

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/227071481>

Mineralisation of crop residues on the soil surface or incorporated in the soil under controlled conditions

Article in *Biology and Fertility of Soils* · July 2007

DOI: 10.1007/s00374-007-0165-2

CITATIONS

52

READS

677

2 authors:



Samuel Abiven

Ecole Normale Supérieure de Paris

142 PUBLICATIONS 8,840 CITATIONS

[SEE PROFILE](#)



Sylvie Recous

French National Institute for Agriculture, Food, and Environment (INRAE)

267 PUBLICATIONS 10,955 CITATIONS

[SEE PROFILE](#)

Some of the authors of this publication are also working on these related projects:



ResidueGas project [View project](#)



Greenhouse gas emissions and soil carbon fluxes associated with mixtures of crop residues and organic waste products as a fertilizer in sugarcane cropping systems
[View project](#)

Mineralisation of crop residues on the soil surface or incorporated in the soil under controlled conditions

Samuel Abiven · Sylvie Recous

Received: 30 August 2006 / Revised: 15 December 2006 / Accepted: 16 December 2006 / Published online: 7 February 2007
© Springer-Verlag 2007

Abstract In the present work, we compare the effect of mature crop residues mixed into a ferrallitic soil or placed as a single layer on soil surface on the mineralisation of C and N over 55 days. As residues, we used dry stems of rice, soybean, sorghum, brachiaria and wheat. There were no significant effects of residue placement on C mineralisation kinetics. Decomposition of the residues on the soil surface slightly increased net N mineralisation for residues having the smallest C/N ratio.

Keywords Carbon · Crop residue · Location · Nitrogen · Mineralisation

Introduction

The initial location of crop residues in soil, e.g. the presence or absence of mulch on the soil surface or the spreading of fragments in the soil, modifies the physical,

biological and chemical properties of soil, such as water content, temperature, O₂ content (Allmaras et al. 1996), N content, pH and the composition of the decomposer community (Holland and Coleman 1987). The reduced rate of decomposition usually observed under field conditions on the surface (Seneviratne et al. 1998) may be attributed to a limited contact between soil and plant residues. Under controlled conditions, differences related to residue placement appear unclear and sometimes contradictory depending on the duration of incubation or the residue quality (Cogle et al. 1989; Tester 1988). Bremer et al. (1991) observed that mineralisation of carbon from residues with large nitrogen content and large soluble compounds content was not affected by initial location on the soil surface. Fruit et al. (1999) showed that the soil-residue contact influences several biological, chemical and physical parameters that interact and modify residue decomposition. Within this context, the objective of our study was to investigate specifically the effect of placement of residues and its interaction with biochemical residue quality under controlled conditions of decomposition.

S. Abiven (✉)
Department of Geography, University of Zurich,
Winterthurerstrasse 190,
8057 Zurich, Switzerland
e-mail: abiven@geo.unizh.ch

S. Abiven · S. Recous
UR1158 Unité d'Agronomie, INRA,
rue Fernand Christ,
02007 Laon, France

S. Recous
e-mail: recous@laon.inra.fr

Materials and methods

The soil used was ferrallitic with 48% clay, 1.74% organic C and pH 5.6 and was sampled at 30 cm from the surface of an experimental field site in Goiânia (Brazil). The moist soil was sieved (<4 mm) and pre-incubated at 15°C for 7 days. Mineral N content in the soil was adjusted to 80 mg N kg⁻¹ of dry soil with KNO₃ to allow decomposition without N limitation. Dry stems from rice (*Oryza sativa*),

soybean (*Soja hispida*), sorghum (*Sorghum* spp.), brachiaria (*Brachiaria ruziziesens*) and wheat (*Triticum aestivum*) were added to the soil at the rate of 3.2 g dry matter kg⁻¹ soil. Residues were previously chopped to a 2- to 3-mm particle size. The chemical characteristics of the residues are given in Table 1. The details about the methods and an extensive discussion of the results could be found in Abiven et al. (2005). The residue particles were incorporated homogeneously into the soil or placed as a single layer on soil surface. Fresh soil (30 g) with and without residues was placed into 2-l glass jars and incubated at constant temperature (25°C) and moisture (–60 kPa) for 55 days. The CO₂ produced was trapped in 9 ml of 0.25 M NaOH and back titrated with 0.25 M HCl to determine CO₂ production. Mineral N was extracted with 1 M KCl on seven occasions during the incubation (after 0, 2, 3, 10, 17, 23, 37 and 55 days), after destructive sampling of the soil, and analysed for NH₄⁺ and NO₃⁻ by continuous flow colorimetry. Mineralisation of the residue C was calculated as the difference between the treated and the control treatments and expressed per unit of added C. Net N mineralisation was calculated by subtracting the initial soil mineral N content and the soil mineral N content of the control from the mineral N of the treated soil on each sampling date.

