Nitrogen cycling in cereal stubble retained systems

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Background

In low fertility agricultural soils of Southern Australia, crop residues are one of the major sources of carbon (C) for soil biota in low fertility agricultural soils of Southern Australia. As a result, stubble retention can provide benefits through changes in soil physical, chemical and biological properties. However, the selection of stubble management strategy could have a significant impact on the potential benefits to be gained from the activity of soil biota in their role in carbon turnover, nutrient mineralisation, and subsequent availability of nutrients to crops.

Why was the project done?

As part of the GRDC project (CSP00186) we are conducting focussed studies at Karoonda in South Australia, Temora in New South Wales and Horsham in Victoria, to strengthen our knowledge on seasonal changes in the (1) biological value of stubble (2) mineralisation: immobilisation balance (ratio) and (3) the direct supply of N from stubble to crops as influenced by stubble management.

How was this done?

Stubble was produced in 2014 that was labelled so that the contribution of this stubble to the nutrition and productivity of the next crop could be measured. This contribution in response to a range of stubble management practices was measured in the 2015 growing season.

Key messages

- The 2014 wheat crop at Karoonda had a harvest index of 0.4 and fertilizer N recovery was 35%.
- Wheat stubble from the 2014 crop contained 16 kg N/ha and had a C:N ratio of 95 which is common for cereal crop residues in these environments .
- Mineralization during summer resulted in the accumulation of 18-33 kg/ha of mineral N to 50cm depth across all the treatments at sowing in 2015.
- Incorporation of 2014 cereal stubble increased microbial biomass and N supply potential at sowing in the surface soil when compared with standing stubble.
- The management of cereal stubble affects the microbial activity that influences the cycling and supply of nutrients (nitrogen (N) and phosphorus) to growing crops.
- There was no significant effect of management of 2014 stubble on subsequent wheat grain yield in 2015.

Field Experiment Methods

During the 2014 crop season wheat was fertilized with ^{15}N isotope labelled Urea applied in two doses (i.e. 2 weeks after sowing and at GS 32) @ 70 kg N/ha. Similar experiments were set up at Horsham, Vic and Temora, NSW (@ 100 kg N / ha). Labelling stubble with ^{15}N helps directly trace the transfer of N from wheat stubble into soil organic matter and to the crop in 2015.

Following the harvest of 2014 wheat crop, replicated stubble retention treatment plots representing nil (stubble cut low and removed), surface (stubble cut low and retained), standing (stubble cut at standard height and retained) and incorporated (cultivation to 10cm depth following harvest) stubble were established on 2014 wheat crop plots adjacent to the ^{15}N labelled area. A uniform mixture of ^{15}N labelled stubble and chaff samples was prepared using the ^{15}N residue collected after the 2014 crop harvest, e.g. stubble cut to 5-10cm length pieces, and applied in microplots (~2 sq M plots) in the 'Incorporated' and 'Slashed' treatments. At Karoonda, stubble was applied @ 2.5t/ha. The trial at Karoonda was sown with Mace wheat on the 21st of May with DAP at 50 kg/ha and Urea at 24 kg/ha.

Surface soil samples were collected during the summer and at sowing and were analysed for microbial biomass (MB) and activity, mineral N and N supply potential (the amount of N that could potentially be supplied through in-season mineralization). Soil and crop residue samples from the microplots were analysed for ^{15}N in the mineral N, decomposing residues and total soil N pools. Plant samples were collected from the microplots at GS31, anthesis and grain and stubble samples at harvest for ^{15}N uptake from the previous year's stubble; analysis in progress.

Results and discussion

Data on grain yield and total plant biomass indicated significant differences in the harvest index between the lower rainfall Karoonda and Horsham sites and the higher rainfall Temora site (Table 1). Crops at all the three sites experienced dry spring and grain filling periods (Figure 1) which had a significant effect on the overall crop performance. These conditions could also be attributed to the lower fertilizer Urea ^{15}N recovery, especially at Horsham and Karoonda (Table 1).

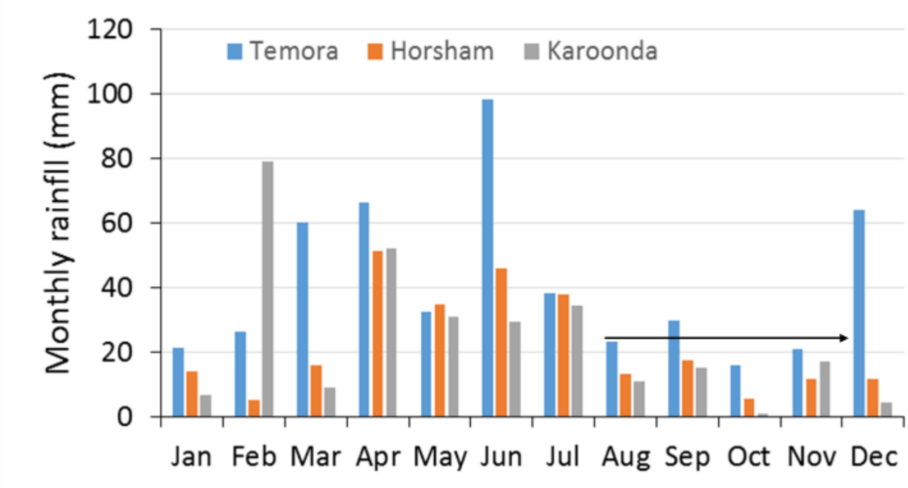

Figure 1. Rainfall distribution during 2014 season at the three field sites

Results from the ^{15}N analysis indicated that the level of ^{15}N enrichment in the stubble fraction (average atom% 5) would allow us to track the fate of stubble N in the 2015 crop season. At Karoonda, stubble at harvest contained 4.5% N which was 24% of the total N taken up compared to 38% at Horsham and Temora.

