AVAILABILITY OF N FROM CEREAL STUBBLE: ^{15}N TRIAL SUMMARY 2014–2016

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TAKE HOME MESSAGES

- Cereal stubble contributes only a small percentage of the nitrogen requirement for a following cereal crop (2 to 11% of N from 2014 wheat stubble was taken up by 2015 and 2016 crops).
- Urea fertiliser nitrogen use efficiency of the 2014 wheat crop was 35%.
- The 2015 drought reduced the influence of stubble management treatments on nitrogen cycling, yield and carry over effects on microbial activity.

BACKGROUND

Nitrogen (N) management is challenging for farmers and is a regular point of discussion despite the vast amount of research that has been done in this area. Gaps remains in the ability to measure and predict the amount of N in different N pools via; soil organic matter, crop residues above and below ground, rates of N mineralisation over summer and in-crop, and leaching or volatilisation.

Stubble retention provides a valuable carbon source for microbial activity and is known to influence the various biological processes involved in N cycling affecting mineralisation, potential for tie up and losses through denitrification and leaching (Gupta 2016).

To better understand the cycling of N in the cropping system, a trial was established in 2014 and maintained over three cropping years, to more clearly understand the N cycle and the role of cereal stubble in the system. This has been achieved by labelling wheat stubble using an isotope of N as ^{15}N-labelled urea which enables tracking the movement of N from fertiliser N into crop and soil over a number of years. It also improves the ability to measure N transfer into different soil organic matter pools and mineralisation.

Having a better understanding of how much N is tied-up in residues, and the time frame for release, depending on different management choices, we can make better N budgeting decisions and tailor N additions and timing to crop demands.

Previous studies have shown that N application can be delayed or split until peak crop N demand, but the effectiveness of this is varied with seasonal rainfall conditions (Bell et al. 2016). The trials were established at Horsham, Karoonda (SA) and Temora (NSW) and were undertaken as part of GRDC project CSP00186.

AIM

To determine the amount and availability of N from wheat stubble under varying stubble management practices over three cropping seasons.

PADDOCK DETAILS

Location:	Horsham
Annual rainfall:	Refer to Table 1
GSR (Apr-Oct):	Refer to Table 1
Soil type:	Heavy clay
Paddock history:	2013 vetch hay (0.3t/ha)

TRIAL DETAILS

Horsham trial details for the main treatments, 2014 to 2016, are presented in Table 1.

Table 1. Trial details for 2014, 2015 and 2016 at Horsham.

Trial details	2014	2015	2016
Crop year rainfall (Nov–Oct) (mm)	226	228	450
GSR (mm)	172	125	352
Wheat variety	Scout	Mace	Corack
Target plant density (plants/m²)	150	100	140
Seeding equipment	Knife points, press wheels, 30cm row spacing		
Soil sampling date	21 May	1 June	16 May
Stubble incorporation	Only applies to 2015 and 2016	19 January	1 June
Sowing date	22 May	2 June	18 May
Replicates	Four	Four	Four
Fertiliser at sowing	5.5kg N/ha 10.8kg P/ha	8.3kg N/ha 17.5kg P/ha	5.1 + 15.6kg N/ha 10kg P/ha
Urea (N) at GS15/22	41kg N/ha 21 July		
Urea (N) at GS49			20kg N/ha 11 September
Harvest date	29 November	16 November	22 December
Trial average yield (t/ha)	1.2	0.4	5.5
Post-harvest soil sampling date	1 December	18 November	23 December

All pests, diseases and insecticides were managed as to best practice.

METHOD

Part 1. N labelled stubble preparation in 2014

^{15}N labelled stubble was prepared during the 2014 season to measure the amount of (i) N transferred from stubble from the previous crop into wheat sown in 2015 and 2016 and (ii) N transferred from wheat stubble into soil organic matter.

In 2014 three buffer plots of wheat were sown on 22 May with 30kg/ha of single super. On 19 June liquid labelled N (as ^{15}N) was applied at 40kg N/ha; this was repeated on 11 August with another 30kg N (as ^{15}N).

After harvest, the stubble from these plots was collected and cut into 5-10cm pieces. For the standing and incorporated stubble treatments (see details below), a mixture of ^{15}N labelled stubble and chaff was applied soon after the 2014 harvest. This was spread onto 1m^2 micro-plots (inside all the main plots) at an equivalent rate of 2.5t/ha. Stubble, chaff and grain samples were analysed for ^{15}N concentrations.

