Scientific Paper

Decomposition of the foliage of Leucaena leucocephala *cv. Cunningham associated to* Morus alba *var. tigriada*

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ABSTRACT: This study was designed in an experimental plot where the foliage of *Leucaena leucocephala* (leucaena) is being used since ten years ago as green manure in the *Morus alba* (mulberry) crop, in order to determine the decomposition rate of the legume foliage and the relation of this process with some of the biotic and abiotic factors present in the system. For the study of the foliage decomposition dynamics the litter bag method was used. The foliage deposited in these bags was evaluated at six moments during the study stage, which comprised two years. In each recollection date, the macrofauna population was determined on the remnant litter of each bag through manual separation, according to the methodology of the International Research Program "Tropical Soil Biology and Fertility" (TSBF). The taxonomic composition of the macrofauna associated to the decomposition process of the leucaena foliage was constituted by four Phyla, six classes and seven orders. From the organisms, 97 % were detritivores and 3 %, predators. The type of bag did not influence the foliage decomposition and the climate factors played a decisive role in this process.

Key words: climate factors, edaphic factors, leucaena, mulberry, green manure, macrofauna

INTRODUCTION

Mulberry (*Morus alba*) is a shrub that has proven to have excellent qualities to be used in (small and large) ruminant feeding, because its high levels of crude protein and digestibility largely exceed those of the most used forages in the tropic and are only comparable to the ones reported in concentrate feeds (Benavides, 2002; Martín, 2011).

That is why mulberry has become a known and used species in Cuba and is highly accepted by entrepreneurial and private producers, especially to feed small species in the different livestock production subprograms of urban agriculture (Martín *et al*., 2012).

However, its high dependence on soil nutrients constitutes a limitation for its utilization, although high yields can be expected with the use of chemical fertilizers, but their application is restricted by the high cost and the environmental effect they can have. In this sense, several studies have been conducted related to the use of different organic fertilizers, whose results are encouraging (Martín *et al*., 2007).

The use of tree or herbaceous legumes as green manure is an alternative which should be considered in the implementation of sustainable production systems of mulberry, as a forage plant (Sánchez and Reyes, 2011).

In this sense, Reyes *et al*. (2002) recommended the use of the leucaena foliage as green manure in mulberry plantations. The knowledge of the biotic and abiotic factors that intervene in the foliage decomposition processes of green manures, allows to make a more efficient use of them in production systems. That is why the objective of this work was to determine the decomposition dynamics, the associated fauna and the relation of this process with some biotic and abiotic factors of *Leucaena leucocephala* cv. Cunningham associated to *M. alba* var. tigriada.

MATERIALS AND METHODS

Location and edaphoclimatic characteristics of the experimental area

The study was conducted at the Pastures and Forages Research Station "Indio Hatuey", located between 22º 48º and 7" North latitude and 81º and 2º West longitude, at 19,01 m.a.s.l., in the Perico municipality, Matanzas province, Cuba (Academia de Ciencias de Cuba, 1989); during the period 2008-2010.

The climate characteristics during the development of the research are shown in table 1.

The soil where the experimental stage was conducted is classified as lixiviated Ferralitic Red (Hernández *et al*., 1999), of flat topography, which prevails in 15 % (approximately) of the country surface. Some chemical characteristics are: OM 3,43%; pH 5,80; P_2O_5 1,60 mg /100g and K_2O 5,70 mg /100g of soil.

Description and management of the experimental area

The experimental plot had an association of leucaena with mulberry in a total area of 25 m of length x 50 m of width where the leucaena foliage was used as green manure in the system, and the experimental subplots measured 3,6 x 2,1 m (7,56 m^2), with 63 plants in the net area. The orientation of the sowing was from East to West and the framework was 0,6 x 0,4 and 3 x 3 m for mulberry and leucaena, respectively.

