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Foliar decomposition of Caatinga species in Alagoas

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Abstract

Leaf decomposition is one of the main processes that regulate nutrient cycling. Understanding how the decomposition process occurs makes it easier to understand ecological processes in ecosystems. The aim of this study was to evaluate the leaf decomposition of *Byrsonima gardneriana* A. Juss, *Tocoyema formosa* (Cham and Schltl) K. Schum and *Tabebuia* sp. of Caatinga in Delmiro Gouveia, Alagoas. To evaluate the decomposition, leaves were collected from the three species, oven dried at 65 °C for 72 hours, weighed 15.0 g of leaves and inserted into the litterbags, which were distributed on the soil surface, withdrawing monthly ten per species, which again were dried and weighed for determination of decomposition relative to the initial weight. About the species evaluated during the 300 days, *T. formosa* presented a higher rate of decomposition, followed by *Tabebuia* and *B. gardneriana*; The decomposition of leaf material is influenced directly by rainfall, since when precipitation is higher, decomposition increases; The studied region went through a long period of drought, making it difficult to decompose the leaf material of the species sampled; The carbon and organic matter contents are superior to other Caatinga environments, due to the good conditions of the experimental area, however these variables did not present significant relation with decomposition of the species; The C/N ratio influences the decomposition of species leaf material of *T. formosa* and *Tabebuia*; Due to the microclimatic conditions and characteristics of the plant material, *B. gardneriana* was the slowest decomposing species.
Keywords: Semiarid; Native species; Nutrient cycling; Climate conditions.

Resumo

A decomposição foliar é um dos principais processos que regulam a ciclagem de nutrientes. Entender como se dá o processo de decomposição torna mais fácil a compreensão sobre os processos ecológicos em ecossistemas. Objetivou-se avaliar a decomposição foliar das espécies *Byrsonima gardneriana* A. Juss, *Tocoyema formosa* (Cham e Schltl) K. Schum e *Tabebuia* sp. da Caatinga em Delmiro Gouveia, Alagoas. Para avaliar a decomposição foram coletadas folhas das três espécies, secas em estufa a 65 °C por 72 horas, pesadas 15,0 g das folhas e inseridas nos *litterbags*, as quais foram distribuídas na superfície do solo, retirando mensalmente dez por espécie, que novamente foram secas e pesadas para determinação de decomposição em relação ao peso inicial. Das espécies avaliadas durante os 300 dias, *T. formosa* apresenta maior velocidade de decomposição, seguida de *Tabebuia* e *B. gardneriana*; A decomposição do material foliar é influenciada diretamente pela precipitação pluvial, visto que quando a precipitação é mais elevada, a decomposição aumenta; A região estudada passou por um longo período de estiagem, dificultando a

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decomposição do material foliar das espécies amostradas; Os teores de carbono e matéria orgânica são superiores a outros ambientes de Caatinga, decorrente das boas condições da área experimental, no entanto essas variáveis não apresentaram relação significativa com a decomposição das espécies; A relação C/N influencia a decomposição do material foliar das espécies *T. formosa* e *Tabebuia*; Em virtude das condições microclimáticas e das características do material vegetal, *B. gardneriana* foi a espécie que apresentou decomposição mais lenta.
Palavras-chave: Semiárido; Espécies nativas; Ciclagem de nutrientes; Condições climáticas.

I. INTRODUCTION

Semi-arid region has as main characteristic irregular rainfall, with a high drought that is reflected in the landscape, because even in the rainy season the precipitation regime is variable, presenting high evapotranspiration rate due to the high temperatures, resulting in the occurrence of water deficits (PAUPITZ, 2010). Consequently, this climatic variability interferes with vegetative composition of Caatinga and its dynamics. This can be understood by the process of decomposition of plant species that maintain the functionality of ecosystems, (OLSON, 1963; ODUM, 1969). In turn, the decomposition of this material is regulated by the interaction between the physical and chemical conditions of the environment, which are controlled by the climate, edaphic characteristics and organic and nutritional quality of the substrate. Determining, in this way, their degradability and nature of the decomposition community, which is formed by soil macro and microorganisms (HEAL et al., 1997; CORREIA and ANDRADE, 1999)

