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Floor quantification of fuel on the forest in the semiarid region of Paraiba, Brazil

Quantificação do material combustível em piso florestal no semiárido da Paraíba, Brasil

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ABSTRACT: Knowing the type and amount of combustible material in the forest floor is essential for the estimation of parameters related to fire behavior. The main objectives was developed in an area of Caatinga in the Private Reserve of National Patrimony owned by belonging to "Tamanduá Farm", located in Santa Terezinha municipality, Paraiba State, Brazil, to quantify the fuel in the forest floor. Samples were collected from October to December/2009 demarcated into seven transects in the Reserve. With the aid of a template was demarcated portion of 1.0 m x 1.0 m which was collected combustible material, living and dead, which was weighed to determine wet weight and then oven-dried to obtain dry weight. All material was further separated into leafy and non-leafy to determine the share of each class in the composition of combustible material. Moreover, there was the burning of all combustible material collected in each transect to assess the speed of propagation, the burning time and percentage burned. The greatest amount of combustible material was obtained in November with 535.3 g m^2. In relation to the physiological state of the plant residue, the largest contribution to the formation of combustible material was dead.

Keywords: caatinga, organic matter, forests fires.

RESUMO: O conhecimento do tipo e da quantidade de material combustível no piso florestal é imprescindível para a estimativa de parâmetros ligados ao comportamento do fogo. Este trabalho foi desenvolvido em área de Caatinga na Reserva Particular do Patrimônio Natural pertencente à Fazenda Tamanduá, localizada no município de Santa Terezinha (PB), com o objetivo de quantificar o material combustível presente no piso florestal. As coletas foram realizadas no período de outubro a dezembro/2009 em sete transectos demarcados na Reserva. Com o auxílio de um gabarito foi demarcado parcela de 1,0 m x 1,0 m onde coletou-se o material combustível, vivo e morto, que foi pesado para determinação do peso de matéria fresca e, em seguida, seco em estufa para obtenção do peso de matéria seca. Todo o material foi separado em folhoso e não folhoso de modo a determinar a participação de cada classe na composição do material combustível. A maior quantidade de material combustível foi obtida no mês de novembro com 535,3 g m^2. Em relação ao estado fisiológico dos resíduos, a maior contribuição na formação do material combustível foi do material morto.

Palavras-chave: caatinga, material orgânico, incêndios florestais

INTRODUCTION

The Caatinga is composed of xerophytic vegetation-sized arboreous, shrubs and herbaceous, with a wide range of physiognomy and flora, and high species diversity (DRUMOND et al., 2000). Souto (2006) points out that, due to climatic conditions, vegetation endemic to this biome is branched, shrubs looking, with small leaves on thorns or modified so as to prevent sweating, occurring loss of leaves during the dry season (shedding). It is a mixture of herbaceous, shrub and arboreous, crooked, thorny and very resistant to drought. The vegetation is distributed unevenly, contrasting areas that resemble forests, with almost bare soil areas. It presents a great biodiversity with species of varying sizes and arrangements phytosociological, making it very complex and little is known about its dynamics.

The surface fuels are those located on, and immediately above or in the forest floor, up to 1.80 m in height, and have basically leaves, branches, trunks and other materials found in this interval. The underground fuels are all combustible materials that are below the surface of the forest, such as humus, roots of trees, decaying wood, peat, and others (BATISTA, 1990).

According to this author, living and dead fuels have different mechanisms of water retention and different responses to climate variations.

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Yebra et al. (2006) report that knowledge of the moisture of combustible materials is essential for the estimation of parameters related to fire behavior, such as intensity and speed of propagation as well as being a decisive factor in obtaining good results with controlled burning. It is also one of the most important factors to be analyzed to estimate the risk of forest fires.

Forest fires are causing major damage to forests and other vegetation types. There are several techniques and measures that can be taken to prevent and / or reduce fire damage by preventing sources of ignition and fire spread prevention (BATISTA & BIONDI, 2009).