Mulberry, as the main crop, was cut with a 90-day frequency, at a height of 30 cm. The leucaena trees were cut at a height of 2 meters, every three months in the rainy season and every 6 months in the dry season; which was in correspondence with 3 prunings in the rainy season and 2 in the dry season, the woody biomass was withdrawn from the system and the foliage was deposited on the soil.

Treatments and design

The treatments consisted in two types of bags: bags with pores of 1 cm^2 diameter and bags with pores of 1 mm^2 diameter, with 120 repetitions each. The design used was completely randomized.

Procedure used

The foliage decomposition was determined from the biomass loss through time, with regards to the initial weight (Liu *et al*., 2000).

For such purpose the method of litter bags, proposed by Caldentey *et al*. (2001), was used, located in three plots. The bags measured 10 x 10 x 10 cm, with pores of 1 cm diameter (treatment 1), which allows the access to the inside of a wide range of the edaphic biota and bags with pores of 1 mm diameter (treatment 2) which does not allow the access to the inside of the edaphic biota. The foliage in these bags was deposited at six moments during the study stage (10/24/08 to 04/13/09; 04/28/09 to 07/30/09; 08/07/09 to 10/23/09; 11/10/09 to 03/15/10; 04/01/10 to 07/27/10 and from 08/10/10 to 10/26/10). At each moment 240 bags were deposited with 70 g of the leucaena foliage (120 of each type). The bags were placed in such a way that their entire surface was in contact with the organic horizon and they were fixed to the soil through metallic stakes.

Ten bags were randomly chosen (5 of each type), with a bimonthly sampling frequency in the dry season and weekly in the rainy season. In each collection date, the macrofauna population was determined on the remnant litter of each bag through manual separation, according to the methodology of the International Research Program "Tropical Soil Biology and Fertility" (TSBF) proposed by Anderson and Ingram (1993) and the average value of density (individuals m^{-2}) was calculated, as well as the proportional abundance (%) for each taxon. The density was determined from the number of individuals and the relative abundance, through the relation between the quantity of individuals that belong to a taxonomic group and the total of individuals of all the taxonomic groups.

Afterwards, each sample was washed with distilled and deionized water and was put to dry in stove at 60 ºC to constant weight. Then, the difference between initial and remnant weight was calculated.

Table 1. Climate characteristics

Periods of litter decomposition	Season	Variables		
		Mean temp. ºC	RH (%)	Rainfall (mm)
10/24/08 04/13/09	Dry season	20,4	81	252,1
04/28/09 07/30/09	Rainy season	26,2	80	411,8
08/07/09 10/23/09	Rainy season	26,4	84	507,9
11/10/09/ 03/15/10	Dry season	20,4	83	198,8
04/01/10 07/27/10	Rainy season	28,3	86	644,1
08/10/10 10/26/10	Rainy season	26,9	92	528,4

Statistical analysis

Descriptive statistics was used in the variables foliage decomposition, performance of density and biomass of the macrofauna. Besides, to know the interrelation between the variables weight of the residual litter and climate factors a correlation analysis was used. For processing the information the statistical pack SPSS version 11.5 was used.

RESULTS AND DISCUSSION

The performance dynamics of the foliage decomposition in leucaena is shown in figure 1. A similar decomposition pattern was observed in the two types of bags used; however, it was different depending on the deposit time of the bags, a much faster decomposition in the first days being observed in most cases.

In this sense, Martín (1995) reported that the decomposition cycle of the plant material has 3 stages: 1) fast biodegradation of most hydrosoluble and polysaccharide compounds, due to the microbial action and the rain leaching that occur in the first 20 or 30 days; 2) slow decrease of phenolic hydrosoluble compounds and hemicelluloses because of fragmentation, transport, mixture and biodegradation of litter, due to