According to Muller (2011), Schumacher et al. (2004) and Haag (1985), the degradation or decomposition of vegetal material occurs initially by the material deposition that forms the litter, where the nutrients present will be gradually transformed into organic matter and humus that will be reused in the nutrient cycle of the ecosystem and later released to the soil and reabsorbed by the plants. Holanda et al. (2015) also highlight the importance of foliar material deposited in the soil as one of the main sources of nutrient transfer for the same in forest ecosystems. In addition, it emphasizes the importance of climatic conditions, especially the rainfall that influences the activity of the microorganisms in the soil, favoring the decomposition of the deposited foliar material, since part of elements supply that maintain the stability and the functionality of the ecosystems comes decomposition of this material.

Studies on nutrient cycling in natural ecosystems are important because they provide medium and long term subsidies to understand the relationships existing in a given site, since knowledge of the deposition, accumulation and decomposition of leaf material favors the definition of strategies for the sustainable

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management of a particular ecosystem, especially in Caatinga (SOUZA et al., 2019). Thus, we sought to develop this research with three species that are abundant in the studied region: 1) *Byrsonima gardneriana* A. Juss (Murici), which presents numerous utilities, with a high socioeconomic potential for semi-arid population, since fresh fruits are highly appreciated, and there is also the possibility of ingestion of products derived from Murici (SANTOS et al., 2018); 2) *Tocoyema formosa* (Cham. And Schltl.) K. Schum (Genipapo), which is correlated to adaptation strategies to the environment acting as sources of resources for the fauna, maintaining the balance of ecosystems (MENDONÇA et al. 2013); 3) *Tabebuia* sp. (Pau d'arco), widely used as an antirheumatic in popular medicine (RIBEIRO and CUNHA, 2004). It has heavy, hard and indefinitely durable wood under all conditions, which makes it possible to use it in heavy constructions and external structures (IPEF, 2014).

Due to the scarcity of information on the process of foliar decomposition of Caatinga plant species, characterized by its great biological diversity and economic potential, we sought to understand the dynamics of species decomposition of this biome, considering the time that the material deposited in the soil led to its decomposition, and relating it to edaphoclimatic elements that act on the plant material. In this context, the aim of this study was to evaluate the process of foliar decomposition of *Byrsonima gardneriana* A. Juss (Murici), *Tocoyema formosa* (Cham. and Schltl.) *K. Schum* (Genipapo) and *Tabebuia sp.* (Pau d'arco) in Caatinga of Delmiro Gouveia, Alagoas. *Tocoyema formosa* is the one with the highest rate of decomposition; The decomposition of leaf material is directly influenced by rainfall; The experimental period was not sufficient for the decomposition of the foliar material of *Byrsonima gardneriana*.

II. MATERIAL AND METHODS

General characterization of the study area

The research was conducted in Delmiro Gouveia, Alagoas, located in the Geographic Meso-region of the Alagoano Semi-arid and Alagoas Geographic Microregion of São Francisco, at the geographic coordinates 9° 23' 19'' S and 37° 59' 57'' W, with a high altitude of 256 m, occupying an area of 608.491 km^2 (SEPLANDE, 2015). The climate of the surveyed area is BSh-Tropical Semi-Arid, according to the classification of Köppen (PEEL et al., 2007), with rainfall of 512.1 mm/year, air temperature of 25.5 °C/year and relative humidity of 74.4%. In this region, summer rains occur during the rainy season from November to April, elevated diurnal temperatures and milder night temperatures, providing daily thermal amplitudes above 13 °C (MASCARENHAS et al., 2005). The predominant soils are Littoral Neosols and Neosols Regolithic, consisting of stony fragments (EMBRAPA, 2012).

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The vegetation is composed of Hypoxerophilic Caatinga with stretches of deciduous forest (MASCARENHAS et al., 2005), where *Pilosocereus piauhiensis* (Facheiro), *Bromelia laciniosa* (Macambira), *Croton ssp* (Mimosa), *Mimosa ssp* (Jurema), *Zizipus joazeiro* (Juazeiro) and *Cereus jamacaru* (Mandacaru) (CORDEIRO and OLIVEIRA, 2010).

