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SHORT COMMUNICATION

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

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Abstract In the present work, we compare the effect of mature crop residues mixed into a ferralitic 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, O_2 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.

Materials and methods

The soil used was ferralitic 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 KNO_3 to allow decomposition without N limitation. Dry stems from rice (*Oryza sativa*),

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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 CO_2 produced was trapped in 9 ml of 0.25 M NaOH and back titrated with 0.25 M HCl to determine CO_2 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 NH_4^+ and NO_3^- 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

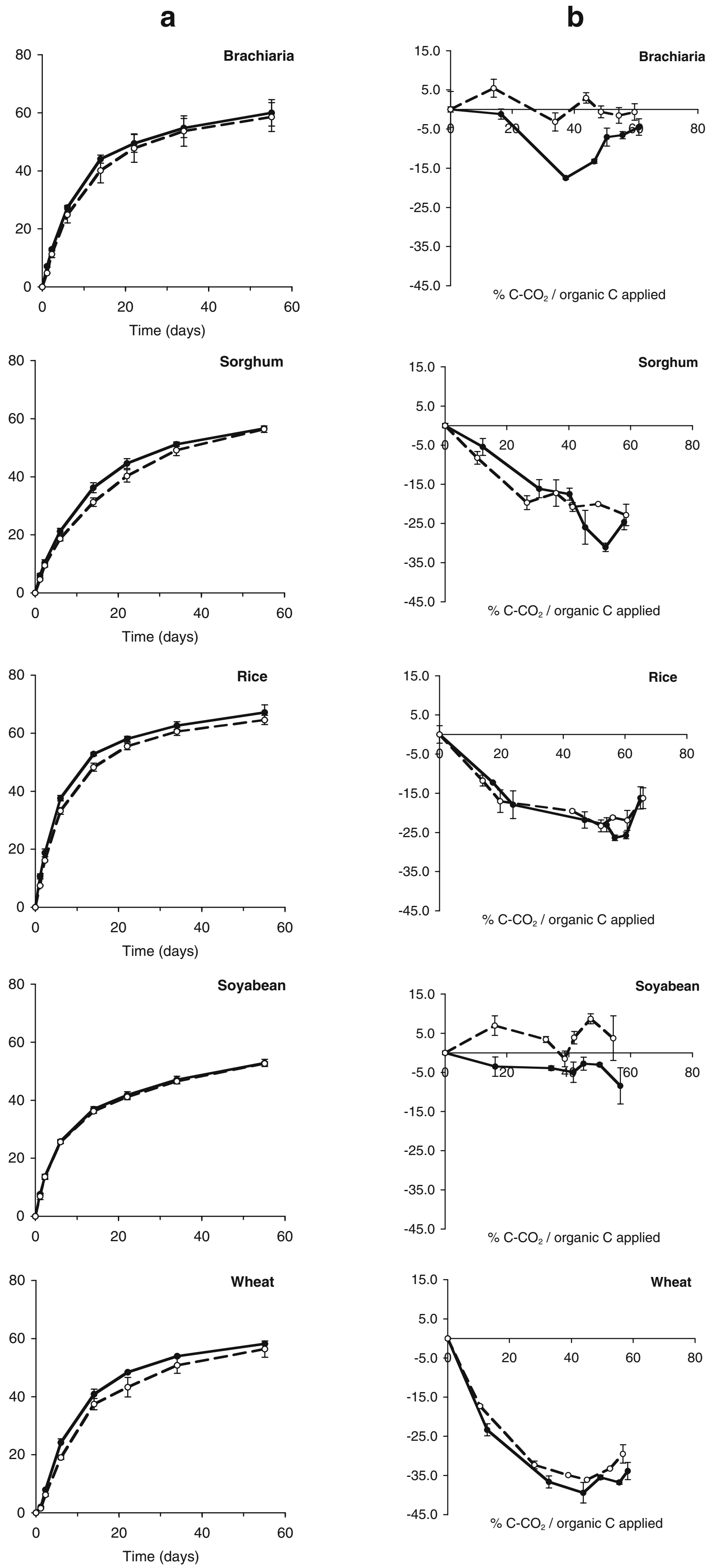

Fig. 1 Cumulative CO_2 mineralised expressed as % C–CO_2/organic C applied (**a**) and net changes in soil mineral N contents (**b**) during decomposition for brachiaria, sorghum, rice, soybean and wheat stems. *Continuous lines* correspond to incorporation of residues and *dotted lines* correspond to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

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