Soil Biol. Biochem. Vol. 24, No. 12, pp. 1535–1538, 1992
Printed in Great Britain.

0038-0717/92 $5.00 + 0.00

EFFECT OF SOIL ORGANIC MATTER QUALITY ON ITS ASSIMILATION BY *MILLSONIA ANOMALA*, A TROPICAL GEOPHAGOUS EARTHWORM

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Summary—Assimilation by *Millsonia anomala* of organic material of decreasing quality (i.e. plant debris at various stages of decomposition, and particle size fractions of soil organic matter) was investigated using cultural and labelling techniques. Assimilation rates were highest with fresh organic matter (undecomposed plant debris or incubated for 2 weeks) and with leaf material rather than root material; this partly results from the high content of watersoluble compounds and the high N availability in fresh organic matter. Earthworm labelling experiments based on ^{13}C showed that after several weeks of decomposition, the nutritive value of plant material rapidly decreases to become equivalent to that of the coarse and fine fractions of the soil organic matter.

INTRODUCTION

As regards the hierarchical model proposed by Lavelle *et al.* (1992), decomposition in soils of the humid tropics is directly under the control of biological factors, such as soil microflora and soil macrofauna. As a consequence, management of soil fertility in the region requires a good knowledge of the diet of organisms feeding on soil.

In most of the humid savannas, soil macrofauna is largely composed by geophagous species (termites and earthworms) which feed on the soil organic matter (Athias *et al.*, 1975; Lavelle *et al.*, 1981). In the wet savannas of Lamto (Ivory Coast), geophagous earthworms represent from 52.5 to 77% of the soil fauna biomass, and annually ingest more than 1000 t soil ha^{-1}, essentially in the upper 20 cm of the soil (Lavelle, 1975). As a result, 15 t ha^{-1} organic matter passes annually through the digestive tracts of earthworms, representing one third of the reserves accumulated in a grass savanna soil and 60% of the organic matter in the first 10 cm of the soil, biotically the most active part of the soil (Lavelle, 1978).

Previous studies showed that the quality, not only the quantity, of soil organic matter determines the growth rate of the worms (Lavelle *et al.*, 1980). In this study we aimed to establish the importance of organic matter quality on its assimilation by *Millsonia*

of their total consumption rate, their growth rate and their growth efficiency. The ^{13}C labelling technique provided a complementary approach to study the assimilation of physical fractions of SOM by *M. anomala*.

MATERIAL AND METHODS

This study was carried out at Lamto, Ivory Coast (5°N, 6°W); the climate is characterized by a high mean annual temperature (28°C) and irregular annual rainfall (rainfall averages 1300 mm yr^{-1}, with a dry season from November to March and in August) (Lecordier, 1975). Most soils lie on a granitic bedrock and are classified as "sols ferrugineux tropicaux" (Riou, 1974) or Ferralsol (FAO).

Vegetation is a mosaic of grass and shrub savannas and forest patches (César and Menaut, 1974). Savanna, the most widespread vegetation type, is maintained by regular annual burning.

Savanna soils are very sandy and have a low clay content (from 2 to 10%); as a consequence water retention is low (field capacity from 10 to 13%). These soils have a low C content (from 5 to 12 mg C g^{-1} soil) and the C:N of the 0–10 cm horizon range from 13.9 to 16.2 (Table 1). pH ranges from 5.5 to 6.5. Rivers are fringed with gallery forests developed

Table 1. Main characteristics of the experimental soils

	Particle size (μm)	Relative mass (%)	C distribution (mg C g^{-1} soil)	C:N
Shrub savanna (10–25 cm)	Total soil		6.5	15.5
Grass savanna (0–10 cm)	250–2000	44.6	0.84	18.2
	20–250	47.6	2.06	17.6
	0–20	7.8	1.42	13.2
	Total soil		4.32	16.2
Gallery forest (0–10 cm)	250–2000	3.3	1.9	22.2
	20–250	48.4	3.3	14.3
	0–20	48.3	12.3	10.8
	Total soil		17.5	12.6

Three different experimental soils were used: Soil sampled from the 10 to 25 cm layer of the soil profile in a shrub savanna; the soil C content ranges from 6 to 7 mg C g^{-1} soil. Leaves and roots of *Loudetia simplex*, the predominant grass of Lamto grass savannas, were also collected and allowed to decompose under aerobic conditions over 2, 5 or 10 weeks, to obtain plant materials referred as L_0, L_2, L_5, L_{10} for leaves, and R_0, R_2, R_5, R_{10} for roots. 10 mg g^{-1} soil [redacted]

(1.4 mg C g^{-1} soil) was substituted with an equivalent fraction of forest soil. The last experimental soil was obtained adding 1 mg g^{-1} soil of fresh wheat roots to unfractionated savanna soil.