Results and discussion

Overall, no significant differences (brachiaria and soybean) or small differences (rice, sorghum, wheat) were observed in the C mineralisation kinetics between incorporated and surface-applied residues (Fig. 1a). Incorporated residues decomposed faster at the beginning of decomposition, but generally, no significant differences were observed after 22 days. The decomposition of the wheat residue, with low N content (Fig. 1a; Table 1), was not affected by placement, thereby confirming results reported by Bremer et al. (1991). Thus, there was no interaction between residue quality (N content) and type of residue placement on C mineralisation.

The brachiaria and soybean residues had high N contents (i.e. smaller C/N ratios) and induced less net

N immobilisation than the other three residues (Fig. 1b), as found by Trinsoutrot et al. (2000). For these two residues, the net N mineralisation was higher with surface residues than incorporated residues treatment. Net N immobilisation was similar for sorghum, rice and wheat residues irrespective of the residue placement (Fig. 1b).

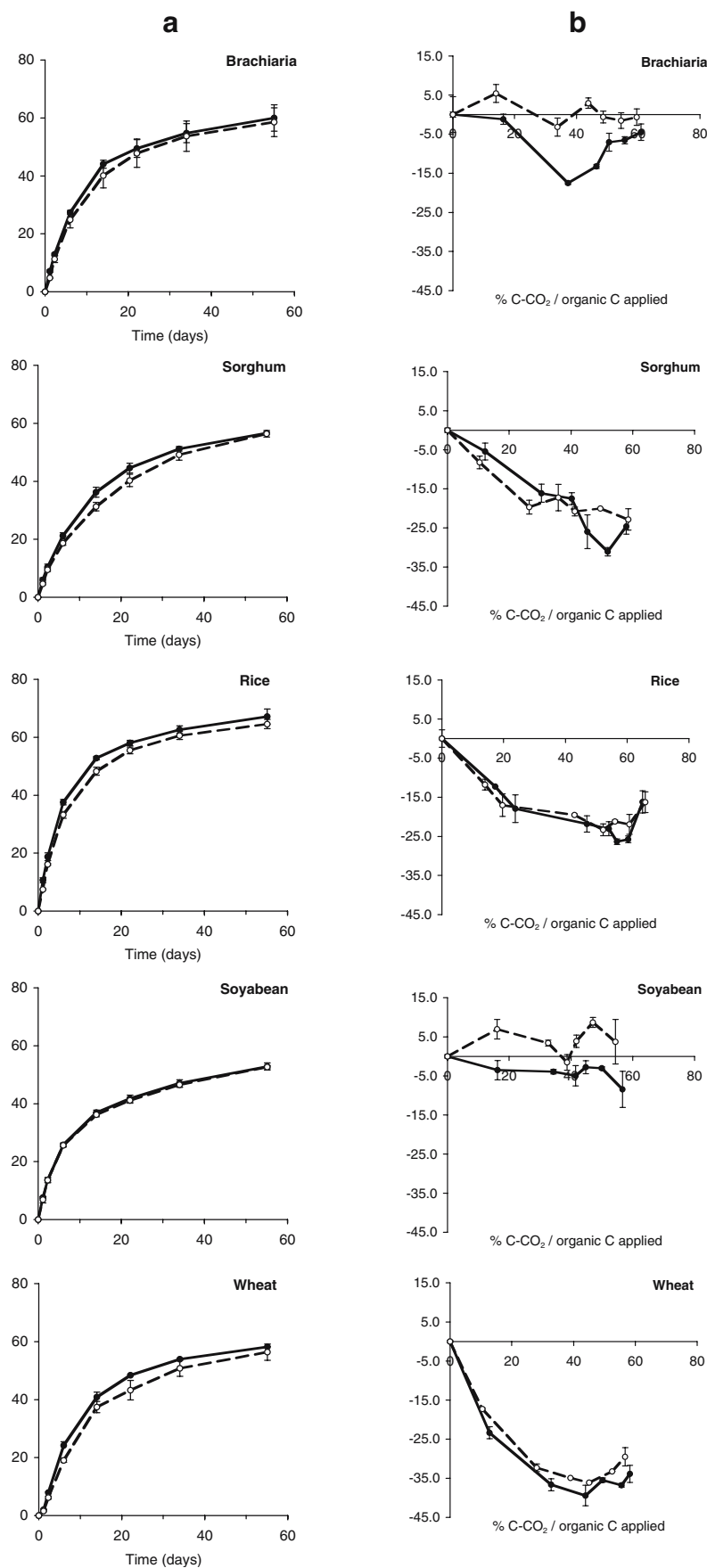
Mineral N was added to the soil to prevent N limitation during decomposition. The absence of an effect of residue placement on C mineralisation suggests that placing a single layer of residue on the soil surface does not affect the availability of soil mineral N to decomposer microorganisms. The micro-aggregated structure of the ferralitic soil probably also increased soil-surface contact with the residue. In addition, the ability of fungi to colonise residue surfaces with their hyphae, even when not directly in contact with the soil, may also explain the observed behaviour because N was translocated through the hyphae (Frey et al. 2000). This mechanism may not be deactivated by increasing the thickness of the mulch on the soil surface, resulting in a larger fraction of the residue mass having no direct contact with the soil. It is important to underline that the laboratory conditions of these experiments are different from those under field conditions, where gradients in temperature, moisture and N are associated with residue location (Coppens et al. 2006).