Part 2. Main trial design

In 2015 and 2016, wheat was sown into four stubble treatments each with four replicates:

i. nil above ground stubble (removed by raking off)

ii. standing stubble (cut at 12cm height)

iii. stubble incorporated to 10cm depth after first significant rainfall event

iv. stubble cut low and retained on the surface

Surface soil samples (0-10cm) were collected during the summer (2014/15 and 2015/16), at sowing and post-harvest in 2015 and 2016. These were analysed for microbial biomass (MB) and activity, mineral N and N supply potential (the amount of N that could be supplied through the combination of the mineral N pool and in-season mineralisation). Additionally, soil profile sampling (down to 1m depth) was carried out in each of the micro-plots at sowing and harvest. All soil and crop residue samples from the micro-plots were analysed for ^{15}N as mineral N, decomposing residues N and soil N pools. Crop biomass, total and ^{15}N uptake were measured during the growing seasons (2015 and 2016) at key growth stages; first node (GS31), anthesis (GS65) and grain maturity (GS99). Grain yield and quality parameters were also measured.

Following harvest 2015, the four stubble treatments were implemented once again for the 2016 season. Crops in microplots were hand harvested and the stubble kept within the microplots.

RESULTS AND INTERPRETATION

Crop yield

Seasonal conditions during the three years that the experiment was conducted resulted in large differences in average wheat grain yields across treatments (Table 1). The average grain yield in 2015 was only 0.4t/ha due to the very dry conditions and there were no differences in yield between treatments.

Table 1. Average grain yield for 2014, 2015 and 2016 at Horsham.

Year	GSR rainfall (mm)	Yield (t/ha)
2014	206	1.9
2015	125	0.4
2016	393	5.3

In 2016, the different stubble treatments had a limited, but significant effect on crop yield (Table 2). This observation was partly due to the residual effects of drought in 2015 in terms of nutrient availability and microbial activity. In addition, the no-stubble treatment in this experiment was a short-term treatment only, and may not represent the long-term effects of lack of stubble retention.

Table 2. N in soil at sowing (to a depth of 1m) and grain yield and protein in 2016.

Treatment	Soil N pre-sowing (kg/ha)	Grain yield (t/ha)	Protein (%)
No stubble	84	5.5	10.3
Standing	104	5.7	10.7
Surface	81	5.3	10.8
Incorporated	62	5.3	10.8
Sig. diff. **LSD (P=0.05)**	P<0.04 27	P=0.001 0.2	NS

Fertiliser N use efficiency

Fertiliser N use efficiency is calculated as the amount of N applied which ends up in the wheat plant the year the fertiliser is applied. In the 2014 season it was 35% including both above and below ground N uptake. Fertiliser N use efficiency in the wheat crop was also low in the Mallee sand at Karoonda (40%) and red brown earth at Temora (45%). These results support previous observations from across different regions of Australia (Angus and Grace 2017). Fertiliser use efficiency is affected by seasonal conditions and soil properties influencing the conversion of fertiliser N into plant available nitrate and losses of N as gases and N leaching. Immobilisation (tie-up and or opposite of mineralisation) of N fertiliser in microbial biomass would also affect its immediate availability to plants.

Residual fertiliser N use efficiency

Residual fertiliser N use efficiency refers to the amount of N applied to a previous crop which becomes available to the following crop. In 2015 it was 10% and in 2016 it was 13% (for example 10% of the total amount of N in the 2015 wheat crop was supplied through the residual fertiliser of the 2014 crop) which becomes available in the following year.

Availability of N from wheat stubble to the following crop

Results from 2015 and 2016 seasons showed that only a small portion (2-11%) of N from 2014 wheat stubble was taken up by the 2015 and 2016 wheat crops (Figure 1). Observations at Karoonda and Temora showed a similar trend suggesting that cereal stubble contributes only a small percentage of N requirement of the following crop. At Horsham, the drought in 2015 season resulted in a low amount of decomposition and subsequent release of N for crop uptake (2-3%) but the decile 10 season in 2016 increased this contribution (11%). Crop residues (stubble) are a source of carbon and nutrients (N, P and S) to microorganisms.