The spatial arrangement of the components that make up the landscape has a major influence on fire behavior. The homogenization of the landscape favors the spread of flame, which can result in fires larger. Generally, areas not occupied by humans or intensely disturbed tend to be more homogeneous (MAGALHÃES, 2011).

Forest fires cannot be managed without an understanding of the basic characteristics of the fuel. Knowledge of fire behavior and its relationship with combustible material is essential for effective decision making on fire management and on educational programs (WHITE, 2010).

The amount of combustible material in a forest varies widely, depending mainly on the type and age of the forest and other parameter settings relating to the site. The estimated amount of fuel is an important factor in plans to prevent and control fires, because it determines the intensity of the fire (SOARES, 1979).

Souza et al. (2003) support that the information related to fire behavior is of paramount importance to ensure the efficiency of combat operations, whose design depends critically on details of the amount of combustible material.

For Melo (2005), the quantity and quality of information related to combustible material in native forests are very limited. This information is important to reduce the risk of fire, for planning the control of forest fires and to achieve other goals set out in management plans of protected areas.

Thus, this study aimed to quantify surface fuel material in an area of Caatinga preserved, whose data could support programs to prevent and combat forest fires in protected areas.

MATERIALS AND METHODS

The study was conducted in the Private Reserve of Natural Heritage (PRNH), which has an area of 325 ha, the vegetation is not operated for over 25 years, being characterized as arboreous shrub Caatinga closed. The reserve belongs to Tamanduá Farm, and is located in Santa Terezinha municipality (PB), 07th among the coordinates 7º 2 '20 "S and 37 26' 43" W (Figure 1).

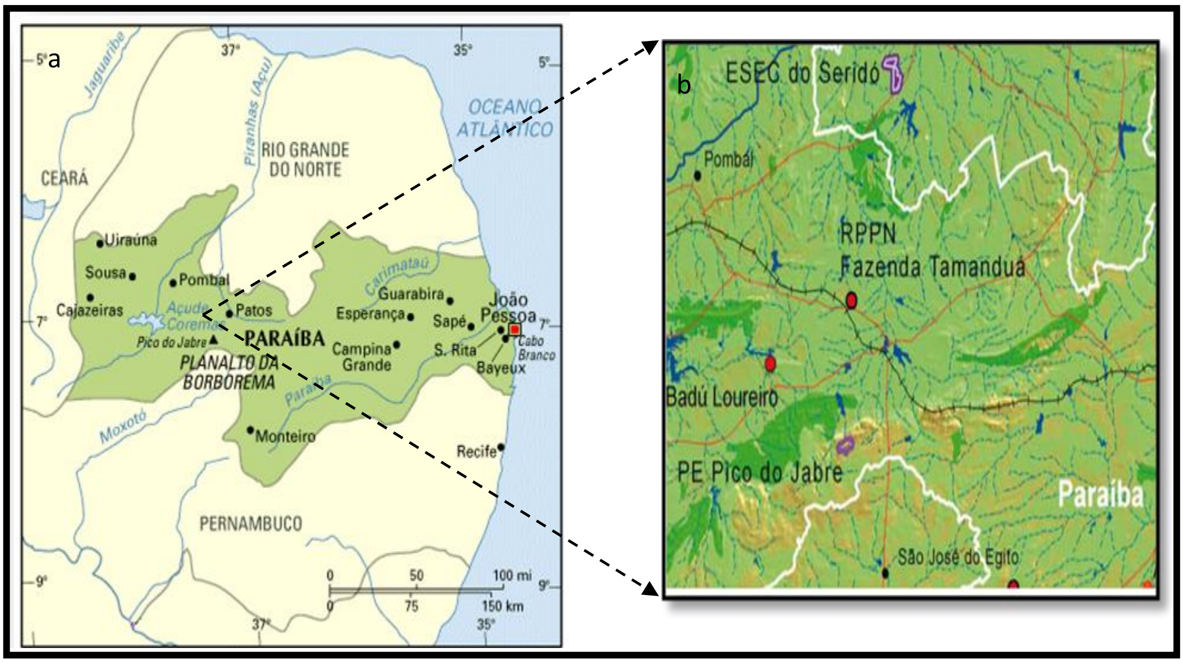

Figure 1. Map of Paraiba (a) highlighting the location of the Tamandua Farm RPPH (b)

The climate is semiarid BSh type according to Köppen, characterized with temperatures above 25 º C and average rainfall of less than 1000 mm yr^{-1} with irregular rains. According to Araújo (2000), the study area is characterized by a dry season and a rainy season, with average annual rainfall around 600 mm, and the early dry season in May and may extend into January. The predominant soils in the municipality are associations of Entisols and Alfisols (EMBRAPA, 2006).

