Nitrogen mineralisation from shoot and root residues of crop and pasture species

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ABSTRACT

Net mineralisation or immobilisation of soil nitrogen (N) was related to the carbon (C) to N ratio (C:N) of added residues of shoots or roots of 10 crop and pasture species. Net mineralisation increased as C:N decreased below 18, and for most residues net immobilisation increased as C:N increased above 18. Some root residues caused less change in mineral N levels than expected on the basis of C:N. Information on the biochemical composition of residues is needed for understanding the differences between shoots and roots, or for modelling the dynamics of N (and C) during decomposition.

Key words

Carbon, immobilisation, mineralisation, nitrogen, root residues, shoot residues.

INTRODUCTION

The decomposition and N mineralisation dynamics of shoot and root residues of the component species in crop:pasture phase farming systems can exert a major influence on the cycling of N in these systems (Kumar and Goh 2000). We studied the effect of adding shoot or root residues of a number of crop and pasture species common to southern Australia on soil N dynamics.

METHODS AND MATERIALS

Three crops: wheat (*Triticum aestivum*), canola (*Brassica napus*) and lupin (*Lupinus angustifolius*); and 7 pasture species: burr medic (*Medicago polymorpha*), lucerne (*Medicago sativa*), balansa clover (*Trifolium balansae*), subterranean clover (*Trifolium subterraneum*), capeweed (*Arctotheca calendula*), phalaris (*Phalaris aquatica*) and lovegrass (*Eragrostis curvula*) were studied. Plants were grown in deep pots filled with coarse sand. Plants were harvested when the crops were near maturity and pasture species were flowering. Shoots were cut from roots, and the roots were washed free of sand. Seeds were threshed from the crop shoots and discarded. Residues were dried at 60 ^{o}C and ground to a 1-mm particle size. The C and N content of residues was determined using an elemental analyser.

For N mineralisation assays, 1.35 g of residue was mixed with 270 g of a loamy, red-brown earth soil from Ardlethan, NSW, wetted to field capacity. There was also a control treatment with no residue added to the soil. The soil was packed to a bulk density of 1.4 g cm^{-3} in PVC rings 100 mm diameter by 25 mm thick, and each soil ring was inserted into a bag of low-density polyethylene, which allowed CO_2 exchange but inhibited water loss. There were 4 replicate soil rings of each treatment. The soil rings were incubated at 15 ^{o}C. Two soil cores, 15-mm diameter, were taken from each ring at 0, 1, 2, 4 and 8 weeks of incubation. Mineral N was extracted from soil samples by shaking in a 2 M KCl solution for 1 hour. Filtered extracts were analysed for NO_3^- and NH_4^+ using an autoanalyzer, and mineral N was calculated as the sum of NO_3^- and NH_4^+, expressed as mg of N per kg of dry soil. Net mineralisation or immobilisation of N was determined by comparing treatment values to those of the control soil.

RESULTS AND DISCUSSION

For most residues, net N mineralisation or immobilisation at 8 weeks was closely related to the C:N of the plant residues (Fig. 1). The cross-over between mineralisation and immobilisation occurred at C:N=18, with legume residues generally promoting net mineralisation and non-legume residues promoting immobilisation. The root residues of lovegrass, phalaris and wheat led to lower immobilisation of N than would be expected from their C:N based on the fitted relationship. A high cell wall content and low amount of readily available C in the soluble fraction can explain the low N immobilisation by lovegrass and phalaris roots, but not for wheat roots where these fractions were nearly the same as for wheat shoots (data not presented).

The short-term dynamics of mineralisation and immobilisation are shown in Fig. 2 for residues representative of low (subclover), intermediate (wheat) or high (lovegrass) C:N. It is clear that roots cause less change than shoots, but the differences are not well accounted for by C:N. For example, subclover shoots and roots had identical C:N, but soil with added shoots initially immobilised more mineral N and subsequently mineralised more rapidly than soil with added roots. In some cases, these differences can be explained by the size and amount of readily available C in the soluble fraction (e.g. lovegrass). However, in other cases (e.g. wheat) biochemical components such as lignin or polyphenols may be involved.