For each soil sample, six earthworms collected in [redacted] rate and consumption rate were measured at the end of the experiment.

In that experiment, the introduction of C3 plant material (leguminous, wheat, organic fractions from gallery forest soil) into a soil developed under a C4

RESULTS

Addition of fresh plant material, except roots of *Loudetia*, improved the growth rate of earthworms and induced a decrease of the consumption rate (Table 2). As a result, yield efficiency defined as:

$$Y = \frac{\text{growth rate}}{\text{amount of C ingested}},$$

was significantly greater in soil supplemented with grass leaves, leguminous leaves and wheat roots, as compared to the control; it was from 1.7 to 2 times that of the control when legume leaves or wheat roots were added to the soil, three times that of the control when *Loudetia* leaves were added (Fig. 1). The increase of yield efficiency did not seem to be correlated with the quantity of N added as fresh plant material. On the other hand, ^{13}C abundance measurements of earthworm tissues pointed out that earthworm fed for 25 days on savanna soil supplemented with legume leaves or wheat roots were significantly

Table 2. Growth rate, consumption rate and yield efficiency of young *M. anomala* fed with savanna soil supplemented with different plant materials (Rel. = relative value)

		N added μg g^{-1}	Growth rate (G) ($\Delta p/p$ 100 day^{-1})	Rel.	Consumption rate (C) (g soil g^{-1} day^{-1})	Rel.	Yield efficiency (% mg^{-1} C soil)	Rel.
Control			1.9		18.0		8.1	
L. simplex	L_0	72	4.1	2.1	10.7	0.6	16.6	2.0
leaves	L_2	111	4.3	2.3	7.6	0.4	24.1	3.0
	L_5	78	3.9	2.0	12.2	0.7	13.6	1.7
	L_{10}	78	2.3	1.2	12.4	0.7	8.0	1.0
L. simplex	R_0	65	2.3	1.2	13.0	0.7	7.7	0.9
roots	R_2	61	3.1	1.6	14.4	0.8	9.1	1.1
	R_5	80	2.7	1.4	20.2	1.2	5.8	0.7
	R_{10}	57	1.4	0.7	14.4	0.8	4.3	0.5
Control	m		1.3a		26.4a		10.5a	
	σ_{n-1}		0.28		5.4		4.2	
Legume	*m*	52	1.9b	1.5	24.3a	0.9	17.0b	1.6
leaves	σ_{n-1}		0.51		5.0		5.1	
Wheat	*m*	16	2.1b	1.6	20.7b	0.8	21.1b	2.0
roots	σ_{n-1}		0.31		4.0		5.3	
250–2000 μm	*m*		1.5a	1.1	24.3a	0.9	12.6a	1.2
Fract. of SOM	σ_{n-1}		0.39		7.2		3.6	
0–20 μm	*m*		1.7a	1.3	27.1a	1.0	11.2a	1.1
Fract. of SO:M	σ_{n-1}		0.08		6.1		1.7	

For L_x and R_x: x = number of weeks of incubation.
Data from a same column with different letters are significantly different ($P = 0.05$).
m = Average value; σ_{n-1} = standard deviation; 6 replications.

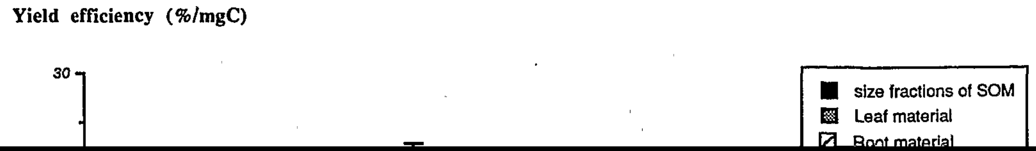
Yield efficiency (%/mgC)
30
size fractions of SOM
Leaf material
Root material

Table 4. Index of assimilation of different plant materials by *M. anomala*

	I*	
	m	σ_{n-1}
Wheat root	7.6a	1.9
Legume leaves	10.5b	1.1
250–2000 μm Fraction of SOM	3.3c	1.4
0–20 μm Fraction of SOM	2.9c	0.7

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