In PRNP samples were collected along seven transects whose distance is 200m. Quantification of combustible material was held in October, November and December/2009.

The collection of combustible material was carried out on plots of 1.0 m², demarcated with the help of a template, randomly distributed three times in each transect. Based on work of Beutling et al. (2005), the quantity of accumulated fuel in the experimental plots was classified according to the physiological state in the following classes: a) combustible material live, consisting of small shrubs and herbaceous material, which was later cut, b) dead fuel material, consisting of the material dead in bed on the surface of the stand. All this material was carried to the Laboratory of Mineral Nutrition of Plants, Federal University of Campina Grande, Patos Campus, where it was made all determinations.

Souto (2006) conducted sampling of arboreous vegetation and shrubs present in each transect, whose most conspicuous constituents are listed in Table 1. In these individuals, it was found during sampling, the presence of panasco grass (*Aristida setifolia*) most clearly in transects 5, 6 and 7.

Table 1. Main species of small trees and shrubs present in each transect.

COMMON NAME	SCIENTIFIC NAME
Catingueira (T1-T7)*	*Poincianella pyramidalis* (Tul.) L. P. Queiroz
Marmeleiro (T1-T7)	*Croton blanchetianus* Baill.
Mofumbo T1-T4; T6, T7	*Combretum leprosum* Mart.
Angico (T1,T3-T7)	*Anadenanthera peregrina* (L.) Speg.
Malva (T1-T3, T5-T7)	*Sida* sp.
Alfazema brava (T1-T3)	*Hyptis suaveolens* (L.) Poit.
Jurema branca (T2,T4,T7)	*Mimosa verrucosa* Benth.
Imburana de cambão (T2-T5, T7)	*Commiphora leptophloeos* (Mart.) J. B. Gillett
Genipapo (T3)	*Genipa americana*, L.
Juazeiro (T3)	*Ziziphus joazeiro* Mart.
Imbiratanha (T3, T6, T7)	*Pseudobombax simplicifolium* A. Robyns
Feijão bravo (T4,T6)	*Capparis hastata* Jacq.
Pinhão bravo (T4-T7)	*Jatropha mollissima* (Pohl) Baill.*s*
Pereiro (T4- T7)	*Aspidosperma pyrifolium* Mart.
Jurema preta (T4, T6)	*Mimosa tenuiflora* (Willd.) Poir.
Mororó (T5)	*Bauhinia cheilantha (*Bong.) D. Dietr.

*T = Transectic

In the laboratory, the combustible material was weighed on a digital scale to determine the weight of fresh and placed in an oven for drying circulation and renewal of air at a temperature of 65 ° C for 48 hours. After this period it was weighed for determination of dry weight.

The determination of water content of the combustible material collected during the months of sampling was calculated using the equation: TU = PF-PS/PS * 100% where: TU =% Moisture Content, PF = weight of fresh matter; PS = Weight Dry Matter.

Then the separation was made of combustible material in each area in leafy and non leafy (including twigs, bark, resins and reproductive structures), and then weighed and evaluated the level of contribution of each class.

The experimental design was completely randomized with factorial arrangement 3 x 7 (transects multiplied by months), with three replications. Data on combustible leafy vivo were transformed (√x + 1) because, well, the requirements of analysis of variance. The data were subjected to analysis of variance using the statistical software version 7.5 beta ASSISTAT (SILVA & AZEVEDO, 2012), and using the Tukey test to compare means 99% reliability.