The large difference with C:N ratio of stubble fraction between Karoonda and Horsham/Temora could be attributed to the inherent soil fertility and seasonal conditions i.e. soil moisture in profile and rainfall. The wider C:N ratio at Karoonda is likely to cause relatively more immobilization (tie-up) of nitrogen during the early stages of stubble decomposition.

Table 1. Crop performance, N uptake and fertilizer N use efficiency the 2014 wheat crop

Location	Yield (t/ha)			N uptake (kg N/ha)		C:N ratio	Fert N
	Grain	Stubble	HI	Total	Stubble	Stubble	uptake*
Karoonda	2.51	3.31	0.41	66	16	95	35%
Horsham	2.19	4.70	0.32	97	38	56	31%
Temora	3.29	8.38	0.28	142	55	57	40%

HI – Harvest Index; * estimate of fertilizer ^{15}N uptake which doesn't include N in roots

At harvest at Karoonda in December 2014, 49 kg N/ha was found in the soil mineral N pool to 1 metre depth and at sowing the levels ranged between 67 to 83 kg N/ha. Soil N mineralization following rainfall events in summer resulted in a significant increase in mineral N in the top 50 cm of the soil profile in all the treatments. Mineral N accumulated in the summer was lowest in the 'surface stubble' treatment (18 kg N/ha) with no significant difference between the other treatments (27-33 kg N/ha). Lack of difference between the different stubble treatments can be attributed to the generally dry summer conditions not supporting decomposition of crop residues, organic matter turnover and mineralization.

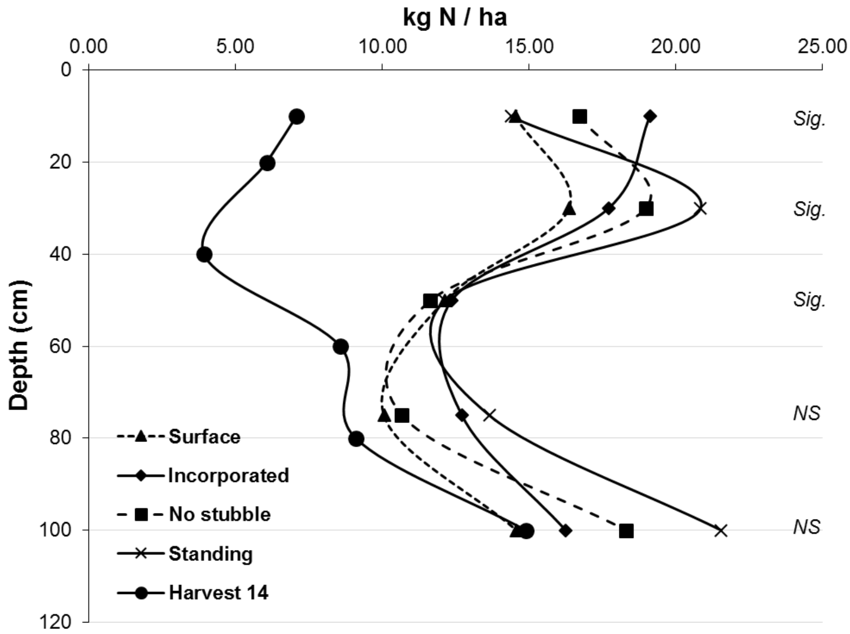

Figure 2. Effect of stubble management on mineral N in soil profile at sowing 2015 compared to that after harvest in 2014 at Karoonda, SA.

Stubble retention significantly increased the amount of microbial biomass C, N supply potential and soil water content in surface 0-10cm soils at sowing, especially in the standing and incorporated treatments compared to the treatment where stubble was removed at harvest (Table 2). There was no difference between treatments in the mineral N and dissolved organic carbon (data not shown, average 19 µg C/g soil) levels.

Stubble retention can influence microbial and nutrient supply properties by providing carbon (energy as MB-C) to support biological activity and also modification to soil moisture levels. In the 'no stubble' treatment, root material from the previous wheat crop would have provided the required carbon source for biological activity.

Table 2. Effect of stubble management on microbial biomass and N supply properties in the top 10 cm of soil at sowing in 2015 at Karoonda, SA.

Treatment	MB-C	Min N	N supply	Field
	ug C/g soil		kg N / ha	(%)
No stubble	**115.8**	**12.2**	**32.5**	**3.50**
Standing	**128.5**	**12.7**	**36.5**	**4.90**
Incorporated	**126.5**	**12.8**	**35.5**	**3.80**
Surface	**115.0**	**11.2**	**32.8**	**3.60**
LSD (P<0.05)	*10.2*	*NS*	*2.3*	*1.02*

Note: field moisture represents gravimetric water content

Results from the analysis of plant samples at GS31 and anthesis and grain samples from harvest showed the presence of ^{15}N from the previous year's stubble (data not shown) suggesting that cereal (wheat) stubble can be a source of N to the following wheat crop. The amount of ^{15}N taken up varied between the three experimental locations. Further analyses of harvest stubble and soil samples are currently in progress.

Despite differences in the availability of N early in the season, there was no effect of stubble management on grain yield in 2015 (Table 3). The 2015 growing season had a particularly dry finish (no significant rainfall after August 2015) which may have negated any potential benefits of N supply caused by variation in stubble management.

Table 3. Grain yield of wheat as influenced by stubble management practices at Karoonda, SA

Treatment	Grain yield (t/ha)	Harvest index
No stubble	**1.59±0.27**	**0.39**
Standing	**1.62±0.44**	**0.44**
Surface	**1.52±0.26**	**0.43**
Incorporated	**1.82±0.19**	**0.42**
F-test	**not sig.**	**nog sig**

Acknowledgements

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