Experimental area

The area selected for conducting the research was a Toposequence, where the litterbegs were distributed to evaluate the leaf decomposition of *B. gardneriana*, *T. formosa* and *Tabebuia* sp. and determinations of carbon and soil organic matter, rainfall, temperature and soil water content.

Evaluation of leaf decomposition

To evaluate the leaf decomposition, leaves of the trees and shrubs of the species *B. gardneriana*, *T. formosa* and *Tabebuia* sp. in August 2013. They were then dried in a forced circulation oven at 65 °C for 72 hours. Subsequently, 15.0 g of dry leaves were weighed and placed in nylon bags (litterbags) measuring 20 cm x 20 cm, totaling an area of 400 cm^2, made with a mesh nylon mesh of 1.0 mm x 6.0 mm (SOUTO, 2006). In September 2013, 60 bags were distributed on the soil surface, being 20 of each species, totaling 300 bags throughout the experiment. From October 2013 to July 2014, six bags were randomly collected at each point, two of each species, totaling 30 bags per month, which were dried in a forced circulation oven at 65 °C for 72 hours to determine the rate of decomposition (g/month) from the initial weight (15.0 g). The percentage of remaining material was calculated by the equation: % Remaining = (MF/MI) x 100, where: % Remaining = MF = final mass; MI = initial mass.

Evaluation of soil water content

The soil water content was conducted by means of monthly collections of 15 soil samples, 10 cm deep, in the same places where the litterbags were distributed, which were stored in previously identified aluminum cans. Subsequently, these were sent to the Soil Physics Laboratory, DSER/CCA/UFPB, for wet soil weighing and then taken to the rectilinear oven at 105 ºC for 24 hours. They were then transferred to a desiccators until they reached room temperature and again weighed and determined the percentage of water present. The water

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content of the soil was determined by the methodology of Tedesco et al. (1995) by the equation: SWC% = ((Ww-Dw) / Dw) x 100, where: SWC = Soil water content; Ww = Wet soil weight; Dw = Dry soil weight.

Determination of carbon and soil organic matter

Carbon and organic matter determinations were performed monthly at the same points where the litterbags were distributed. The organic carbon content was determined by EMBRAPA (1997) using the following equation: C = 0.06 x V (40-Va x f) in g kg^{-1}, where: C = organic carbon; V = Volume of potassium dichromate employed (10 mL); Va = Volume of ammoniac ferrous sulphate used in titration of the sample; f = 40/volume of ammoniac ferrous sulphate used in the titration of the blank; 0.06 = Correction factor, due to aliquots taken. The values of the organic matter contained in the sample were calculated by means of the expression: SOM = Cx1.724 in g kg^{-1}, where: SOM = Soil organic matter, where: MO = Soil organic matter; C = Organic carbon; 1.724 = Factor used because it is assumed that in the average composition of the humus, the carbon participates with 58%.

Obtaining the data of the edaphoclimatic variables

Rainfall data were obtained by means of the Ville de Paris rain gauge installed in the experimental area and soil temperature measurements were made at 10 cm depth using a digital model thermometer.

Statistical analysis

For the analysis of the data the values of decomposition, carbon, organic matter, soil water content and soil temperature were submitted to analysis of variance and the means were compared by the Scott-Knott test at a probability of 5% using ASSISTAT software.

III. RESULTS AND DISCUSSION

The leaf decomposition for the three species *B. gardneriana*, *T. formosa* and *Tabebuia* sp. occurred with greater intensity up to 60 days (Figure 1), due to the consumption of the more labile material as simple sugars by the microorganisms. Swift et al. (1979) mention that in the first three months the rate of decomposition occurs more rapidly because of the greater loss of palatability of decomposing organisms to less resistant compounds such as sugars and organic acids.