RESULTS AND DISCUSSION

These materials, live and dead, have different amounts of water, and the living materials retain more moisture than the materials dead (Figure 2), thus requiring a greater quantity of heat so that ignition occurs. Batista & Soares (1986) stated that the plant material, living or dead, have different mechanisms of water retention and different responses to climate, where the moisture content of living matter is more stable than the dead material. Thus, the dead material is drier and responds more quickly to climate change is therefore primarily responsible for the spread

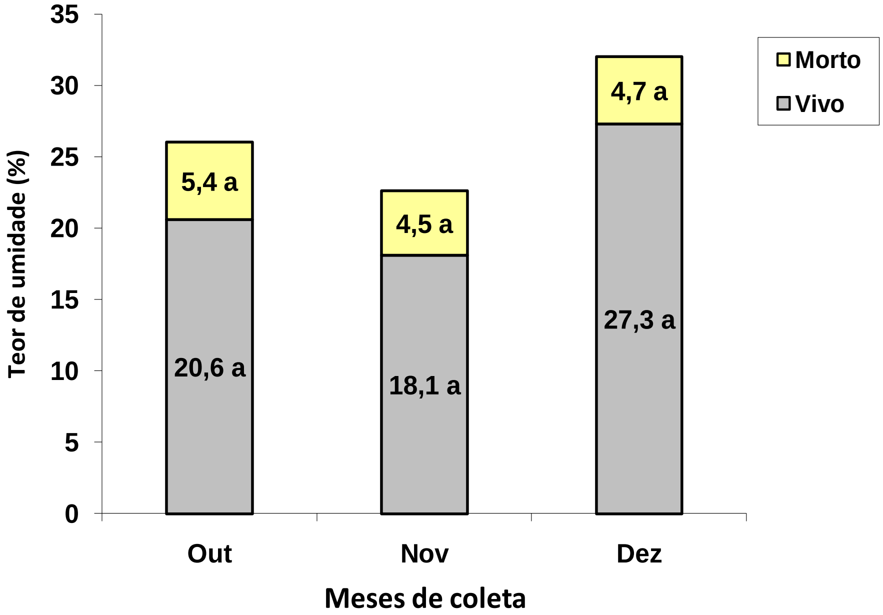

Figure 2. Medium moisture content of combustible material in each physiological state in collection months.

According to data obtained in this study the moisture content in dead fuel material under 6% were alive and ranged from 18 to 27%, so that in situations assessed values did not differ significantly in the months of collection.

For Fenner & Lima (1992), when the moisture content of forest combustible materials are in the range 25-30% are considered dangerous, because in this age there is a high probability of ignition. Therefore, the moisture content of combustible material, dead or alive, obtained in this study in October and November is below the range of risk reported by the aforementioned authors, i.e. the risk of fire in these months is very high. Given these favorable conditions for the occurrence of forest fires, monitoring and surveillance in areas of Caatinga Reserve should be intensified in these critical periods.

Figure 3 shows the mean values regarding the amount of combustible material (dry weight in an oven) collected in the sampling periods. The largest amount of combustible material was obtained in November with 535.3 g m^2, and dead fuels were the most affected in the formation of the total load in all months studied, no differences among them. This greater contribution of dead material during the months when the study was conducted can be attributed to the mechanism of shedding, which is characteristic of most species constituting the vegetation of the Caatinga, since the sampling period coincided with the dry season.

