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Dynamics of plant organic matter decomposition in different agricultural landscapes

Dinâmica da decomposição da matéria orgânica vegetal em diferentes paisagens agrícolas

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ABSTRACT - The functioning of ecosystems or agroecosystems is mainly dependent on the soil-litterfall interaction. Thus, the objective of this work was to evaluate the effect of different soil use and management systems on the dynamics of decomposition of plant residues of *Azadirachta indica* (neem) and *Gliricidia sepium* (gliricidia). The study was conducted in four land occupation systems, namely: remaining forest, agroforestry, agricultural mandala, and pasture. The decomposition rate was estimated using nylon bags (litter bags), containing 20 g of leaves of *A. indica* and *G. sepium*, which were arranged on the soil surface of each area for 18, 36, 54, 72, 90, and 108 days. A completely randomized design was used for each species, considering each area as one treatment, with four replications for each collection. The data were subjected to regression analysis and the means were compared by the Tukey's test (p<0.05). More than 85% and 90% of *A. indica* and *G. sepium* plant matters, respectively, had been decomposed after 108 days, regardless of the system evaluated, denoting that these species present high decomposition rates. The phytomass half-life time varied from 16 to 23 days for *G. sepium* and from 25 to 37 days for *A. indica*, depending on the land use system. Edaphic temperature, soil water content, and leaf physical and chemical characteristics are weight loss predictors. The results provide important information to enable forest management practices.

Keywords: Agroecosystems. *Azadirachta indica*. Phytomass leaf. *Gliricidia sepium*.

RESUMO - O funcionamento dos ecossistemas ou agroecossistemas depende, sobretudo, da interação solo-serapilheira. Assim, objetivou-se avaliar a influência de diferentes sistemas de uso e manejo do solo sobre a dinâmica de decomposição dos resíduos vegetais de *Azadirachta indica* e *Gliricidia sepium*. O estudo foi conduzido em quatro sistemas de ocupação da terra, sendo eles: remanescente florestal, sistema agroflorestal (SAF), mandala agrícola e pastagem. A taxa de decomposição foi estimada com o uso de sacolas de *nylon* (*litter bags*), contendo 20 g de folhas de *A. indica* e *G. sepium*, que foram dispostas na superfície do solo de cada área por um período de 18, 36, 54, 72, 90 e 108 dias. Adotou-se um DIC, considerando cada área como um tratamento e quatro repetições a cada coleta, para ambas as espécies. Os dados foram submetidos a uma análise de regressão e as médias foram comparadas pelo teste Tukey (p<0,05). Após 108 dias, mais de 85 e 90% da fitomassa de *A. indica* e *G. sepium*, respectivamente, havia sido decomposta, independente do sistema avaliado, indicando que estas espécies apresentam rápida taxa de decomposição. O tempo de meia-vida (T½) do material vegetal variou de 16 a 23 dias no caso da *G. sepium* e de 25 a 37 dias no caso da *A. indica*, dependendo do sistema de uso da terra. A temperatura edáfica, o conteúdo de água do solo e as características físico-químicas da fração foliar são preditores da perda de massa. Esses conhecimentos podem fornecer importantes informações que viabilizem práticas de manejo florestal.

Palavras-chave: Agroecossistemas. *Azadirachta indica*. Fitomassa foliar. *Gliricidia sepium*.

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INTRODUCTION

Sustainability in agroecosystems is achieved through energetic interactions, nutrient cycling, and biodiversity. Changes in natural landscapes and ecosystems caused by intensive soil use and inadequate production practices cause many changes in microbial biomass and in the composition and diversity of edaphic macro and mesofauna, which are important factors in the fragmentation process of plant residues and redistribution, mineralization, and humification of soil organic matter (ARAUJO et al., 2016; HOFFMANN et al., 2018).

The litterfall decomposition process regulates soil organic matter accumulation and nutrient cycling, which is important for the maintenance of forest ecosystems (OLIVEIRA et al., 2020). In terrestrial ecosystems, the return of nutrients to the soil through litterfall decomposition is an important pathway of the biogeochemical cycle (ALMEIDA et al., 2019). The decomposition mechanism consists of mineralization of biomass, which results from the activity of decomposer organisms, organic matter biochemical characteristics, and environmental conditions such as moisture and temperature, which are important for the decomposition process (BAUER; SANTOS; SCHMITT, 2016; CUNHA et al., 2018).

Recent studies have indicated that organic matter decomposition and mineralization processes, at local level, are affected by the quality of the edaphic environment and microenvironment, i.e., by the interaction between the decomposer biota and soil factors such as moisture and temperature, whose combined effects depends on the biomass exposure time (SOUTO et al., 2013; PINTO et al., 2016; SOUZA et al., 2019; ASSIS et al., 2020). Thus, understanding the processes involved in decomposition and nutrient cycling and the factors that can affect the dynamics of this cycling is important for decision making related to the choice of appropriate management and species that will compose the system (SOUSA et al., 2020).

