Crop residue dynamics are similar under no-tillage across contrasting crop rotations

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Key Messages

- The quantity of crop residue on the soil surface is affected by both crop residue type and the carry-over of residue from previous years.
- The C:N ratio of the crop residue (residue quality) was lowered by the addition of legume residue and increased by wheat residue,
- Regardless of crop residue type or rotation, the C:N ratio remained above 30, due to the carry-over of previous residues, and highlighted the potential for the immobilisation of N.

Background and Aims

Crop residue retained after harvest forms an important pathway in which nutrients previously acquired from the soil by crops are recycled back into soil system (Chen et al. 2014). In a no-tillage system, crop residue is retained in-situ on the soil surface and with little incorporation into the soil profile (Schoenau and Campbell 1996). This fundamental change in residue management compared to tillage based cropping systems can reduce the rate of decomposition (Schomberg et al. 1994), alter composition of microbial communities (Gupta 2010), and the subsequent release of N from crop residue under long-term no-tillage (Schoenau and Campbell 1996).

Crop residue can decompose at any time of the year when optimum soil moisture and temperature conditions are met for microbial decomposer. In summer, this can occur following significant summer rainfall (van Vliet et al. 2000), but often the soil and crop residue dries rapidly following rainfall, and does not result in large changes in crop residue N content (Sparling et al. 1995). Decomposition of crop residue during winter results in a greater reduction in quantity of crop residue and release of N compared to summer (van Vliet et al. 2000). The decomposition of crop residue is also incomplete in each year, with a significant amount of crop residue being carried forward from the previous year (Amato et al. 1987).

Differences in the rate of decomposition between crop residue types are often attributed to their varying chemical composition (Bremer and van Kessel 1992; Redin et al. 2014). The largest influence on the decomposition of crop residue is the carbon to nitrogen (C:N) ratio, with differences between residue types driven largely by changes in the concentration of N rather than changes in the concentration of C (Bremer and van Kessel 1992; Redin et al. 2014). Crop residue with a C:N ratio below 30 readily mineralises to provide surplus N to the soil (Schoenau and Campbell 1996). Where C:N ratio is above 30, lower amount of N becomes a greater limitation to the decomposition of crop residue (Schomberg et al. 1994; Mary et al. 1996). Crop residue with a high C:N ratio is more likely to induce long term immobilisation of N from the soil, severely limiting decomposition (Chen et al. 2014).

While the effects of single types of crop residue on decomposition processes are well understood, the effect of mixed crop residue is less clear. Redin et al. (2014) found that residue decomposition was influenced by the initial chemical composition (eg. cellulose, hemi-cellulose) of the crop residue, whereas the amount of N released was influenced by the availability of N in the residue. Thippayarugs et al. (2008) found that when mixtures of plants were incorporated into the soil, decomposition of crop residue was increased by a low C:N ratio and high N concentration of the residue. However, this influence has not been tested in the Mediterranean environment of Western Australia where there is an accumulation of a mix of crop residue types on the soil surface under long term no-tillage. The aim of this study was to identify the temporal change in crop residue quantity and C:N ratio (residue quality) for two contrasting crop rotations under long term no-tillage in Western Australia.

Methodology

This study was based on an established long-term no-tillage field site initiated in 2007 by the Western Australian No-Tillage Farmers Association (WANTFA), and has been previously described by Flower et al. (2012). The site was in its third consecutive cycle of crop rotation, where it was considered that any influence of crop rotation on crop residue dynamics would be evident. Crop residue was sampled from a wheat-chickpea-canola rotation and a wheat monoculture during the period from sowing in May 2013 until sowing in 2016 to give three consecutive years of changes in crop residue quantity and C:N ratio (residue quality). Crop residue measurements reported in this paper were taken at sowing in each year, and are composed of freshly deposited residue and residue that remained from previous years. All phases of the crop rotation were present in each year, allowing a year-wise comparison of each crop in rotation.