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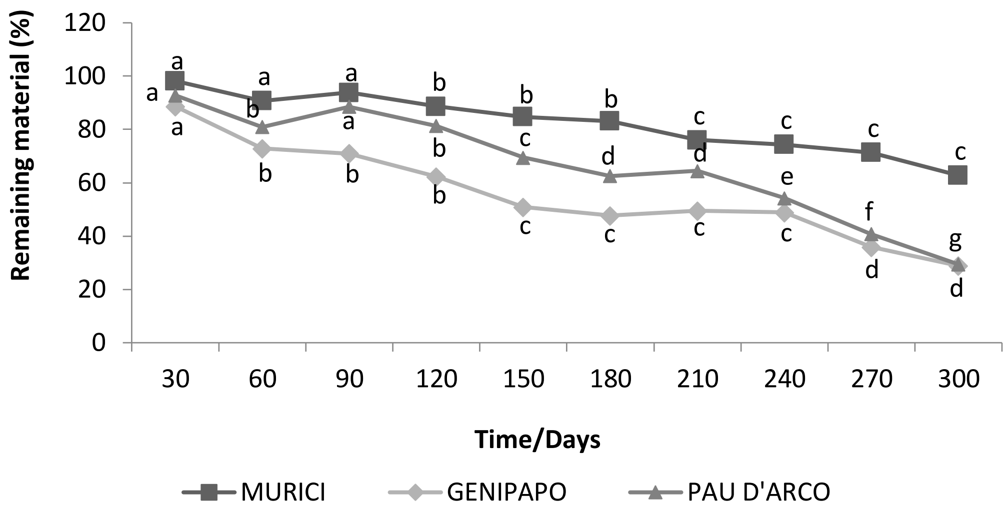

Figure 1. Remaining material of the foliar decomposition (%) of the species *B. gardneriana* (Murici), *T. formosa* (Genipapo) and *Tabebuia* (Pau d'arco) in Caatinga of Delmiro Gouveia, Alagoas. Averages followed by the same letter do not differ among themselves by the Scoot-Knoot test at 5% probability.

Source: Prepared by the author (2014).

It was observed that from 60 to 150 days (Figure 1) the decomposition occurred slower in *B. gardneriana* species and for the other species there was gradual decomposition of the material along the days. It should be noted that at 90 days there was an increase of the material when compared to 60 days, this fact can be justified by the difficulty in cleaning the material, and the rainfall recording at 30 days was responsible for the greater leaf material decomposition at 60 days (Figure 1). The slow decomposition of the leaf material is due to the reduced water content in the soil due to the low occurrence of rainfall in the period of the work. This pattern was also found by Alves et al. (2006) in a study conducted with species of Caatinga in Paraíba, in which they verified that at the end of the drought period 65% of the leaves had not yet been decomposed, due to the low water content of the soil, limiting the decomposition process.

Analyzing the interaction between months and species, it was verified from the analysis of variance, a statistical difference between the species during the months, with gradual decomposition of the plant material, from the moment the material was deposited in the soil (Figure 1).

Regardless of the evaluated species, it was verified that from 150 to 210 days, there was no high variability in the decomposition data. Between the 210th and 240th days, the species *B. gardneriana* practically did not decompose, even though there was record of the highest rainfall in March (117 mm), September (65 mm) and April (81.2 mm), respectively (Figure 2).

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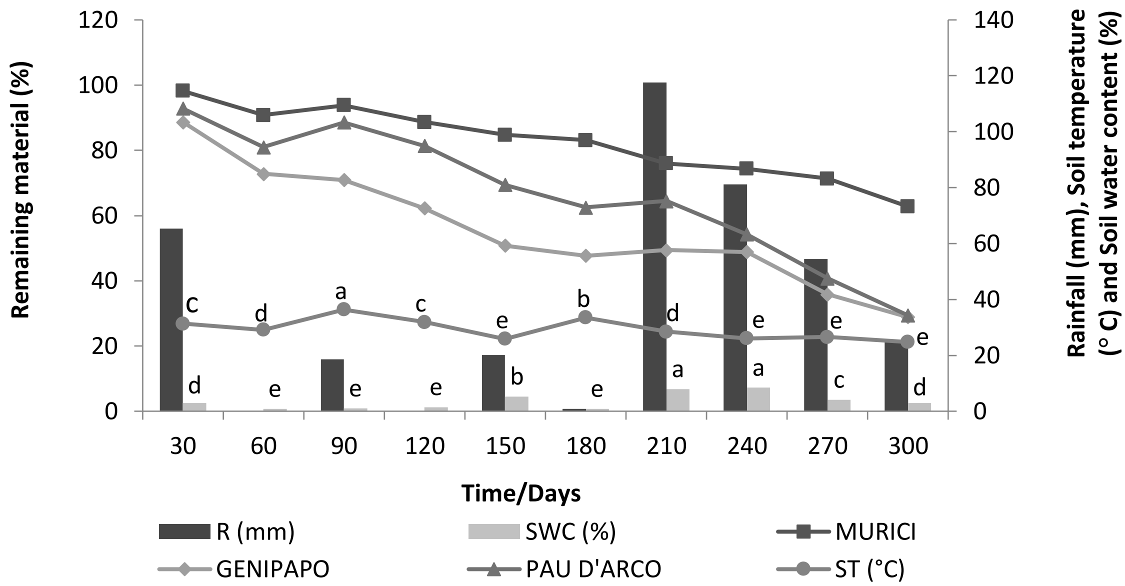