Gliricidia sepium (Jacq.) Kunth (gliricidia) is an arboreous species native to Mexico and Central America, belongs to the family Fabaceae, and has been widely introduced to tropical regions in the last 200 years; it can be easily found in natural degraded pastures, secondary ecological succession areas, and anthropogenic areas (MARIN et al., 2012). *Azadirachta indica* A. Juss. (neem) is an arboreous species native to India and belongs to the family Meliaceae; it was introduced to Brazil in the 1980 decade and spread to several regions of the country, mainly, to the Northeast region, where it was well adapted to the local climate and, despite its multiple uses, it is an exotic invasive species that still needs to be studied (SANTOS; FABRICANTE, 2020). Although several studies have been carried out to evaluate the decomposition mechanism of many forest species in Brazil, including *G. sepium* (ALVES et al., 2006; PAULA et al., 2015; SOUSA et al., 2020), studies on leaf decomposition of *A. indica*, are scarce in the country, although the species present a high potential for use for different purposes (OLIVEIRA et al., 2020).

Assessing the importance of the decomposition process for different soil use and management systems can provide important information to enable forest management practices and recovery projects for degraded areas. In addition, there are few studies about effects of intensification of agricultural landscapes on decomposition of leaf phytomass of exotic species in the Brejo-de-Altitude microregion (upland forests) in the Northeast region of Brazil. In this context, the objective of this work was to evaluate the effect of different soil use and management systems on the dynamics of decomposition of plant residues of *A. indica* and *G. sepium*.

MATERIAL AND METHODS

Study area

The study was conducted in four land occupation systems at the Center for Human, Social, and Agricultural Sciences (CCHSA) of the Federal University of Paraíba (UFPB), Campus III, Bananeiras, Paraíba, Brazil (Figure 1). The municipality of Bananeiras occupies an area of 256 km² in the Agreste mesoregion, more specifically in the Brejo-de-Altitude microregion (upland forests), at approximately 526 meters of altitude, and 141 km distant from the capital of the state, João Pessoa (IBGE, 2021). The climate of the region is classified as O’, tropical rainy, hot, and wet, according to the Köppen classification, presenting temperatures between 18 and 27 °C and mean annual rainfall depths between 1,200 and 1,500 mm, with autumn to winter rainfalls concentrated from March to August.

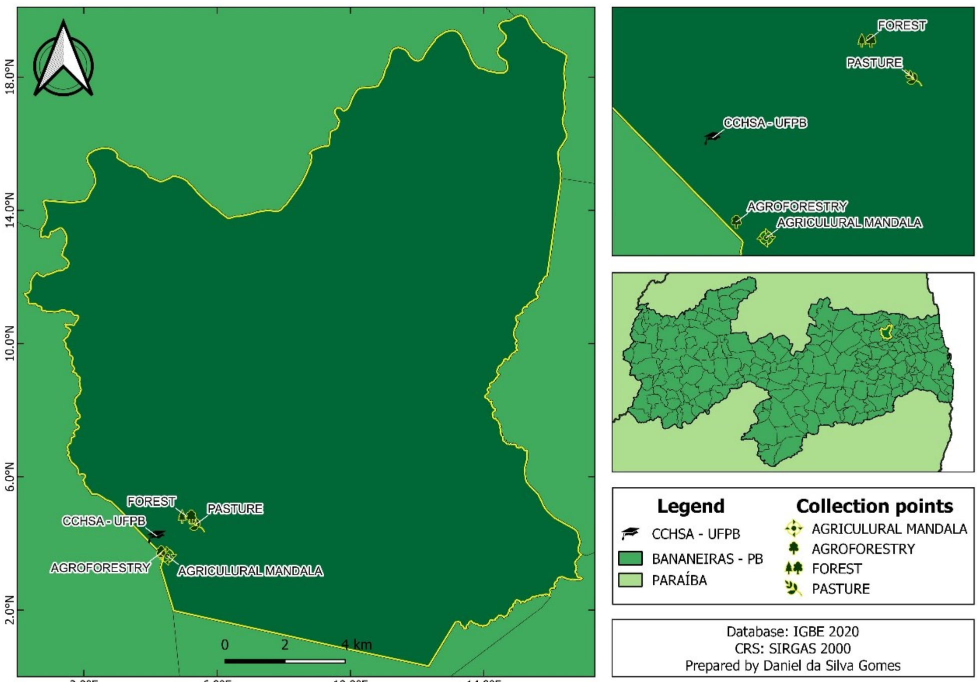


Figure 1. Location of the land occupation systems in the municipality of Bananeiras, Paraíba, Brazil.

The soil of the region was classified with the aid of a specialized agricultural technician. The type of soil found in the evaluated systems was Typic Hapludox (Latossolo Amarelo Distrófico; SANTOS et al., 2018). The phytophysiognomy of the region is typical of the Brejo-de-Altitude microregion of the Northeast of Brazil, which is composed of enclaves of the Atlantic Forest biome in areas with higher altitude and humidity than the xerophilous vegetation of the Caatinga biome (ARAUJO; QUEIROZ; LOPES, 2019). The characteristic humidity of this region is connected to the orographic effect, which increases rainfall levels and decreases temperatures, forming "islands" with different microclimates; this condition makes this region a high biodiversity area.