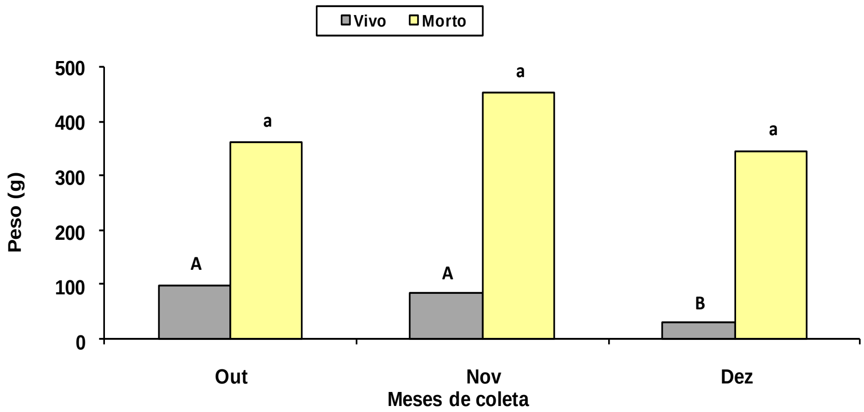

Figure 3. Quantity (g) of combustible material collected during the months of sampling, the PRNH Tamanduá Farm, in Santa Terezinha, PB. Capitalized compared combustible material vivo (LSD = 29.87) and small letter compares combustible dead (DMS = 120.08), between the months.

This greater contribution of combustible material was also found dead by Souto et al. (2009), when assessing the amount of combustible material in forest plantations and the remaining rain forest in the swamp of Paraiba. For these authors, the effective presence of combustible material killed in the native forest can be attributed to the great diversity of forest species in the area that put in many different shapes, positions and arrangements, different types and amounts of organic material on the soil surface.

Melo (2005) determined the charge of the fuels of different forest types of the Iguaçu National Park also showed higher amounts of combustible dead and considers this type of material as a major contributor to the ignition and spread of fire in Araucaria forest, which increases the risk of fires.

The contribution of combustible live material differed between the months; the highest values were recorded in October and November with 98.2 and 83.1 g, respectively. As the samples were taken during the dry season, it is likely that the low water content in soil has hindered the development and growth of herbaceous and shrubby. Thus, the presence of a few herbaceous species is justified, so that the most adapted to these conditions as cocksfoot grass (*Aristida setifolia*), lavender (*Hyptis suaveolens* (L.) Poit.) And mallow (*Sida* sp.) Were the main constituents of the combustible live material in most transects.

Regarding the quantification of combustible material collected in the transects (Figure 4), collections of material in different physiological states differ ($p < 0.01$). The highest average value of combustible live material was recorded in the transect 7 with 121.8 g, although not statistically differ from those transects 4, 5 and 6. The highest amount of dead fuel material was collected in a transect with 660.89 g, this value being statistically equal to those recorded in transects 2 and 5 with 459.44 g and 448.89 g, respectively.

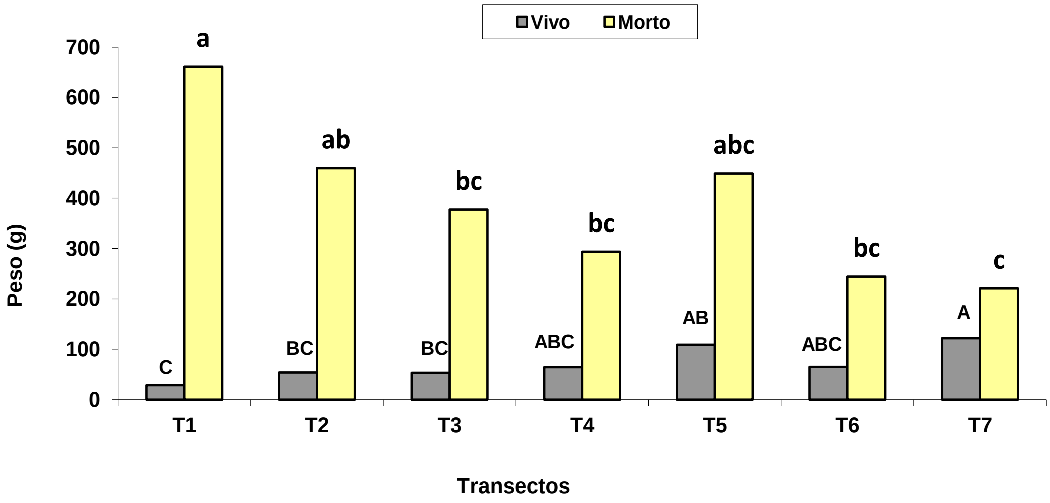

Figure 4. Quantity (g) of combustible material collected in the different transects at Tamandua Farm RPPH in Santa Terezinha, PB. Capitalized compared combustible material vivo (LSD = 58.17) and compares lowercase combustible dead (DMS = 233.87), among transects.

