

Root biomass under different soil uses and native Cerrado in Tocantins, Brazil

Biomassa de raízes sob diferentes usos do solo e Cerrado nativo em Tocantins, Brasil

Biomasa de raíces bajo diferentes usos del suelo y Cerrado nativo en Tocantins, Brasil

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Abstract

Studies on the importance of root biomass and the effects that changes in vegetation coverage cause on carbon amount and stock are scarce, especially in the cerrado biome. Taking into account the scarcity of information about root biomass estimates, this work aimed to quantify root biomass under different land uses and native cerrado in Tocantins, Brazil. The research was conducted in different land uses: agriculture, pasture, eucalyptus and control with native cerrado forest. Six trenches with dimensions of 70 x 70 cm were opened and root biomass was collected at depths of 0-10, 10-20, 20-30, 30-40 and 40-50 cm. With the aid of a sieve, root biomass was collected and separated into fine and coarse roots. The amounts of fine and coarse root biomass showed the highest mean values of 7.7 and 12.9 g, respectively, in the eucalyptus area. Root biomass stocks were higher in the eucalyptus area, with maximum values above 3.68 Mg ha⁻¹. Root biomass amounts and stocks were greater in eucalyptus areas, since forest areas, whether planted or native, manage to keep the environment in balance due to their long-term cycles, greater stability and low degree of disturbance.

Keywords: Underground biomass; Change of vegetation coverage; Root stock.

Resumo

Estudos sobre a importância da biomassa radicular e seus efeitos nas mudanças no uso do solo causam redução na quantidade e no estoque de carbono, principalmente no bioma Cerrado. Tendo em vista a escassez de informações sobre as estimativas de biomassas radiculares, este trabalho tem como objetivo quantificar as biomassas radiculares sob diferentes usos do solo no Cerrado em Tocantins, Brasil. A pesquisa foi realizada em diferentes usos do solo: área de agricultura, pastagem, Eucalyptus sp. e como testemunha floresta nativa de Cerrado. Seis trincheiras foram abertas com dimensões de 0,7 x 0,7 x 0,5 m, e biomassas de raízes foram coletadas em profundidades de 0-10, 10-20, 20-30, 30-40 e 40-50 cm. Com o auxílio de uma peneira, as biomassas das raízes foram coletadas e separadas em raízes finas e grossas. Os teores de biomassa de raízes finas e grossas apresentaram os maiores valores médios de 7,7 e 12,9 g kg⁻¹, respectivamente, em uma área de Eucalyptus sp.. Os estoques de biomassa radicular foram maiores na área de Eucalyptus sp. com valores máximos acima de 3,68 Mg ha⁻¹. As quantidades e estoques de biomassa radicular foram maiores na área de Eucalyptus sp., uma vez que áreas florestais, sejam plantadas ou nativas, podem manter o meio ambiente em equilíbrio, devido aos seus ciclos de longa duração, maior estabilidade e baixo grau de perturbação nessas áreas.

Palavras-chave: Biomassa subterrânea; Mudança de cobertura vegetal; Estoque de raízes.

Resumen

Los estudios sobre la importancia de la biomasa radicular y sus efectos sobre los cambios en el uso del suelo provocan una reducción en la cantidad y stock de carbono, principalmente en el bioma del Cerrado. En vista de la escasez de información sobre estimaciones de biomasa de raíces, este trabajo tiene como objetivo cuantificar la biomasa de raíces bajo diferentes usos de la tierra en el Cerrado en Tocantins, Brasil. La investigación se llevó a cabo en diferentes usos del suelo: área agrícola, pasto, Eucalyptus sp. y como testimonio del bosque nativo del Cerrado. Se abrieron seis zanjas con dimensiones de 0,7 x 0,7 x 0,5 m y se recolectaron biomassas de raíces a profundidades de 0-10, 10-20, 20-30, 30-40 y 40-50 cm. Con la ayuda de un tamiz, se recogió la biomasa radicular y se separó en raíces finas y gruesas. Los contenidos de biomasa de raíces finas y gruesas tuvieron los valores medios más altos de 7.7 y 12.9 g kg⁻¹, respectivamente, en un área de Eucalyptus sp. Las existencias de biomasa de raíces fueron mayores en el área de Eucalyptus sp. con valores máximos superiores a 3,68 Mg ha⁻¹. Las cantidades y existencias de biomasa radicular fueron mayores en el área de Eucalyptus sp., Ya que las áreas forestales, ya sean plantadas o nativas, pueden mantener en equilibrio el medio ambiente, debido a sus ciclos de largo plazo, mayor estabilidad y bajo grado de perturbación en estas áreas.