Characterization of the systems

The land occupation systems are described as follows:

Forest = an open ombrophilous forest remnant of approximately 35.5 ha, considered an important ecotonal forest fragment of the Brejo-de-Altitude microregion by hosting important representative autochthonous specimens of the vegetation typology, which has a phytogenetic and ecological importance for the maintenance of local fauna and flora. The main species found in the area are *Hymenaea courbaril* L., *Talisia esculenta* (Cambess.) Radlk., *Eschweilera ovata* (Cambess.) Mart. ex Miers, and *Licania* sp. The soil of the area was covered by a thick litterfall layer (Figure 2A). No signs of anthropogenic intervention were found in the place, thus indicating that the area was in a good conservation state.

Agroforestry system = the agroforestry had been implemented in an area of approximately 0.68 ha for approximately 16 years, using *Gliricidia sepium* (Jacq.) Kunth ex Walp. as the main plant, and coffee (*Coffea* sp.) as a secondary plant between the tree rows, as this is a crop that demands shade, characteristic of understory species (Figure 2B). The soil of the area had a thin litterfall layer (0.03-0.05 m) composed mainly by phytomass of *G. sepium* and some isolated jackfruit trees (*Artocarpus heterophyllus*). Soil fertilizer application for coffee plants was carried out using caprine/ovine manure at planting and simple superphosphate as topdressing. The plants were irrigated using a dripping irrigation system until the first coffee fruiting. Cultural practices carried out in the area were: selective weeding, pruning of *G. sepium*, and coffee harvest.

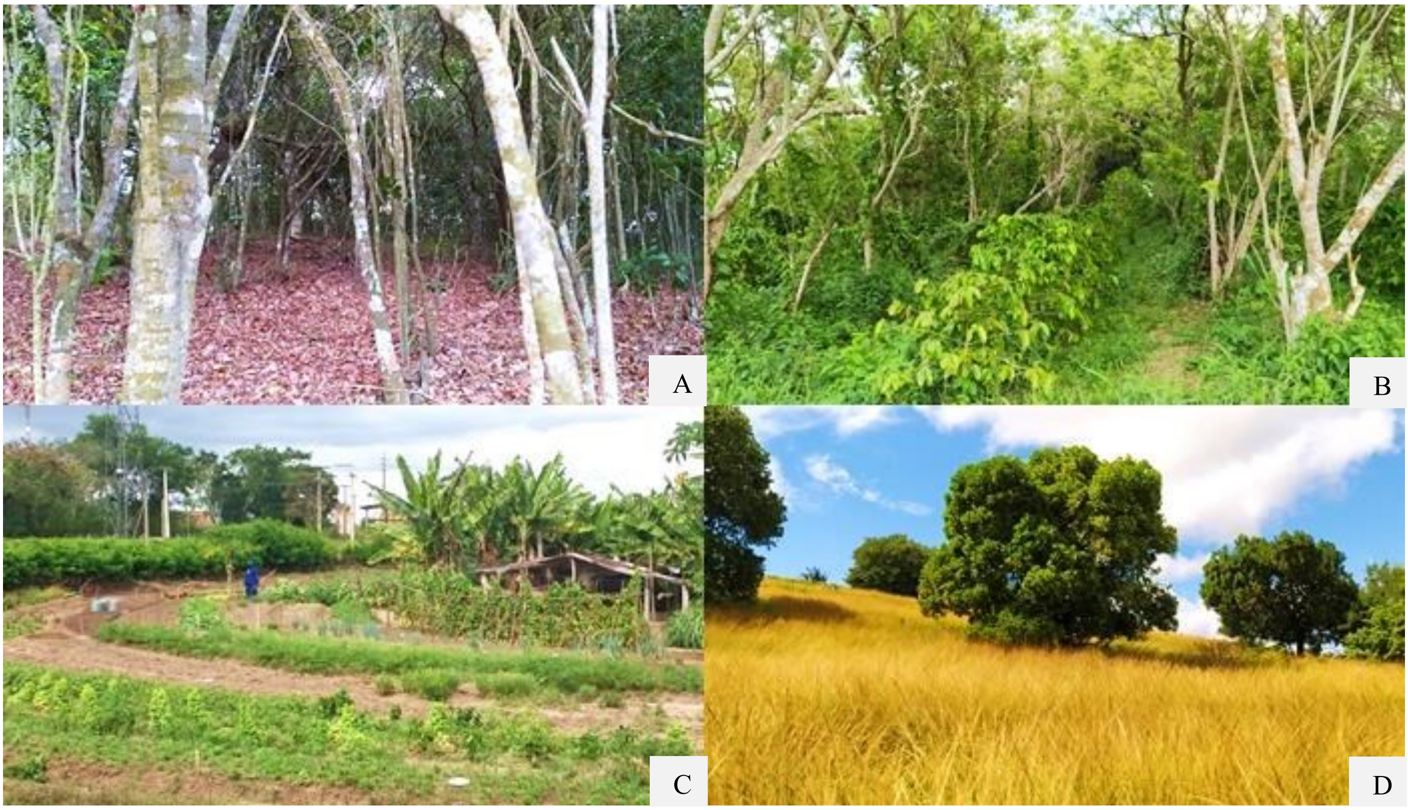


Figure 2. Soil use and management systems: forest (A), agroforestry (B), agricultural mandala (C), and pasture (D).