It was also observed in this figure was also in that was collected 7 transect the least amount of combustible material killed with 220.89 g. The greater presence of combustible material killed in all transects may be associated with soil water deficit that enhances the process of shedding of most species of the caatinga in the dry season.

Beutling et al. (2005) point out that this information becomes very useful from the point of view of prevention of forest fires, because knowing the amount and the physiological state of the existing forest fuels in the field allows the realization of estimates about the risk of fire and fire behavior.

It can be seen in figure 5 that the greatest contribution to the formation of combustible live material was leafy material is not at all sampling periods, with significant reductions in December. As samples were collected during the dry region, it is likely that the lower contribution of combustible material live can be attributed to increased soil water deficit, which prevented the permanence of species in these areas.

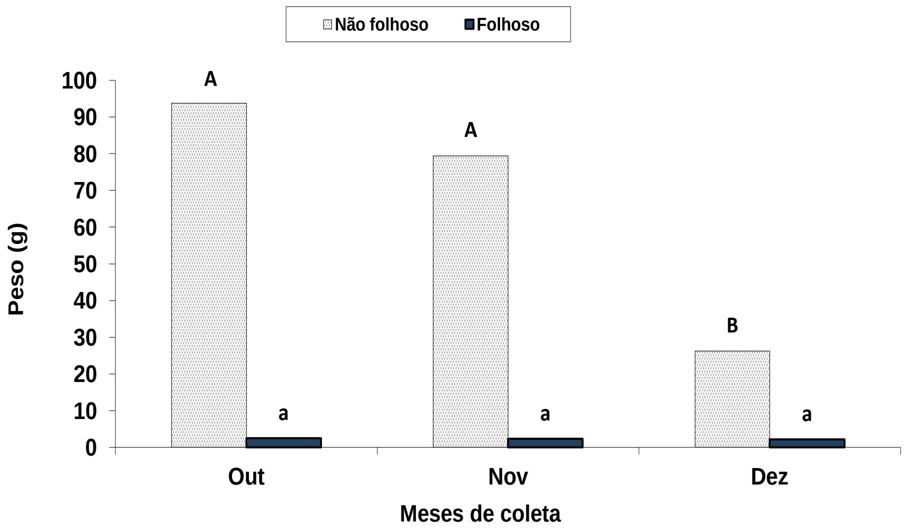

Figure 5. Weight (g) of the combustible material and not live leafy leafy collected during the months of sampling, the PRNH Tamanduá Farm, in Santa Terezinha, PB. Capitalized compared leafy material does not (LSD = 29.66) and compares lowercase leafy material (LSD = 0.90) between months.

According to the result of combustible live material quantification of leafy and non leafy expressed in each transect in Figure 6, it was found that the highest value occurred in the leafy material is not T7 with 117.22 g, which was statistically equal to the amounts recorded in the transects 5 and 6, with 106.7 g and 64.9, respectively. As these transects the presence of cocksfoot grass and mauve were more constant, the contribution of the cocksfoot culms and stems and branches of mauve were higher, reflecting the higher values of living material is not leafy.