Stubble retention significantly influences the biological processes involved in N mineralisation and availability in all environments and seasons. As the majority of N from stubble is transformed through microbial biomass (MB) prior to becoming available to plants, cereal stubble may not be a main source of N to the following cereal crop. When microorganisms use C from wheat stubble with a wide C:N ratio (average 120:1) it results in immobilisation of N from soil to meet the N demand by the growing microbes. For example, the net amount of N mineralised during the summer fallow of 2016 was 15 to 30kg N/ha in the stubble retained systems compared to 64kg N/ha in the no-stubble treatment.

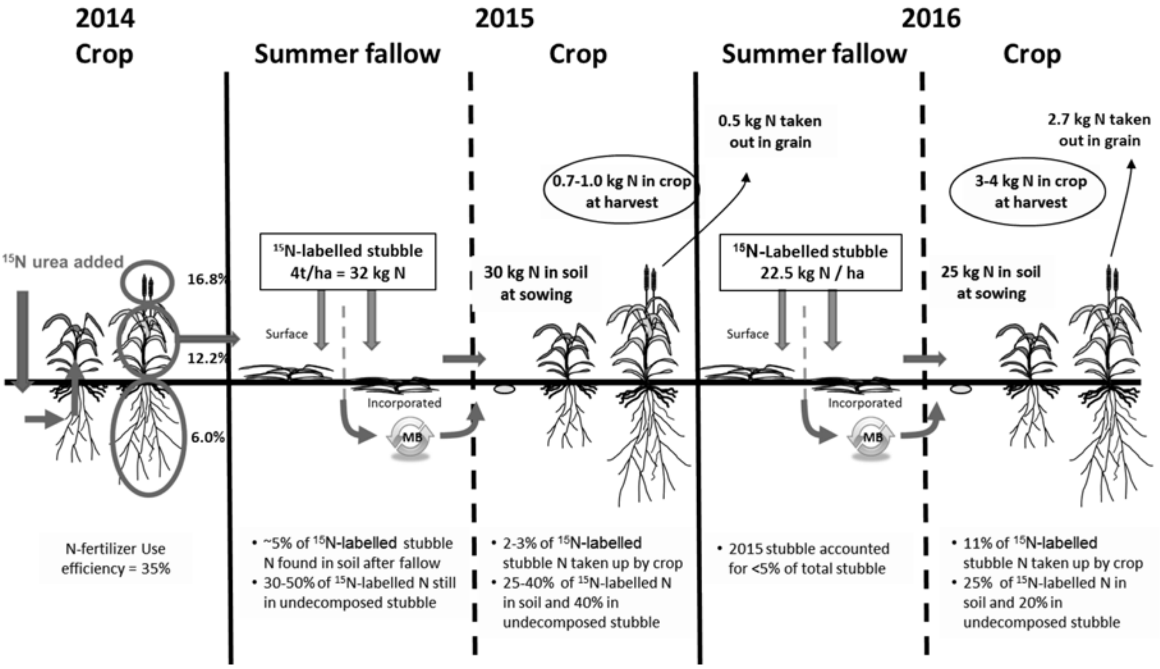

Figure 1. Fate of nitrogen from cereal stubble in stubble retained systems in the following cereal crops at Horsham, Victoria. MB = microbial biomass.

Soil MB dynamics play a significant role in the availability of N to crop plants. Data in Figure 2 shows the amount of different soil N pools, N inputs through fertiliser and stubble at the time of sowing of 2016 wheat crop. The vertisol (clay) soil at the Horsham site contained a large component of microbial biomass carbon (800-950kg C/ha in the surface 10cm soil). This can tie-up N from fertiliser and N mineralised from soil organic matter, for example an immobilisation potential (IMP) of 57-67kg N/ha was calculated at sowing of 2016 crop. The amount of N tie-up and microbial turnover in the soil is generally influenced by the amount and quality of stubble, seasonal conditions such as rainfall, soil type and organic matter status.

At Horsham, microbial biomass in the surface 10cm soil contained 118-132kg N/ha which was significantly higher than that in the mineral N pool (<15kg N/ha). However, MB turnover would be a source of N released later in the crop season contributing to the in-crop N supply potential of soil (eg. NSP of 89-102kg/ha; Figure 2). These results show that N mineralised from soil organic matter through microbial activities accounts for a large portion (>50%) of N uptake by cereal crops. Therefore, as stubble management affects the rate and balance between mineralisation, tie-up and losses of N, appropriate stubble management is critical for achieving high NUE in cropping soils. Immobilisation of N is not a permanent loss of N for uptake and by knowing about it, management for the temporary tie up in N supply which can occur early in the growing season.