Agricultural Mandala = an organic production system in a circular shape (Figure 2C) implemented in an area of approximately 0.38 ha approximately 17 years back, which was composed of fruit trees (papaya and banana); annual crops (maize, cassava, common bean, and pumpkin); vegetables (lettuce, fresh chives, carrot, beetroot, kale, coriander, sweet pepper); medicinal and aromatic plants (basil and mint); and non-conventional food plants (taioba, *Xanthosoma sagittifolium*). There were often significant organic matter inputs from crop residues of the system itself and manure from small ruminants. However, the area was managed with low technical criteria. The areas of the system were frequently weeded, and daily irrigated using hoses and sprinklers; there was no systematic use of plant residues for soil cover in the beds, as a large part of the soil was kept exposed and/or with predominance of weeds, such as tiririca (*Cyperus* sp.).

Pasture = area composed of non-identified exotic and native grass species; some dominant herbaceous species, such as salsa-roxa (*Ipomoea asarifolia* (Desr.) Roem. & Schult.); some sparse arboreal species, mostly jackfruit (*Artocarpus heterophyllus* Lam.); and small shrubs (Figure 2D). The area had approximately 1.15 ha and was managed without frequent cultural practices, except for the use of machinery for plowing and harrowing once a year. There was an attempt to recover the area with the use of a grass species (*Panicum maximum*); however, the area was rapidly infested with weeds. Periodically, ovine animals forage in the area.

Leaf decomposition

Two arboreal species were chosen to estimate leaf decomposition, namely, *Azadirachta indica* and *G. sepium*. These species were chosen because they present several uses and had been introduced to several regions of the Northeast region of Brazil, mainly, to the Semiarid regions; in addition, they are easily adapted to several soil use and management systems (MARIN et al., 2012; SANTOS; FABRICANTE, 2020). Leaves of each species were collected directly from *A. indica* and *G. Sepium* individuals, under the criterion of collecting only mature leaves present in branches, considering that they would be the first to enter the senescence process.

The leaf fresh matter was individually dried in an oven at 65±2 °C for 72 hours, until constant weight. Samples of 20.0 g of dry matter of each species were collected and placed in 0.2 × 0.3 m nylon bags (litter bags) made of a 2 mm^2 mesh. This mesh size was used with the purpose of allowing for the access of mesofauna, as well as soil microorganisms that are a natural part of the leaf decomposition process. Ninety-six nylon bags were used for each species to estimate the decomposition rate; the bags were identified and randomly distributed on the soil surface of each area to simulate the natural fall of leaves that form the litterfall. Four bags of each system were randomly collected after 18, 36, 54, 72, 90, and 108 days, totaling six collections at the end of the study. The interval between collection was chosen based on preliminary tests. After each collection, the leaf residues were sent to the Laboratory of Plant Health of the CCHSA/UFPB for the following phases: cleaning of impurities, removal of soil particles and possible organisms trapped in the leaves; drying in oven; and weighing in an analytical balance with precision of 0.001 g.

The constant of decomposition (k) of the leaf fraction of each species was calculated based on the remaining weight obtained for each collection, which were fitted to the exponential model recommended by Thomas and Asakawa (1993) (Equation 1):

$$Pt = P_0 \,.\, e^{-k.t} \tag{1}$$

where Pt is the remaining dry weight of the sample after t days; P_0 is the initial dry weight placed in the bags at time zero ($t = 0$); t is the time in days; and k is the constant of decomposition.

The leaf phytomass half-life was calculated based on the constant of decomposition (k) to determine the decomposition rate in days (Equation 2). This value was obtained through the linearization of the previous model, and its result corresponded to the time required for half of the initial amount of leaf matter to decompose.

$$T½ = ln\frac{2}{k} \tag{2}$$

where $T½$ is the leaf phytomass half-life and k is the constant of decomposition obtained from the fit to non-linear model.

The residues of the initial dry matter of each species, i.e., those that not were placed in the litter bags, were crushed in a mill to determine: carbon (C) contents, through nitric-perchloric digestion, by burning in a muffle at temperature of 550 °C; nitrogen (N) contents, by the Kjeldahl method; and cellulose, hemicellulose, and lignin contents, through the method of acid detergent fiber, according to methodologies described by Embrapa (2017) and Silva and Queiroz (2002). The results were used to calculate the C to N, cellulose to N, and lignin to N ratios, whose results, together with the nutrient contents, were used as predictors of weight loss in the treatments.

Monitoring of geoclimatic parameters

Parallelly to the plant matter collection, which was carried out from March 01 to June 16, 2021, during the rainy period in the region (Figure 3), temperature and moisture of the soil surface layer were measured in randomly chosen points, always at the same time, at 01:00 p.m., using a digital thermometer (TE-500; Instrutherm®). This evaluation timing was chosen due to the high ultraviolet radiation incidence on the region in this period, which allowed for assessing the effect of land cover, provided by the canopy of plants, on the mean temperature and thermal amplitude of the soil in the evaluated systems.