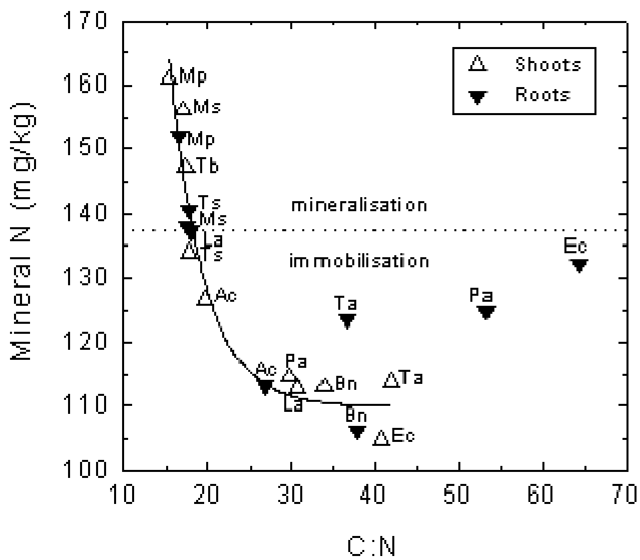

Figure 1. Soil mineral N at 8 weeks as a function of the C:N of added shoot or root residues. The dotted line indicates the mineral N of the control soil. Plant species are identified by the first letters of their genus and species names (see Methods and Materials).

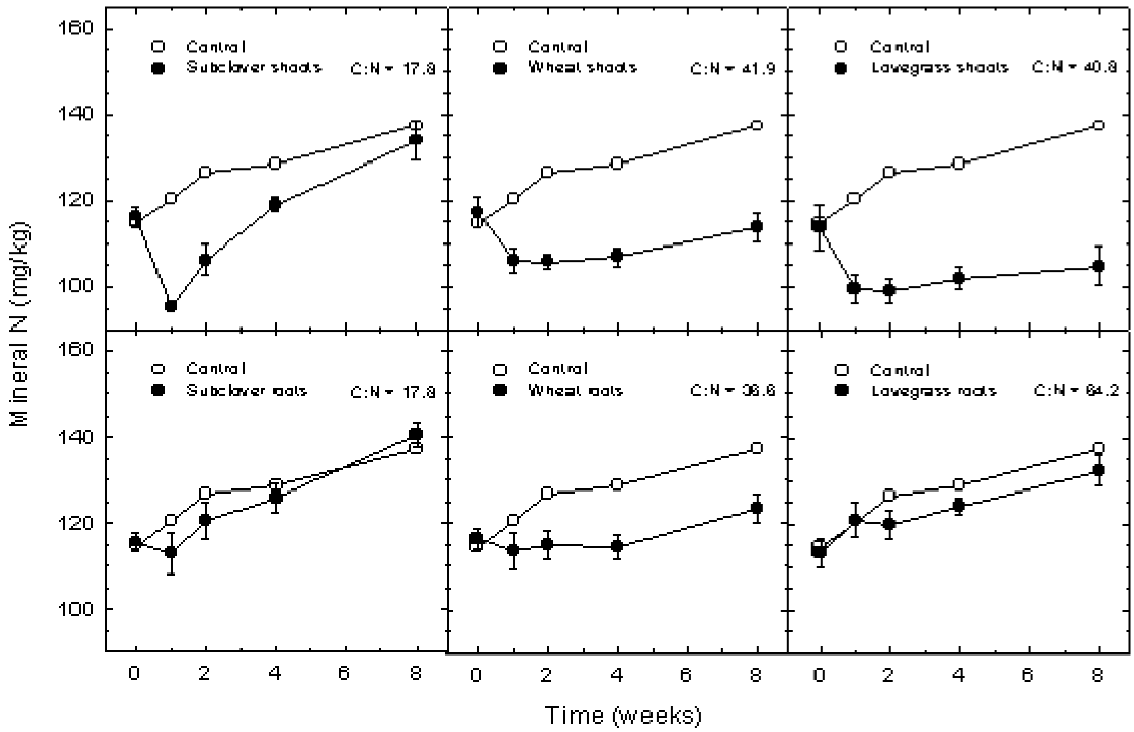

Figure 2. Soil mineral N dynamics during the incubation period for the control, or soil with added residues of three species representing low, intermediate and high C:N.

CONCLUSION

Residue N concentration or C:N is generally sufficient to predict the net effect of residues on soil mineral N, but additional information on the biochemical composition of residues is needed for understanding the differences between shoots and roots, or for modelling the dynamics of N (and C) during decomposition.

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REFERENCES

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