Results

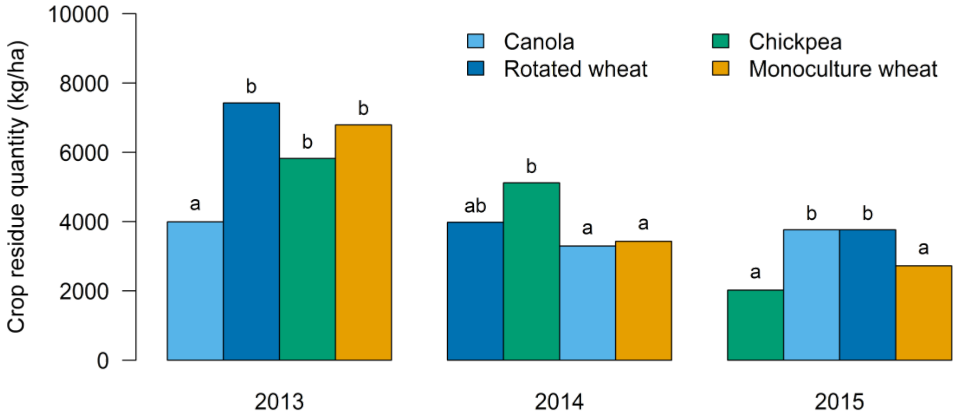

Figure 1 The addition of varying crop residue types had inconsistent effects on the total quantity of crop residue (old + new residue) on the soil surface under long-term no-tillage. The letters denote significant differences (P<0.05) between crop residue type in each year.

There were significant differences between the quantity of crop residue present on the soil surface at sowing in each year for each crop residue type. However, there were no consistent effects of crop residue type in any of the years. The influence of the contribution of the previous years' crop residue to the total amount of crop residue on the soil surface was evident in 2014, where the addition of chickpea residue led to the highest amount of crop residue on the soil surface, as it was following a large amount of wheat residue in the previous year.

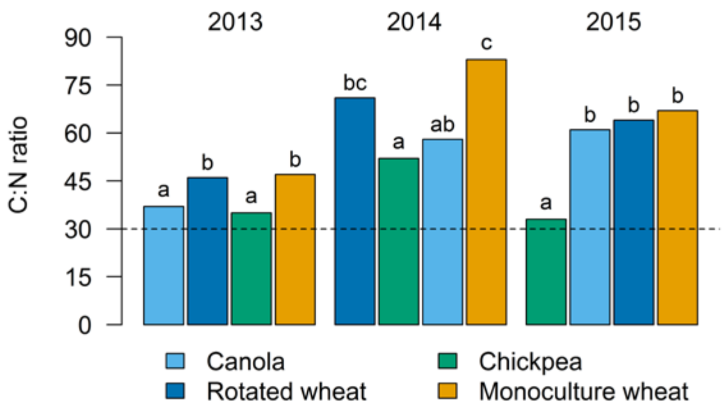

Figure 2 The addition of legume crop residue reduced the C:N ratio of crop residue at sowing in each year, however, the C:N ratio was still above the threshold of 30

where immobilisation begins to occur. Significant differences between crop residue types in each year are denoted by letters (P<0.05).

The addition of chickpea residue decreased the C:N ratio of the crop residue compared to wheat residue, but only for the year following the legume crop. In most years, canola residue tended to lower the crop residue C:N ratio similar to chickpea residue, but was similar to wheat residue in 2015. Wheat residue for both the diverse rotation and monoculture had the highest C:N ratio in each year. However, it is important to note that for the addition of all crop residue types, the C:N ratio did not go below 30. This indicates that there is the potential for the immobilisation of N during the decomposition of crop residue under no-tillage, regardless of the crop rotation employed.

Conclusion

Consideration should be given to the application of nitrogen to optimise the amount of N that reaches the crop plant, versus the amount that can be potentially be immobilised. This could be achieved by simply applying a greater amount of N at sowing by deep banding the fertiliser (>5cm from the soil surface). A more strategic approach could be to target in-crop fertiliser N toward the crop row, avoiding contact with the inter-row where the crop residue is located. These simple considerations ensure that the N fertiliser applied to the crop has a better chance of reaching the plant to improve the uptake of N by the crop plant, and not be immobilised in the crop residue.

Key Words

Crop residue, no-tillage, immobilisation, nitrogen, WANTFA.

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