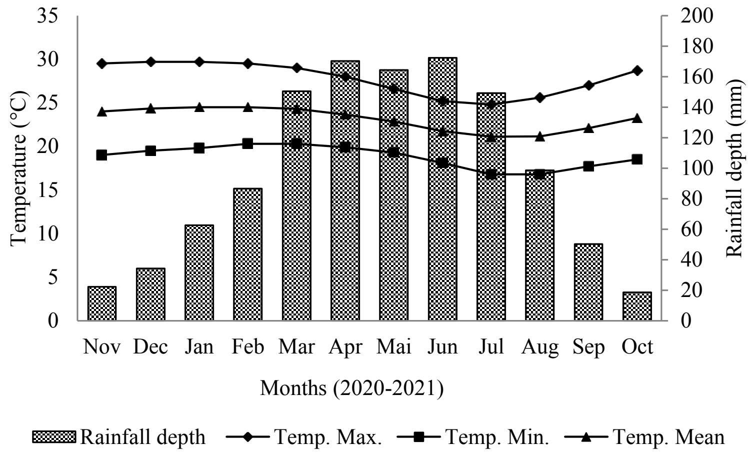


Figure 3. Mean monthly rainfall depths (mm) and maximum, minimum, and mean temperatures (°C) in the municipality of Bananeiras, PB, Brazil (BDMEP, 2021).

Soil moisture was measured on simple samples from the 0-0.1 m soil layer, collected in each area, with two replications for each determination. The soil samples were taken to the laboratory, weighed in a precision balance (0.001 g), inserted in aluminum containers, and placed in an oven at 105±1 °C for 24 hours. The soil moisture was then calculated using the following Equation 3:

$$U\% = \left(\frac{Pu - Ps}{Ps}\right).100 \qquad (3)$$

where *U%* is the soil moisture percentage; *Pu* is the wet weight (g), and *Ps* is the dry weight (g).

Soil chemical analysis

The analyses were carried out at the Laboratory of Soil Physical and Chemical Analysis of the CCHSA/UFPB. Four simple samples of the 0-0.2 m soil layer were collected from each system. The samples were air dried, sieved through a 2 mm mesh sieve to remove stones and branch and root fragments, then ground and homogenized, forming a composite sample. The following chemical attributes were evaluated: pH, P, K^+, Na^+, $H^+ + Al^{+3}$, Al^{+3}, Ca^{+2}, Mg^{+2}, sum of bases (SB), cation exchange capacity (CEC), base saturation percentage (BS), and organic carbon (OC) content, following the methodology proposed by Embrapa (2017). The main chemical characteristics of each soil type and land use system are shown in Table 1.

Table 1. Chemical attributes of soils under different land occupation systems in the Brejo-de-Altitude microregion, municipality of Bananeiras, PB, Brazil.

Attributes	Systems			
	Forest	Agroforestry	Mandala	Pasture
pH (H_2O)	4.99	5.55	5.84	5.61
P ($cmol_c\ dm^{-3}$)	0.02	0.13	0.27	0.05
K^+ ($cmol_c\ dm^{-3}$)	0.14	0.30	0.29	0.24
Na^+ ($cmol_c\ dm^{-3}$)	0.83	0.04	0.23	0.01
H^++Al^{+3} ($cmol_c\ dm^{-3}$)	5.19	4.41	1.49	1.64
Al^{+3} ($cmol_c\ dm^{-3}$)	0.10	0.05	0.35	0.10
Ca^{+2} ($cmol_c\ dm^{-3}$)	1.83	2.70	3.45	0.98
Mg^{+2} ($cmol_c\ dm^{-3}$)	1.80	2.78	1.88	1.75
SB ($cmol_c\ dm^{-3}$)	3.85	5.84	5.73	3.00
CEC ($cmol_c\ dm^{-3}$)	8.06	9.56	7.54	4.14
BS (%)	41.26	55.94	84.34	69.59
OC ($g\ kg^{-1}$)	28.09	26.07	22.87	8.65

pH = potential hydrogen; P = available phosphorus; K^+ = exchangeable potassium; Na^+ = exchangeable sodium; $H^+ + Al^{+3}$ = exchangeable acidity; Al^{+3} = exchangeable aluminum; Ca^{+2} = exchangeable calcium; Mg^{+2} = exchangeable magnesium; SB = sum of bases; CEC = cation exchange capacity; BS% = base saturation percentage; OC = organic carbon.

Statistical analysis

A completely randomized design was used, considering each area as one treatment, with four replications for each collection, for both species. The Shapiro-Wilk and Bartlett tests were used to assess the normality of data and homogeneity of variances, respectively. The data were subjected to regression analysis as a function of collection times and the means were then compared by the Tukey's test (p<0.05). The statistical analyses were carried out in the program R 4.1.0 (R CORE TEAM, 2021).

RESULTS AND DISCUSSION

The treatments (land occupation systems) presented significant effect (p<0.05) on the remaining weight of both species (*Gliricidia sepium* and *Azadirachta indica*). The biochemical analyses of the initial leaf fraction of the species showed the highest C to N, cellulose to N, and lignin to N ratios for leaves of *A. indica* (Table 2).

The decrease in remaining leaf matter of the species over 108 days of study under the edaphoclimatic conditions of the experimental area resulted in significant differences between the means of the treatments evaluated (p<0.05). Table 3 shows the means of remaining weight in the land use system for each collection time for both species. The systems were grouped in a descending order for each species, based on the total percentage of weight loss, caused by decomposition, at the end of the experiment. The remaining weight of *G. sepium* was statistically equal between the systems after 54 days. The remaining weight of *A. indica* was statistically similar between systems only after 72 and 90 days. Both species presented a relatively high decomposition rate; more than 85% of the leaf fraction of *A. indica* had been decomposed after 108 days, regardless of the system evaluated. This percentage was even higher for *G. sepium*, whose weight percentage was higher than 90%, regardless of the land cover system evaluated.