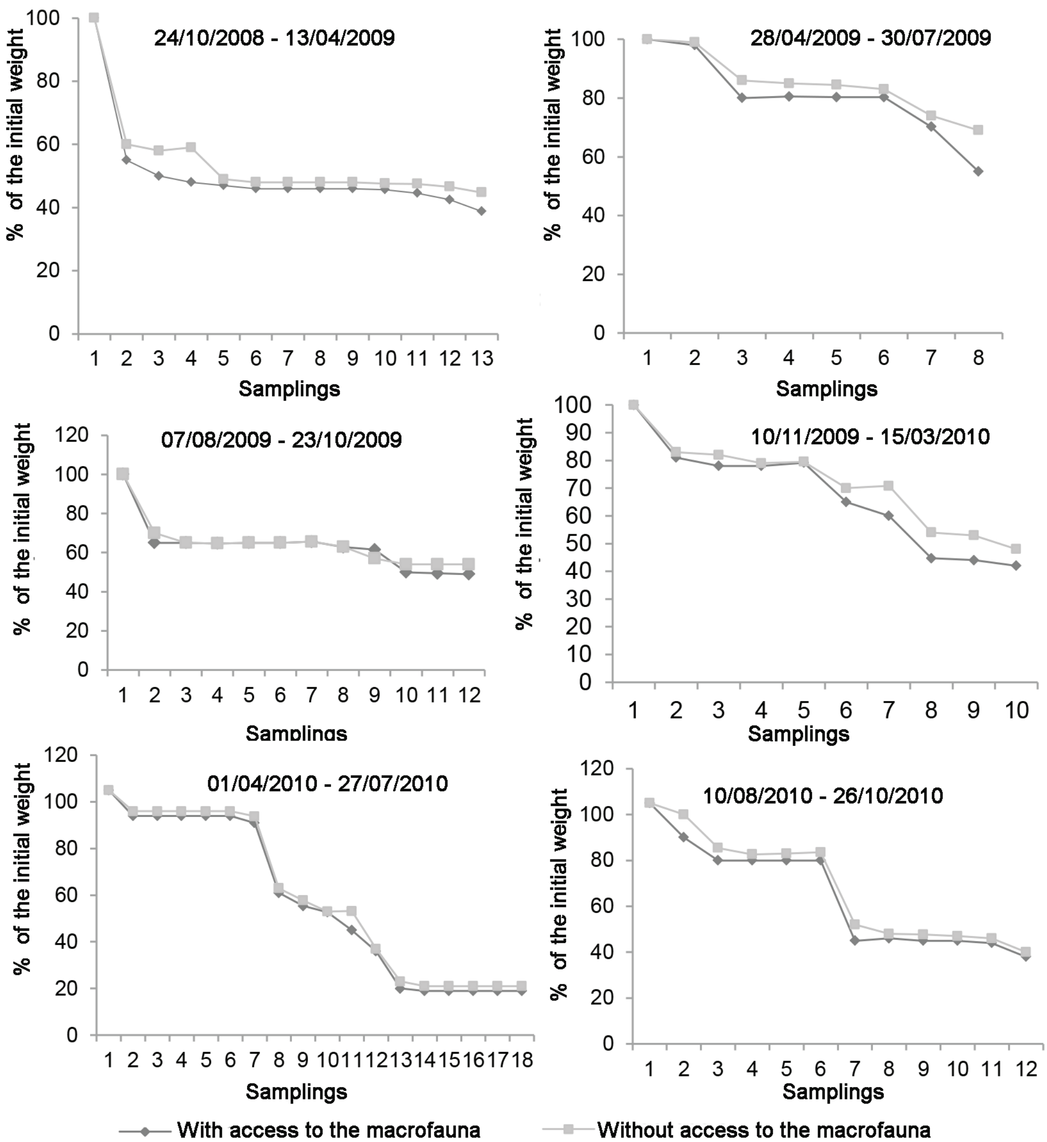

Fig. 1 . Decomposition of the leucaena foliage in different periods.

the microbial and faunistic attack; and 3) increase in the content of lignins and proteins, because of the humic and mineral transformations with the lixiviation of newly-formed hydrosoluble compounds. For such reason, the decomposition rate decreases in time, because the easier substances to decompose are depleted first and a more bioresistant lignin substratum remains afterwards.

