant variability across many of his paddocks. He is, however, managing his sandy rises on paddocks such as the one containing the demonstration separately to the rest of the paddock. This includes applying additional sulphate of ammonia fertiliser on these soil types to account for leaching and nitrogen tie-up.

David has not ruled out adopting a full variable rate system in the future.

Figure 1. Gross margin returns across the four different soil zones, using 50kg/urea/ha as the base treatment and assuming Hind1 barley at $230/t and cost of urea at $500/t



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Acknowledgements

This guideline was developed by Matt Foulis (Northern Ag).