Table 2. Characterization of the initial composition (time zero) of leaf fraction of *Gliricidia sepium* and *Azadirachta indica*.

Species	C	N	Cellulose	Hemicellulose	Lignin	C/N	Cel/N	Lig/N
	g kg^{-1}							
G. sepium	347.25	28.36	190.16	185.70	163.08	12.24	6.70	5.75
A. indica	448.08	18.78	215.10	213.38	207.04	23.85	11.45	11.02

C = organic carbon; N = total nitrogen; C/N = C to N ratio; Cel/N = cellulose to N ratio; Lig/N = lignin to N ratio.

Table 3. Remaining weight (g) and total percentage of weight loss by decomposition of leaves of *Gliricidia sepium* and *Azadirachta indica* for each system and collection time (days).

System	Time (days) 18	36	54	72	90	108	Weight loss (%)
	Gliricidia sepium						
Pasture	8.01 a	3.87 a	3.18 a	1.18 b	0.45 c	0.23 b	98.85
Mandala	11.51 a	6.34 a	3.92 a	2.23 ab	1.66 b	0.64 ab	96.80
Forest	7.43 a	4.92 a	3.26 a	2.10 ab	1.46 b	0.89 ab	95.55
Agroforestry	8.57 a	5.82 a	4.77 a	3.16 a	2.98 a	1.79 a	91.05
	Azadirachta indica						
Pasture	14.69 a	14.53 a	12.23 a	6.11 a	2.94 a	0.68 b	96.60
Mandala	10.89 b	9.35 b	5.65 b	4.24 a	3.34 a	2.33 a	88.35
Forest	8.41 bc	6.88 b	6.53 b	5.22 a	4.49 a	2.43 a	87.85
Agroforestry	7.82 c	6.85 b	5.90 b	4.73 a	4.37 a	2.70 a	86.50

Means followed by the same letter in the same columns are not different from each other by the Tukey's test at 5% significance level.

The leaf weight loss was continuous for *G. sepium* (Figure 4A) and *A. indica* (Figure 4B) in all soil use systems evaluated. The graphic projection of decomposition curves of *G. sepium* (Figure 4A) showed similar results between systems, with the data fitting to a quadratic polynomial model. More than 50% of the leaf matter had been decomposed in the first collection of litter bags after 18 days, except for bags that were distributed in the agricultural mandala, whose remaining weight was 11.5 g, i.e., only 42.5% of the plant matter had been decomposed. However, the mean remaining weight of

G. sepium was close to 1 g after 108 days, considering all systems evaluated (Figure 4A).

Regarding the remaining weight of *A. indica* (Figure 4B), a slower plant residue decomposition was found in the pasture when compared to the other land use systems; the remaining weight was 12.2 g after 54 days, i.e., only 38.85% of leaf matter had been decomposed. However, a pronounced decrease in the remaining weight of *A. indica* was found in this system after 54 days, which reached 0.68 g at 108 days, with data fitting to a linear model. This is probably due to the higher exposure of the nylon bags to weather events, making the leaf residue passing through more intense moistening and dehydration cycles due to rainfall and solar radiation, respectively, as there were little soil cover plants in this system. The mean remaining weight of *A. indica* in the other land use systems fitted to a quadratic polynomial equation, with initial periods presenting the lowest values in the agroforestry and forest systems (Figure 4B), thus indicating that the microorganisms (detritivores) present in these systems are probably more efficient to deteriorate plant organic matter from forest species.