Figure 2 - Remaining material (%) of the species *B. gardneriana* (Murici), *T. formosa* (Genipapo) and *Tabebuia* (Pau d'arco) related to rainfall - R (mm), Soil temperature - ST (°C) and Soil water contente - SWC (%), in Caatinga of Delmiro Gouveia, Alagoas. Averages followed by the same letter do not differ statistically by the Scoot-Knoot test at 5% probability.

Source: Prepared by the author (2014).

The species *Tabebuia* sp. and *T. formosa* presented an accelerated decomposition process between the period of 270 and 300 days, due to the occurrence of rainfall that favoured the increase of the soil water content and the milder soil temperature, favouring the activity of the decomposing organisms (Figure 2). According to Souto et al. (2013) the rainfall regime in Caatinga presents high spatial and temporal variability, being important the monitoring of atmospheric conditions and soil water content in the evaluation of the process of decomposition and activity of edaphic microorganisms.

For Souto (2006), during the rainy season, the water content of the soil is a key factor that influences the decomposition process, since there is the growth of the decomposing community accelerating the leaf decomposition. The low soil moisture makes the decomposition slow in the Caatinga environment, especially when there are irregular rains, reducing the activity of the decomposing organisms of the litter (SANTANA and SOUTO, 2011).

Analyzing soil temperature and soil water content, it was observed a significant difference at 5% probability by the Scoot-Knoot Test during the 300 days of observation for the three species, *B. gardneriana*, *T. formosa* and *Tabebuia* sp. (Figure 2). The rate of decomposition of some Caatinga species is influenced by the

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rainfall variability in the region. This could be verified in this experiment, so that at the end of this 82.37% of the leaves of Murici had not been decomposed, Pau d'arco totaled 66.46% of material remaining and Genipapo with 55.62%. Thus, the experimental time (one year) was not sufficient for decomposition of these species (Figure 2).

The statistical analysis indicated that there was no significant difference in relation to the levels of carbon and soil organic matter during the analysis period when submitted to the Scoot-Knoot test at 5% probability (Figure 3). The mean values of carbon (14.58 g kg^{-1}) and organic matter (25.15 g kg^{-1}) were higher when compared to other areas of the semi-arid Caatinga, as demonstrated by Silva et al. (2013) that detected levels of organic carbon ranging from 9.46 to 13.04 g kg^{-1} in the Caatinga of Piauí. The high levels of carbon and organic matter found in this research are justified by the fact that this area is inserted in a native forest environment.