In the period from 04/28/09 to 07/30/09, the foliage decomposition was more stable among the different samplings, with regards to the same period of 2010. This could have been due to the fact that, in the latter, the mean temperature, relative humidity and rainfall were higher (table 1).

The quantity of decomposed material was higher and decomposition was faster in the foliage deposited in the rainy season. In this sense, the correlation between the remnant foliage weight and the climate factors (temperature, relative humidity and rainfall) which prevailed in each evaluation moment, showed a higher value with the rainfall, although at certain moments there are significant correlations with temperature and relative humidity (table 2).

This marked action of rainfall on the decomposition process can be due to its direct action on the fragmentation of litter, as well as on the adequate humidity provision of the substratum which, together with the action of temperature, can offer more favorable conditions for the activity of the biota responsible for decomposition (Smith and Bradford, 2003).

Brown *et al*. (1994) stated that temperature explains the decomposition process to a higher extent than rainfall. However, Aerts (1997) and Trofymov *et al*. (2002) stated that the decrease of temperature implies the reduction in the activity of decomposers and reduces the quality of the organic materials that are incorporated in the soil. On the other hand, the rainfall not only influences the process directly, through the lixiviation of the most soluble compounds, but they also modify the conditions for the development of the decomposing fauna, for which both factors act on the dynamics of the litter decomposition of the different plant species.

In this sense, the taxonomic composition of the macrofauna associated to the decomposition process of the leucaena foliage was constituted by four Phyla, six classes and seven orders (table 3). The community was constituted by 97 % detritivorous organisms and 3 % predators.

The effect of edaphic invertebrates on the organic matter decomposition is essential, because through their feeding they make the material more accessible for the action of decomposing microorganisms, in addition to contributing to the dissemination of fungi and bacteria and to the vertical transport of organic matter from the surface to the deepest soil layer, which increases the decomposition rate (Cotrufo *et al*., 2005).

The food selection highly depends on the ecological category of the invertebrate. Epigeal invertebrates, which live and feed on surface litter (Cabrera, 2012) produce *in situ* important modifications of the litter and the decomposing wood. Epigeal arthropods have an additional importance, because they participate in infinity of processes that occur in the soil, such as the reduction of plant fragments and nutrient recycling (Torres *et al*., 2005).

The performance of the density and biomass of invertebrates during the decomposition process of

Table 2. Relation between the remnant weight of the leucaena foliage as green manure and the climate factors.

Deposit moments	r		
	Temperature °C	Relative humidity (%)	Rainfall (mm)
10/24/08 04/13/09	0,075	-0,77**	0,82**
04/28/09 07/30/09	-0,04	0,159	0,84*
08/07/09 10/23/09	-0,45	-0,21	0,78**
11/10/09 03/15/10	-0,62	-0,01	0,96**
04/01/10 07/2710	0,64**	0,78**	0,89**
08/10/10 10/26/10	-0,90**	-0,806**	0,902**

*P< 0,05 **P< 0,001

Table 3. Taxonomic and functional composition of the macrofauna associated to the decomposition process.

Phylum Subphylum*	Class	Order	Trophic group
Arthropoda	Insecta	Coleoptera	Detritivore
		Orthoptera	Detritivore
		Dermaptera	Detritivore
		Diptera	Detritivore
		Lepidoptera	Detritivore
	Diplopoda	Spirobolida	Detritivore
	Aracnida	Araneae	Predator
Arthropoda Crustacea*	Malacostraca	Isopoda	Detritivore
Mollusca	Gastropoda	Stylommatophora	Detritivore
Annelida	Oligochaeta	Haplotaxida	Detritivore