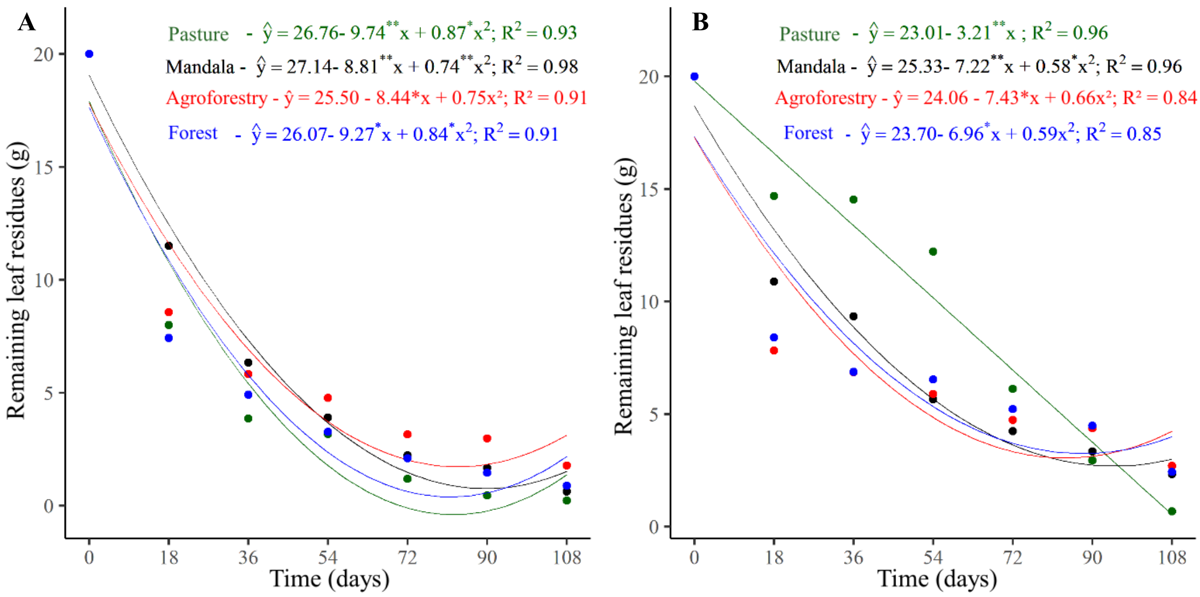


Figure 4. Remaining leaf residues (g) of *Gliricidia sepium* (A) and *Azadirachta indica* (B) as a function of time under different land use and cover systems.

Assis et al. (2020) evaluated litterfall decomposition in two agroforestry systems, one recently-implemented and other already established, with approximately 1 and 10 years of implementation, respectively, and found lower remaining leaf weight and higher decomposition rate for the agroforestry system already established, due to inherent characteristics of the system that favors decomposition. Despite these two systems present similar components, the use and management time can affect the availability and release of nutrients to the soil and their return to plants. Thus, even when two areas are geographically close to each other and under the same climate regime, but present differences in land occupation and cover, they can present heterogeneous decomposition dynamics (BAUER; SANTOS; SCHMITT, 2016). Gomes et al. (2021) also found effect of soil use and management systems on decomposition of dry biomass of *G. sepium*; the agroforestry, consisted of *G. sepium* and coffee was the system that presented the highest decomposition rates, thus indicating that this leguminous species can be recommended for supplying the biomass demand and availability of nutrients in agroforestry systems.

The equations used for estimating the constant of decomposition (*k*) and the half-life projection curve of the species in each land use and management system presented estimates close to those found in the field. The species *G. sepium* and *A. indica* presented *k* values varying from 0.0300 to 0.0433 g g^{-1} day^{-1} and 0.0182 to 0.0268 g g^{-1} day^{-1}, respectively (Table 4).

The results showed that the leaf phytomass half-life, i.e., time for decomposing 50% of the leaf matter, was approximately 16 to 23 days for *G. sepium*, depending on the land use system. In the case of *A. indica*, these values were a little higher, varying from 25 to 37 days, depending on the land use system (Table 4). Despite the half-life of *G. sepium* leaf phytomass was shorter in the pasture system, the longest half-life of *A. indica* leaf phytomass was found in this land use system. It can be connected not only to the microenvironment quality, but also to plant matter physical and chemical characteristics (PINTO et al., 2016). According to Alves et al. (2006), *G. sepium* plants present low resistance to decomposition when compared other species occurring in the Caatinga biome. In addition, the results found in the present study showed higher N content and lower C to N, cellulose to N, and lignin to N ratios for *G. sepium* (Table 2), which would result in less recalcitrance of plant matter when compared to that of *A. indica*.

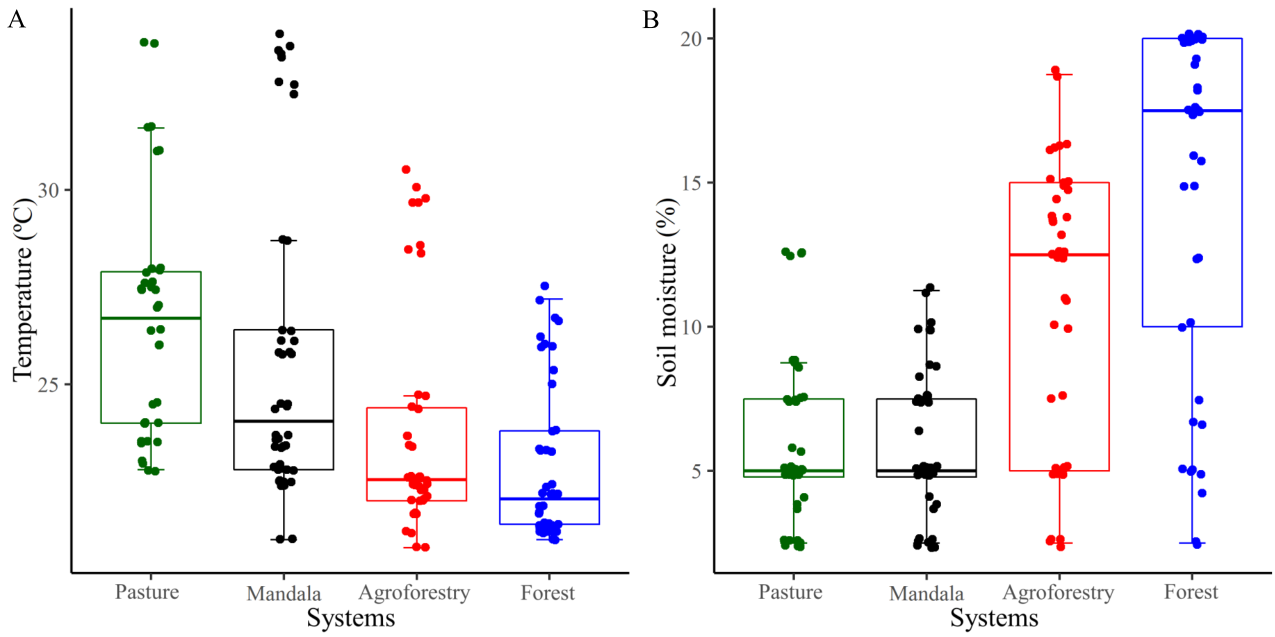
Table 4. Constant of decomposition (*k*) and half-life (T½) of the leaf fraction of *Gliricidia sepium* and *Azadirachta indica* plants, fitted through simple exponential model for each land use and cover system.