For Brachiaria and soybean residues, we observed a lower net N immobilisation by the surface treatment compared to the incorporation treatment, and at the same time, no difference in C mineralisation between these two treatments. This implies a lower gross N immobilisation by the surface treatment during the decomposition. As with these low C/N ratio residues, the soil mineral N contributed less to the overall (soil+residue) N immobilisation; this suggests a specific effect of residue-colonising biomass, either having a more efficient use of N (immobilised N per gram of decomposed C) and/or being different in its composition and N requirements. Additional investigations with a larger set of residues, combining varying biochemical quality and N content, are required to further investigate these findings.

Table 1 Biochemical composition of the residues: % soluble neutral detergent fiber (NDF), % hemicellulose, % cellulose, % lignin-like, % water-soluble C, % N and C to N ratio

	% NDF soluble	% Hemicellulose	% Cellulose	% Lignin-like	% Water-soluble C	% N	C/N
Brachiaria	22	32	39	7	18.5	2.3	19.6
Sorghum	19	30	42	9	22.3	0.9	48.5
Rice	27	37	34	3	28.9	1.0	46.6
Soya	33	14	41	12	24.2	2.0	22.5
Wheat	9	27	52	6	12.5	0.4	127.5

Fig. 1 Cumulative CO_2 mineralised expressed as % C-CO_2 /organic C applied (**a**) and net changes in soil mineral N contents (**b**) during decomposition for brachiaria, sorghum, rice, soybean and wheat stems. *Continuous lines* correspond to incorporation of residues and *dotted lines* correspond to surface placement of residues. Values are mean of three replicates



Acknowledgement This research was developed in the framework of a collaborative project between INRA and CIRAD (2000–2002).

References

- Abiven S, Recous S, Reyes V, Oliver R (2005) Mineralisation of C and N from root, stem and leaf residues in soil and role of their biochemical quality. *Biol Fertil Soils* 42:119–128
- Allmaras RR, Copeland SM, Copeland PJ, Oussible M (1996) Spatial relations between oat residue and ceramic spheres when incorporated sequentially by tillage. *Soil Sci Soc Am J* 60:1209–1216
- Bremer E, Houtum WV, Kessel CV (1991) Carbon dioxide evolution from wheat and lentil residues as affected by grinding, added nitrogen, and absence of soil. *Biol Fertil Soils* 11:221–227
- Cogle AL, Saffigna PG, Strong WM (1989) Carbon transformations during wheat straw decomposition. *Soil Biol Biochem* 21:367–372
- Coppens F, Garnier P, De Gryze S, Merckx R, Recous S (2006) Soil moisture, carbon and nitrogen dynamics following incorporation and surface application of labelled crop residues in soil columns. *Eur J Soil Sci* 57:894–905
- Frey SD, Elliot ET, Paustian K, Peterson GA (2000) Fungal translocation as a mechanism for soil nitrogen inputs to surface residue decomposition in a no-tillage agrosystem. *Soil Biol Biochem* 32:689–698
- Fruit L, Recous S, Richard G (1999) Plant residue decomposition: effect of soil porosity and particle size. In: Berthelin J, Huang PM, Bollag JM, Andreux F (eds) *Effect of mineral-organic-microorganism interaction on soil and freshwater environments*. Kluwer, New York, pp 189–196
- Holland EA, Coleman DC (1987) Litter placement effects on microbial and organic matter dynamics in an agrosystem. *Ecology* 68:425–433
- Seneviratne G, Van Holm LHJ, Kulasooriya SA (1998) Quality of different mulch materials and their decomposition and N release under low moisture regimes. *Biol Fertil Soils* 26:136–140
- Tester CF (1988) Role of soil and residue microorganisms in determining the extent of residue decomposition in soil. *Soil Biol Biochem* 20:915–919
- Trinsoutrot I, Recous S, Bentz B, Linères M, Cheneby D, Nicolardot B (2000) Relationships between biochemical quality of crop residues and C and N mineralisation kinetics under non-limiting N conditions. *Soil Sci Soc Am J* 64:918–926