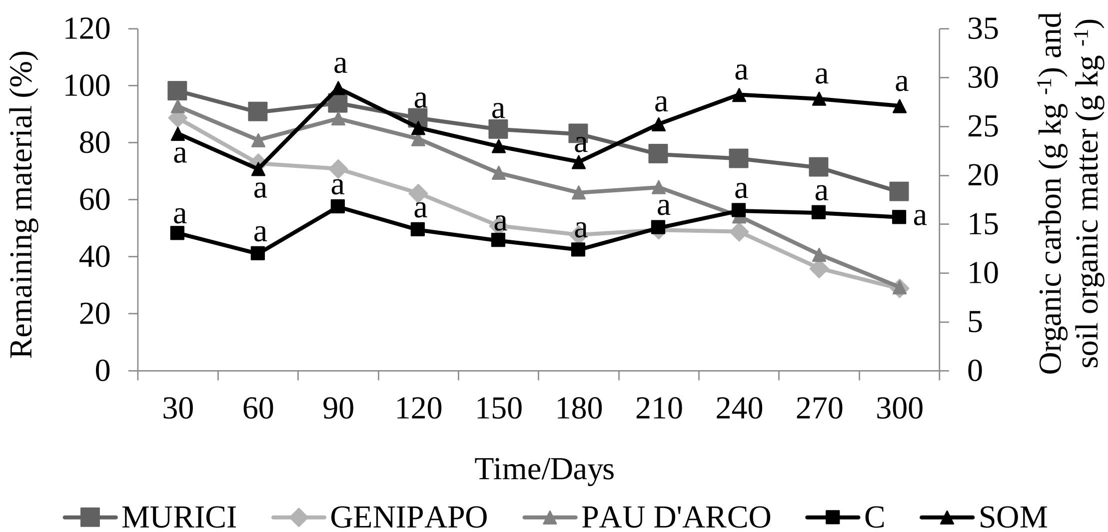

Figure 3 - Remaining material (%) of the species *B. gardneriana* (Murici), *T. formosa* (Genipapo) and *Tabebuia* (Pau d'arco), related to the contents of Carbon - C (g kg^{-1}) and Organic matter - SOM (g kg^{-1}), in Caatinga of Delmiro Gouveia-Alagoas. Means followed by the same letter do not differ statistically by the Scoot-Knoot test at 5% probability.

Source: Prepared by the author (2014).

The rapid decomposition of the leaves of the *T. formosa* species is due to the low C/N ratio (18.75%) of the material (Table 1). For Holanda (2012) the C/N ratio between 20 and 30 is ideal for microbial activity, with no immobilization or mineralization at the beginning of the decomposition process. The leaves of the *B. gardneriana* species presented slow decomposition throughout the analyzed period due to their high C/N ratio (34.81%), presenting a resistance to the attack of the organisms when compared to *T. formosa* (19.43%) and

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Tabebuia sp. (18.75%). Thus, the higher the C/N ratio, the slower is the leaf material decomposition (Table 1). Leaf material present in the soil is the main source of food for soil organisms as it is one of the main sources of nutrient return to the soil.

Table 1 - Leaf chemical composition of the species *B. gardneriana* (Murici), *T. formosa* (Genipapo) and *Tabebuia* (Pau d'arco) in Caatinga of Delmiro Gouveia, Alagoas.

	Byrsonima gardneriana	*Tocoyema formosa*	*Tabebuia* sp.
Components	Leaf chemical composition (g kg^{-1})		
Nitrogen (N)	13.59	24.75	25.37
Phosphorus (P)	1.11	0.89	0.75
Potassium (K)	4.75	3.44	0.82
Carbon (C)	473.1	48.1	47.57
Lignin	113.9	51.58	37.34
C/N ratio	34.81	19.43	18.75
LIG/N ratio	8.38	20.84	14.72

Source: Prepared by the author (2014).

Holanda et al. (2015) mention that residues with low C/N ratios (less than 20) have higher rates of decomposition and consequently mineralization is more accelerated, favouring greater cycling of nutrients, even without their incorporation. Thus, when the C/N ratio is lower, the material decomposes faster. Analyzing the leaf decomposition of Caatinga species in Paraíba, Holanda et al. (2015) observed a C/N ratio between 10 and 18% registering rapid decomposition. According to Selle (2007) when the C/N ratio is high, the microorganisms will seek other sources of Nitrogen to satisfy the demand, consuming forms of nitrogen that are available to the plant, which results in a net immobilization and can cause a temporary deficiency of nitrogen for plants.

Nitrogen content (N) in *B. gardneriana* leaves was 13.59 g kg^{-1}, lower than the results of *T. formosa* and *Tabebuia* sp. which presented 24.75 and 25.37 g kg^{-1}, respectively (Table 1). Holanda et al. (2015) observed the N value of 22.0 g kg^{-1} in leaf material in a remnant of Caatinga in Paraíba.