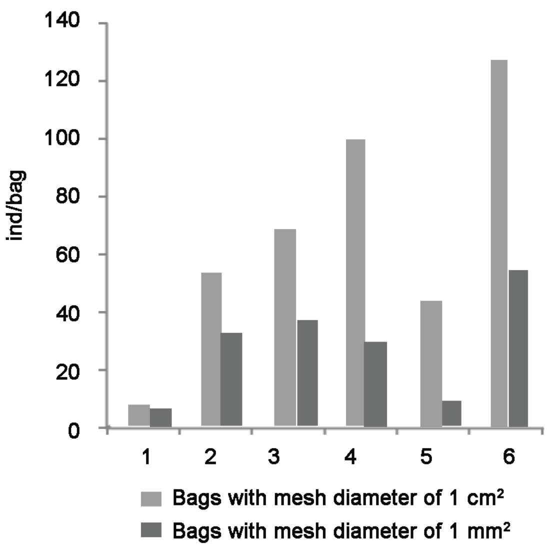

Fig. 2. Performance of the macrofauna density.

the foliage is shown in figures 2 and 3. The highest quantity of the biomass of individuals was reached in the bags with mesh diameter of 1 cm^2 and in general, the performance is also closely related to the performance of meteorological variables.

In addition, the humidity and temperature conditions that are generated in the system, from the presence of leucaena and mulberry seem to have also favored this performance. On the other hand, trees, especially those from the legume family, show a biomass with high protein content, which when deposited on the soil is a food source for edaphic organisms, because it is known that litter is their main food way, besides constituting an ideal niche to take refuge (Hernández *et al*., 2010).

The presence of the different orders of the macrofauna at the different moments of foliage decomposition in the system is shown in figure 4. There was generally higher richness of orders

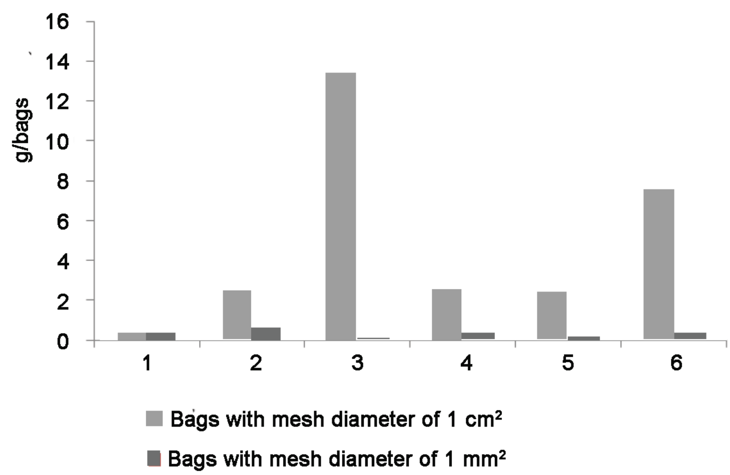

Fig. 3. Performance of the macrofauna biomass.