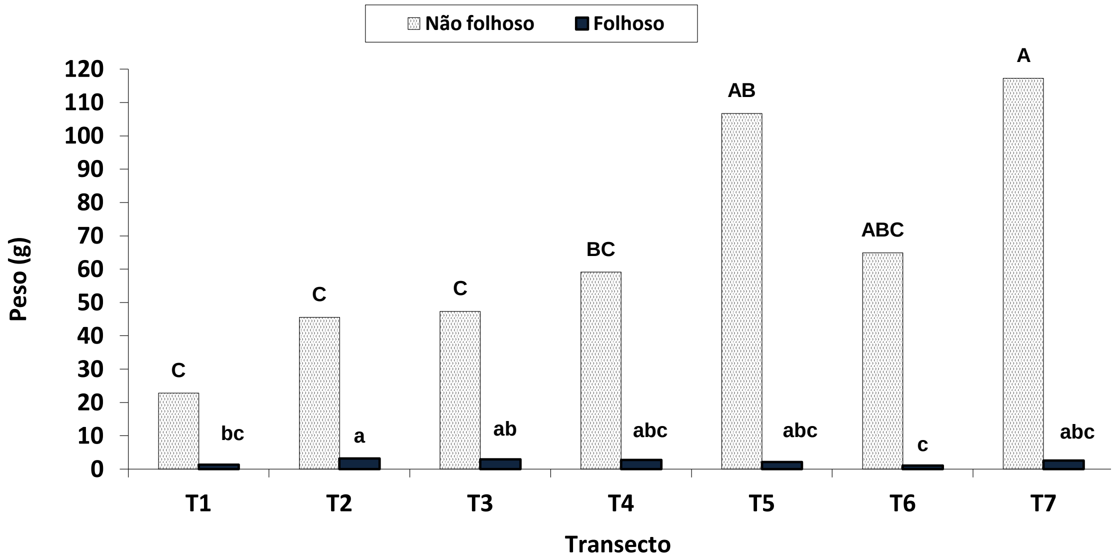

Figure 6. Weight (g) of the combustible live material and not live leafy collected in different transects in the PRNH Tamanduá Farm in Santa Terezinha- PB. Capital letter compares live material not compare leafy (LSD = 57.77) and compares lowercase leafy living matter (LSD = 1.75) between transects.

Sousa et al. (2010) assessing the burned areas in the stretch between the towns of Patos and Condado, along the BR 230 in the state of Paraiba observed that the predominant type of vegetation on the site was grass cocksfoot (*Aristida setifolia*) , which allowed a greater amount of combustible material along the right of way of said sections of the highway. According to the authors of this native grass Brazilian semiarid region has a strong power of combustion, therefore, a determining factor in the frequency of fires along this stretch.

The mean values of living material in leafy transects were statistically different, being 3.16 go highest value recorded in transect 2, although statistically resemble the values obtained in transectos 3, 4, 5 and 7. In relation to the dead leafy material, the total charge during the sampling period was 341.73 g. It was observed that despite the presence of sheets in the forest floor, mainly in the small sheets catingueira the weight contribution of this part of the plants in the formation of combustible material is not lower than the leafy.

Figure 7 displays the contribution of waste and non-leafy leafy and vegetables in the formation of dead fuel material collected in the three months of conducting the study. The total charge of combustible material not leafy killed during the sampling period was 833.71 g, with the major contribution of material occurring in the month of November with 299.43 g, while the average values obtained in each month did not differ statistically. Therefore, this major contribution of the leafy material is not every month is due to the criteria adopted in this study, which was not considered material leafy twigs, bark, stems, resins and other materials, except leaves. Thus, because they are weighed against the sheets, the contributions of these materials overcome the leafy in every sampling period.

