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# Recycling of N between soil and plants during the growing season

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## Abstract

In spite of the known below-ground biomass production of plant roots that concurrently introduce significant amounts of carbon and nitrogen into the soil, the effects of these inputs on N cycling in the soil-plant system are seldom considered. Two field data sets were used to estimate N rhizodeposition by winter wheat plants: (1) a N-turnover experiment to determine the N-fluxes derived from $^{15}$N-labelled clover-residues incorporated into the plough layer of defined plots; (2) a root production experiment to assess the above (shoot) and below ground (gross and net root) biomass production of winter wheat in different fields but near the $^{15}$N plots. Based on the depth distribution of winter wheat net root biomass (root production experiment) and on soil organic $^{15}$N depth distribution ($^{15}$N-turnover experiment), the root N input into soil was estimated to be 282 kg ha$^{-1}$. This was equivalent to 54% of total net N-assimilation of winter wheat. These results give substantial evidence for a N-loop between soil and growing plants, whereby a part of the net mineralised N taken up by the plants is continuously returned into soil by their roots.

## Introduction

The proportion of assimilated N recovered below ground at plant maturity ranges from 14% to 57% in annual plants (Jensen, 1996; McNeill *et al.*, 1996; Janzen, 1990). Rhizodeposition represents a labile fraction of soil N (Jensen, 1996). Due to the difficulties using $^{15}$N labeling techniques in the field, the N rhizodeposition was quantified in pot experiments, where rooting depth and volume were most likely to be restricted as compared to conditions in the field. Thus, we estimated N rhizodeposition under field conditions using complementary data of $^{15}$N fluxes in the plant-soil system and of root dry mass production.

## Materials and methods

The experiments were carried out at the FAM Research Station Scheyern (Bavaria, Germany). In the N turnover experiment $^{15}$N labelled clover residues were incorporated into the plough layer in Oct. 23, 1996. The $^{15}$N signature and N turnover in different soil pools were followed until harvest of the successive crop (winter wheat). The net and gross root production (root length and volume) was measured between 1995 and 1997 at different winter wheat fields adjacent to the $^{15}$N plots.

## Results

Between spring 1997 and the harvest of winter wheat, a significant increase of organic $^{15}$N and concurrent decrease of mineral $^{15}$N was found in the subsoil (Fig. 1). During the first 130 days after straw incorporation, a rapid 50% decrease of initial soil organic $^{15}$N levels was observed (Fig. 2). This stabilised after day 138, whereby $^{15}$N contents remained constant until the harvest of winter wheat at day 286. Within 14 days following incorporation of clover residues, maximum $^{15}$N contents in soil microbial biomass were observed, which decayed exponentially with a turnover rate of 0.0024 day$^{-1}$ (half-life of 289 days, Fig. 2). A pronounced decrease in root length and root dry mass was found with increasing soil depth (Table 1). The gross root production in the upper 30 cm between tillering and early yellow ripeness of wheat plants was 2.6 fold higher than the average values of net root production during this period.

Based on depth distribution of root dry mass and of $^{15}$N in the soil, the gross N-input into the soil (0-90 cm) by winter wheat roots in the N-turnover experiment was estimated at 282 kg ha$^{-1}$ (Table 1), equivalent to 54% of total net N-assimilation of winter wheat.

## Discussion

Our results emphasise that the $^{15}$N which was taken up by winter wheat returned partly into the soil as rhizo-deposits, thus inducing a net increase of organic $^{15}$N in subsoil within the growing period. The stabilisation of organic $^{15}$N in the plough layer was the net effect resulting from N mineralisation and N rhizodeposition.