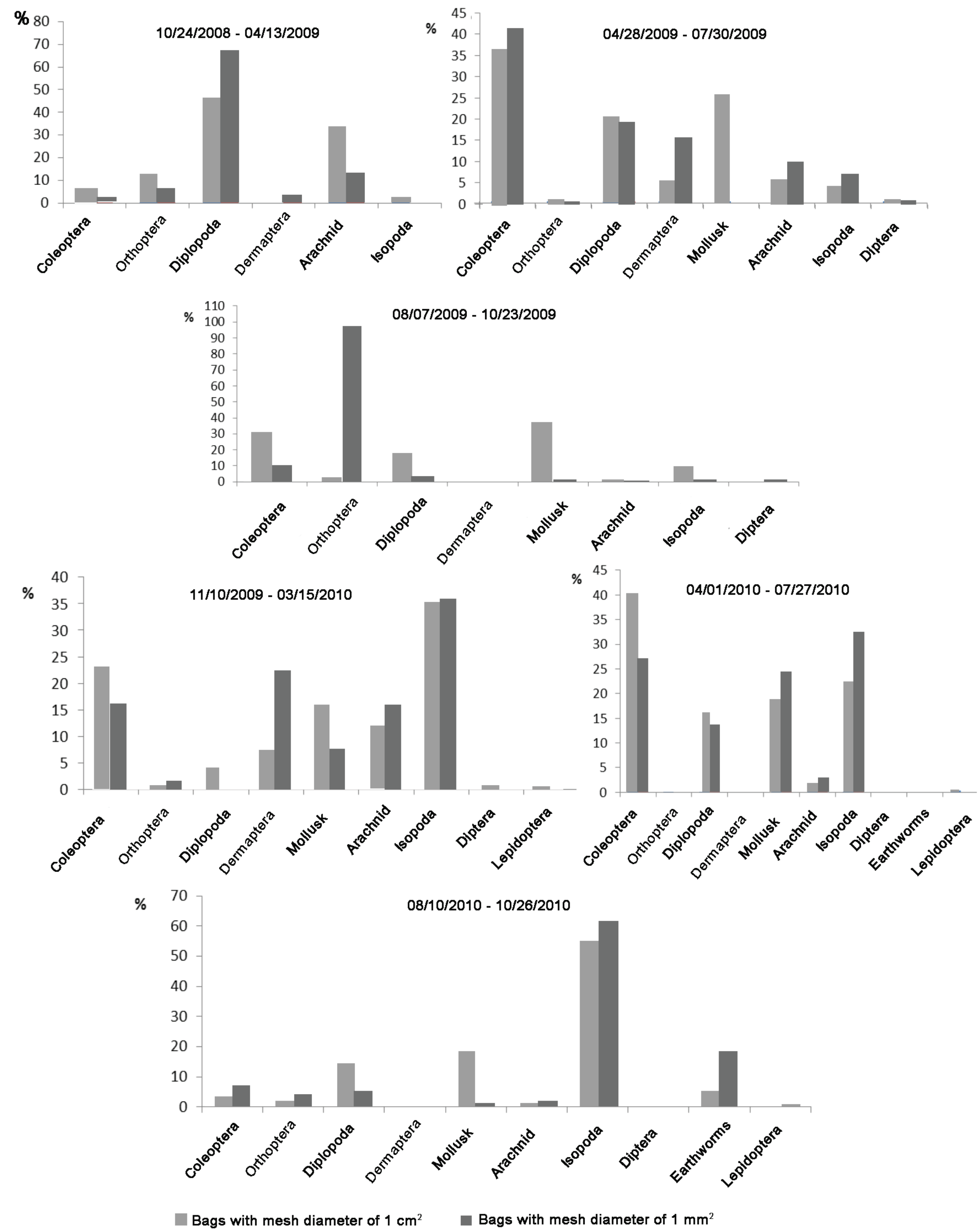

Fig. 4. Proportional abundance (%) of the fauna groups associated to the different decomposition moments of the leucaena foliage.

throughout the decomposition process at the moments that corresponded to the rainy seasons, corroborating the above-explained facts.

Besides, the similarity can be observed, in general, regarding the abundance of orders with regards to the bags used, differing only in the size and weight of the organisms (fig. 2).

In studies conducted by Sánchez and Reyes (2012) in order to determine the richness and abundance of the edaphic macrofauna as indicators of soil quality in a mulberry-legume trees association, found higher diversity when they deposited 100 % of the foliage of the tree legumes on the soil, and especially the predominance of some orders considered vitally important, such as Diplopoda and Isopoda.

García *et al*. (2012) stated that the diversity and abundance of the edaphic macrofauna, as well as the presence of certain groups in a system, can be used as indicators of soil quality; thus, the results of this study allow to infer that, in a certain way, the system of associating trees with mulberry could constitute a sustainable alternative, because there was a higher presence of orders in the system.

According to the results it is concluded that the type of bag did not influence the leucaena foliage decomposition and that the climate factors play a decisive role in the decomposition process.

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