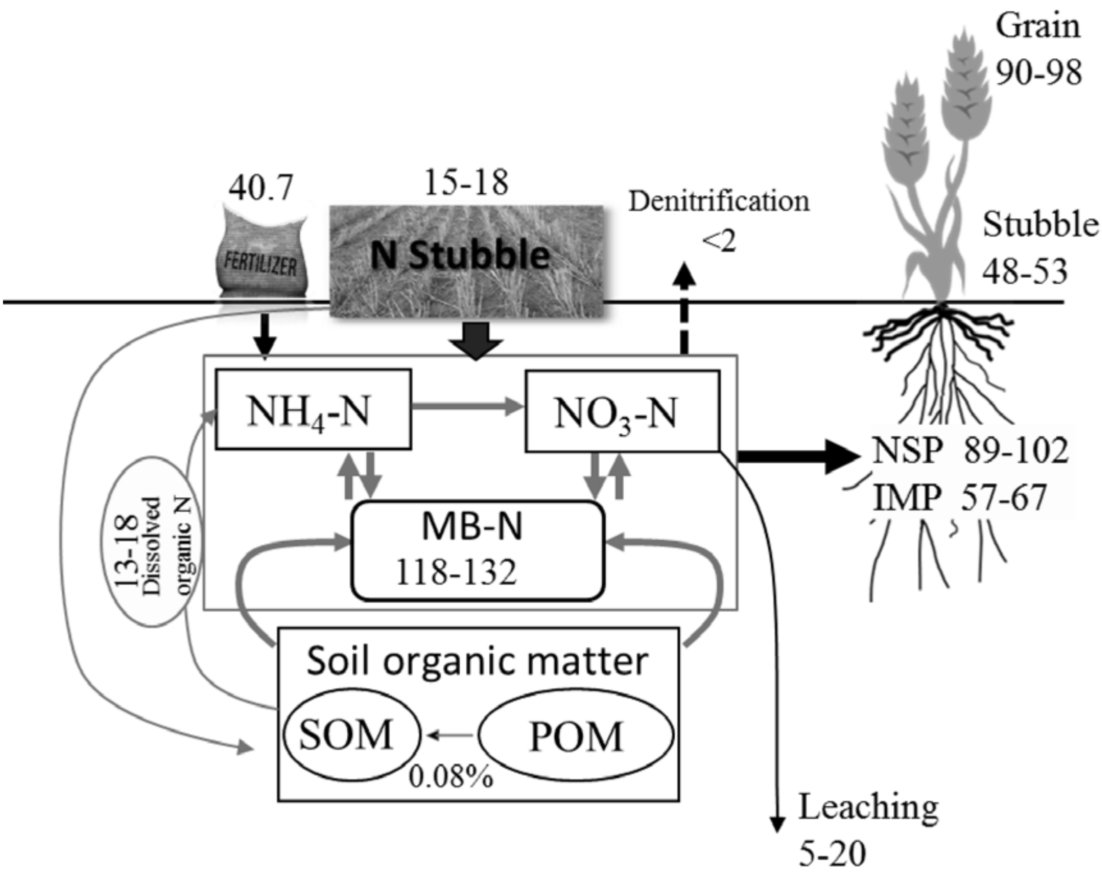

Figure 2. Amount of N (kg/ha) in different soil N pools prior to sowing the 2016 crop and N uptake by the wheat crop at harvest in 2016 season. MB=microbial biomass, SOM=soil organic matter, POM=particulate organic matter, NSP=N supply potential, IMP=N immobilisation potential. Values for leaching and denitrification are estimates based on other research in the region whereas other pools are measured values.

COMMERCIAL PRACTICE

The direct contribution of N contained within wheat stubble to the N requirement for the following cereal crop (<10%) in a dry year followed by a wet year is relatively small. However, stubble remains an important source of carbon and nutrients for soil microorganisms which drive the supply of N to crops via organic matter (>50% of a crop's total N uptake) and the management of stubble drives the timing and amount of this supply.

The process of N immobilisation (tie-up) by the microbial biomass which affects the availability of N from soil organic matter and fertiliser early in the growing season should be considered in N management decisions in stubble retained systems.

N is only a small component of total costs but can have a large impact on income. Further research being undertaken on mineralisation is suggesting there are possible methods for better estimating inseason mineralisation. Given crop N uptake is 35-45% from the fertiliser in the year of application and the remainder from soil processes, a better prediction of in-crop N supply from soil is potentially important.

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