Systems	*Gliricidia sepium*			*Azadirachta indica*		
	k (g g^{-1} day^{-1})	SE	T½ (days)	*k* (g g^{-1} day^{-1})	SE	T½ (days)
Pasture	0.043	0.002	16	0.018	0.002	37
Mandala	0.031	0.006	22	0.023	0.004	29
Agroforestry	0.030	0.006	23	0.026	0.005	25
Forest	0.036	0.183	19	0.025	0.166	26

k = constant of decomposition; SE = standard error of the *k* estimate; T½ = leaf phytomass half-life.

Paula et al. (2015) and Sousa et al. (2020) also found shorter half-life for *G. sepium* phytomass when compared to other commonly used species in agroforestry systems. According to these studies, biomass uptake and plant residue decomposition can be important sources of carbon and nutrients to the soil biota and, then, to plants. Arboreal species have deep root system; thus, they can extract nutrients from deeper soil layers, making them available for the growth of plants through nutrient cycling.

The analysis of the edaphic temperature in each land occupation system showed the highest temperatures for the pasture system, with median of 27.4 °C, followed by the agricultural mandala, agroforestry, and forest systems, with medians of 24.0, 22.5, and 22.0 °C, respectively (Figure 5A). However, the soil water contents found for the systems (Figure 5B) presented the following ascending order: 5% (pasture), 5% (agricultural mandala), 12.5% (agroforestry), and 17.5% (forest). These are interesting results, as they denote that land use systems with a dense plant cover present low edaphic temperatures and high soil water contents because of presence of litterfall. These characteristics can affect the decomposition dynamics of plant residues that are deposited on the soil surface, mainly by the activity of soil microorganisms.



Horizontal lines inside the boxes represent the medians; lower and upper limits of the boxes represent the lower and upper quartiles, respectively; vertical lines point out the maximum and minimum values.

Figure 5. Distribution of frequency of edaphic temperature (°C) (A) and soil moisture (%) (B) in systems under different land use and cover systems.

Soil moisture may have been a determinant factor for the decomposition process of the samples, as the study was conducted during the rainy period in the region, resulting in temperatures and soil moisture contents considered favorable for the decomposition process. Plant residues deposited on the soil surface are efficient for conserving soil moisture and reducing soil temperature in approximately 8 °C (VIEIRA et al., 2021). Some studies also found higher leaf litterfall decomposition rates for other arboreal species in periods with higher soil water contents, which result in an intense activity of microorganisms (SOUTO et al., 2013; ALMEIDA et al., 2019; SOUSA et al., 2020).

Silva et al. (2022) found that areas with natural vegetation present approximately 28% lower soil temperature when compared to areas with little plant cover, and that environmental stimuli, such as temperature and soil moisture, affect the organic matter decomposition dynamics and, consequently, the release of soil CO_2, indicating that management techniques that reduce the soil surface temperature and increase organic matter contents should be prioritized to improve soil biota. These attributes emerge as important indicators of soil environmental quality, as they estimate the extent of functional sustainability regarding ecological aspects of land use and occupation systems (SILVA et al., 2021).

The biomass production of *G. sepium* and *A. indica* may favor, in the long-term, improvement in soil fertility and increase in availability of nutrients to crops interspersed with agroforestry or in agriculture-livestock-forest systems. However, it requires adjusts in pruning managements and densities of intercrops to avoid possible competition with crops of agronomic interest. Moreover, despite the two species present several uses, both are exotic, and the introduction of these species to agricultural and scenic sectors should be carried out with caution, mainly regarding *A. indica*, as it is an aggressive exotic invasive species and some studies have indicated that it can release potent allelochemicals into the environment, causing impacts on native biota (SANTOS; FABRICANTE, 2020).

Further studies should be conducted on this research line, evaluating the kinetic decomposition of other arboreal species, mainly native species with potential for recovery of degraded areas. These studies could provide important information to enable forest management practices and recovery projects for areas susceptible to desertification.

CONCLUSIONS

Plants of the species *Gliricidia sepium* and *Azadirachta indica* may present heterogeneous leaf decomposition dynamics in different land use and cover systems.

The species *G. sepium* and *A. indica* presented high leaf decomposition rate in the period evaluated, regardless of the land cover system.

The leaf phytomass half-life varied from 16 to 23 days for *G. sepium* and from 25 to 37 days for *A. indica*, depending on the land use system.

G. sepium leaves presented higher decomposition rate in the pasture, followed by the forest, agricultural mandala, and agroforestry systems, in this order.

A. indica leaves presented higher decomposition rate in the agroforestry, followed by the forest, agricultural mandala, and pasture systems, in that order.

Edaphic temperature, soil water content, and plant matter physicochemical characteristics are factors that strongly affect leaf decomposition.

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