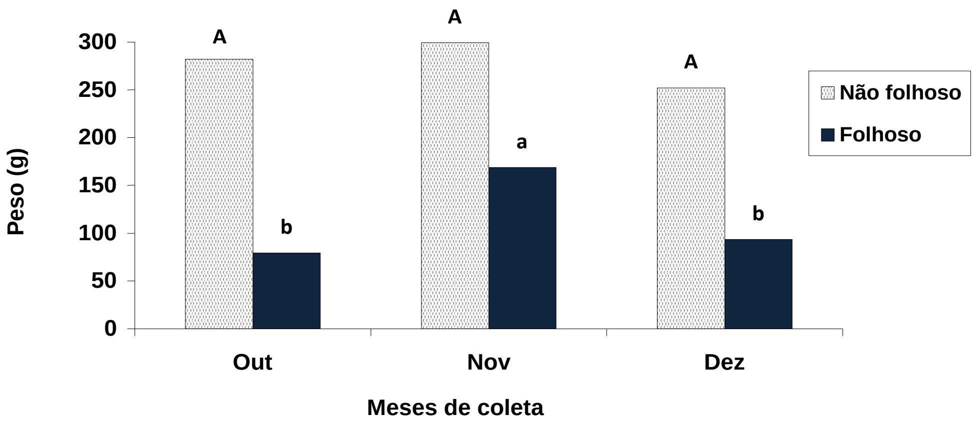

Figure 7. Weight (g) of combustible dead leafy and non leafy collected during the months of sampling, the PRNPH Tamanduá Farm, in Santa Terezinha, PB. Capitalized compares dead material not leafy (LSD = 90.89) and compares lowercase dead leafy material (LSD = 62.11), between months

Similar results were obtained by Souto et al. (2009) in a stand of *Pinus* in the municipality of Areia (PB), in which the percentage contribution of woody material was superior to the settlement areas with teak (*Tectona grandis*) and the Atlantic Forest fragment. For these authors, the presence of large amounts of woody material is an ideal environment for the spread of fire was more intense.

According Stangerlin et al. (2007), the large amount of fuel would increase the difficulty of fire control, not only by increased heat and length of the flames, as well as the operational difficulty of breaking the continuity of material through the opening of firebreaks.

The accumulation of combustible material killed in the leafy and non leafy transects (Figure 8), it appears that the largest contribution came from the leafy material is not especially a transect which recorded the highest average with 457.0 g, differing the other, however, similar to transect 2, 3 and 5. The leafy combustible material also had greater accumulation in the transect with a mean value of 251.11 g, resembling statistically only the second transect with 145 g.

Interestingly, in all transects evaluated, there is greater accumulation of combustible material not leafy, living and dead, indicating that this environment and this time there is a greater concentration of dry twigs, bark, stems, resins, which will influence the propagation velocity fire.

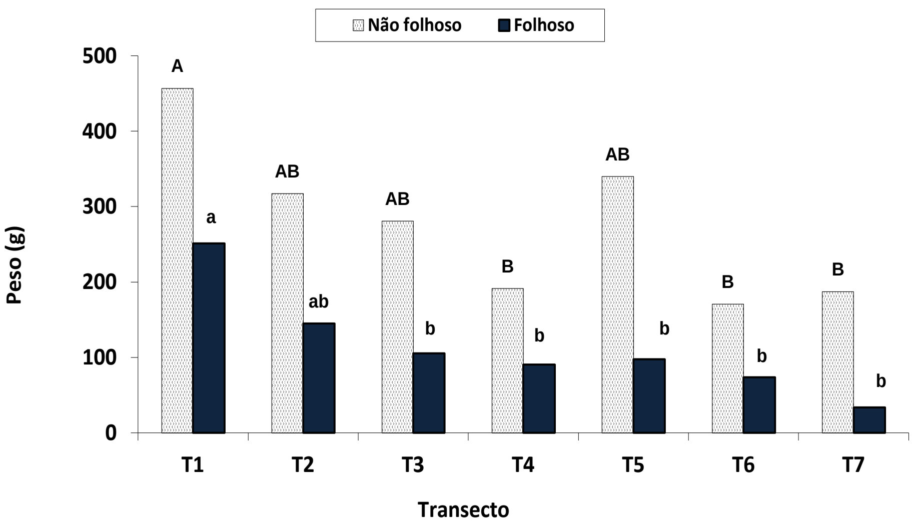

Figure 8. Weight (g) of combustible dead leafy and non leafy collected in different transects in the PRNH Tamanduá Farm in Santa Terezinha, PB. Capitalized compares dead material not leafy (DMS = 177.00) and compares lowercase dead leafy material (DMS = 120.95), among transects.

CONCLUSIONS

1. The PRNH Tamanduá Farm runs a high risk of fire in December due to low humidity in the dead plant material, making it highly flammable;

2. Greater attention should be given the PRNH Tamanduá Farm, in the dry season, the area under the transects 1,2,3, and 5, as well as the surroundings, due to high accumulation of combustible material on the forest floor, which may encourage the spread fire in the event of wildfire.

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