B. gardneriana species had a high lignin value (113.9 g kg^{-1}) compared to *T. formosa* (51.58 g kg^{-1}) and *Tabebuia* sp. (37.34 g kg^{-1}), which together with the high C/N ratio explain the slow decomposition of the species during the period of the research (Table 1). Lima et al. (2015) mention that the high values of lignin of Caatinga species vary according to the environmental conditions of the species, being a strategy for the reduction of

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transpiration losses, since the leaves present a more rigid texture as a way of adapting the climatic conditions. The same authors, when studying the litter decomposition in the South Caatinga in Piauí, observed a low decomposition of the leaf material attributed to the high lignin and tannin contents contained in the litter that influenced the decomposition process.

Van Soest (1994) characterizes lignin as a phenolic polymer complex, a component of the cell wall of plants, acting with the structural carbohydrates cellulose and hemicelluloses. Lignin is undigested by enzymes and also impairs the microbial degradation of structural carbohydrates which comprise plant material.

It should be mentioned that the leaves of *B. gardneriana* present a rigid texture which serves as a barrier for the rapid wetting of the material, being a factor that makes the decomposition of the leaves slower, not occurring with *T. formosa*, whose leaves helps to fix the water droplets on its surface, maintaining the moisture of the material. According to Witkamp (1966) Caatinga species are heliophytes and most of them have leaves of rigid texture that take longer to moisten, which hinders the action of organisms in drier periods, making the decomposition process slower. It is worth mentioning that the period during which the research was conducted coincides with the dry season, with higher temperatures and although these favour the biological activities, increase the dryness of the soil and the deposited material.

For Amado et al. (2000), the decomposition patterns of the vegetal residues follow different phases, of which the last stage corresponds to the decomposition of the more resistant material, such as cellulose, hemicellulose, waxes, tannins and lignin, being therefore slower. Krainovic (2008) states that lignin and cellulose are structural components that impart greater rigidity to the cell wall and high concentrations delay or prevent the arrival of the microorganisms into the cellular interior in search of the nitrogen, key constituent of the amino acids.

Phosphorus (P) levels varied among the studied species, especially *B. gardneriana* with 1.11 g kg^{-1}, *T. formosa* and *Tabebuia* sp. presented values of 0.89 and 0.75 g kg^{-1}, respectively. However, it can be observed that even *B. gardneriana* was the one with the lowest leaf decomposition, it presented P levels higher than the other species studied, being one of the factors that help the loss of leaf mass when immobilized in the process of decomposition. This behaviour can be justified by the fine soil particles that are adhered to the foliar material during the rainfall that occurred in some periods, making it difficult to clean the leaf material.

According to Vieira et al. (2014), some nutrients, mainly N and P, are immobilized during the process of decomposition of the foliar material, being verified when the loss of mass of the foliar material presents a

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positive correlation with the concentration of nutrients, indicating that the greater the loss of mass, the higher the concentration of some elements in the remaining leaf material. Terror et al. (2011) mention that with the passage of days N contents increase in relation to the initial content and attribute this increase, most of the times, rainfall and the activity of soil organisms that fix N in the foliar material. The fixation of the nutrients in the leaf material was only observed in the species *T. formosa* and *Tabebuia* sp..

IV. Conclusions

- Of the species evaluated during the 300 days, *Tocoyema formosa* is the one with the highest rate of decomposition, followed by *Tabebuia* sp. and *Byrsonima gardneriana*;
- The decomposition of leaf material is directly influenced by rainfall, since when rainfall is higher, decomposition increases;
- The studied region underwent a long period of drought during the conduction of the experiment, which made it difficult to decompose the leaf material of the species sampled;
- Carbon and organic matter contents are higher than other Caatinga environments due to the good conditions of the experimental area, however, these variables did not present a significant relation with the decomposition of the species;
- The C/N ratio influences the decomposition of leaf material of the species *Tocoyema formosa* and *Tabebuia* sp.;
- By virtue of the microclimatic conditions and the characteristics of the plant material, *Byrsonima gardneriana* was the slowest decomposing species.

V. References

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