## References

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*Table 1.* N-inputs by winter wheat roots into the soil in the field experiment deduced from the depth distribution of root dry mass and $^{15}$N-signature in organic N.

| Depth | root dry mass [a)] | Soil organic $^{15}$N total | Soil organic $^{15}$N derived from roots | Soil organic N [d)] derived from roots |
|---|---|---|---|---|
| cm | % of total | % of added $^{15}$N | | kg N ha$^{-1}$ |
| 0-20 | 48 | 41.1 | 15.0 [b)] | 161 |
| 20-50 | 30 | 9.5 | 9.5 [c)] | 103 |
| 50-90 | 22 | 1.8 | 1.8 [c)] | 19 |

a) according to consistent results observed in the root production experiment between 1995 and 1997 (not shown)
b) assuming that $^{15}$N deposition by winter wheat roots was proportional to the root dry mass in each depth
c) assuming that all $^{15}$N in the subsoil was derived from winter wheat roots
d) assuming that mean $^{15}$N signature in the roots was identical to that measured in the shoots of winter wheat plants

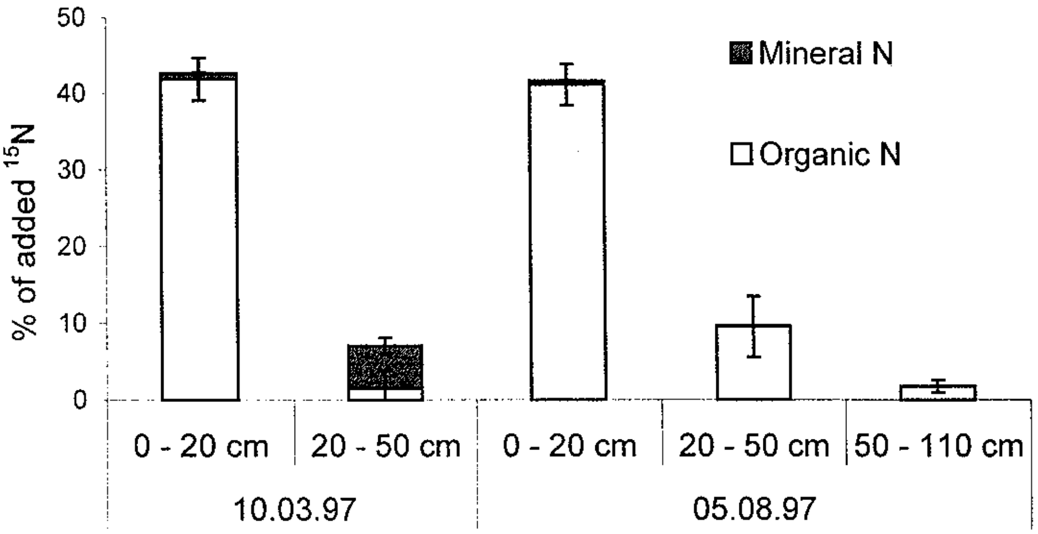


*Figure 1.* Depth distribution of clover-derived $^{15}$N in soil.

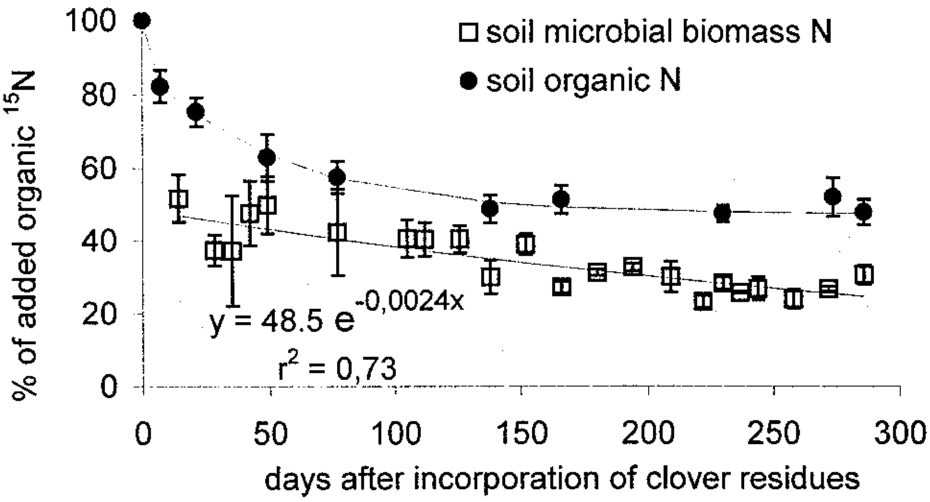


*Figure 2.* Measured values (points) and fitted temporal course (lines) of clover derived $^{15}$N in soil organic matter and soil microbial biomass (0-20 cm depth).