Palabras clave: Biomasa subterrânea; Cambio de cobertura vegetal; Stock de raíz.

1. Introduction

Plants have the ability to produce their own food through the photosynthesis process, and as a result, it generates biomass (Vinhai-Freitas et al., 2017). This process assimilates CO₂ from the atmosphere and stores carbon in the biomass, and with that, studies on biomass production and storage of greenhouse gases, particularly carbon dioxide, have been developed (Soleimani et al., 2019).

Human activities have caused an increase in the concentration of greenhouse gases (GHG) in the atmosphere, mainly due to interference in land use, which consequently influences the capacity of soils to store CO₂ present in plant biomass (Le Quéré et al., 2018; Santana et al., 2020).

Non-anthropized forest coverages provide greater carbon stocks in the soil due to the high deposition of nutrients,

organic matter, since management, disturbance intensity, land use changes and successional stages are factors that influence biomass volume and carbon reserves that are deposited in the soil over time (Primieri et al., 2017).

Studies on estimates of aboveground carbon stocks have been carried out on a global scale, which showed that the largest stocks (>200 Gt C) are found in woody plants (Freitas et al., 2017; Villarino et al., 2018; Marengo et al., 2018).

On the other hand, studies on root biomass are scarce, especially in the cerrado biome, as the heterogeneity of plant species, soil and environment in these areas impairs collection and standardization of methods for data assessment (Narvarez et al., 2017).

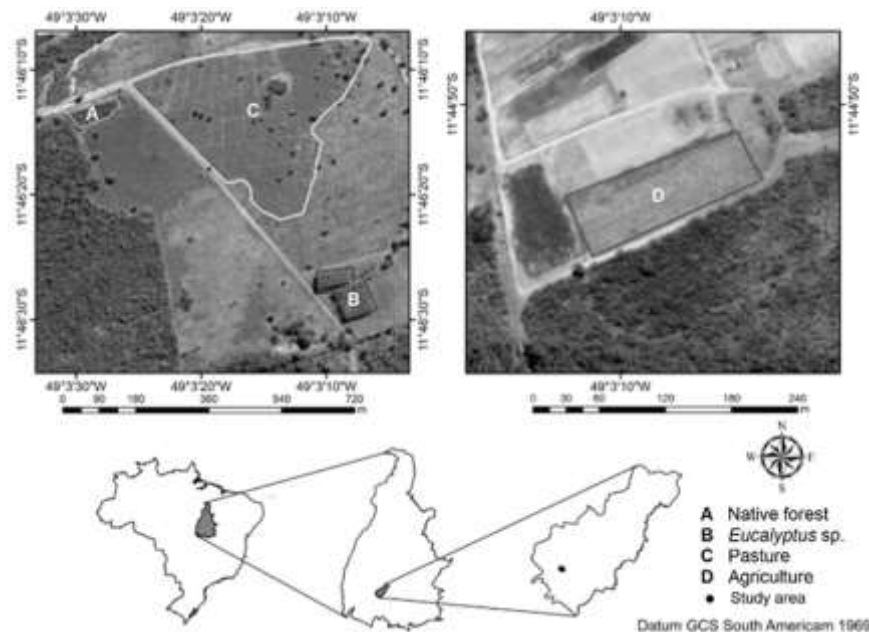
Land use changes can lead to changes in natural properties causing loss of nutrients and organic matter; however, the use of vegetation coverage appropriate to the region can provide less soil degradation and greater environmental sustainability (Toniello, 2019) (Feitosa et al., 2016).

Root biomass quantification regarding land use and change is still little explored, which can be observed through the reduced amount of studies (Marinho-Junioret et al., 2020). Taking into account the importance of root biomass in carbon storage and the lack of information, this work aimed to quantify root biomass under different land uses and native cerrado in Tocantins, Brazil.

2. Methodology

This work was conducted at the experimental farm of the Federal University of Tocantins, municipality of Gurupi, state of Tocantins, at geographical coordinates 11°46'25" S and 49°02'54" W (Figure 1).

Figure 1. Location of experimental areas with native forest, Eucalyptus sp., pasture and agriculture in Gurupi, Tocantins, Brazil.



Source: Marinho-Junior et al., (2021).

According to Thornthwaite, the climate of the region is B1wA'a' type, having two well-defined seasons, with about six months of drought, comprising the winter period and six months of rain that correspond to the summer period. The average annual temperature is 27°C and the average annual precipitation is 1,500 mm (Tocantins, 2017). The soil was classified as petric Plinthosol (Santos et al., 2018). The study areas were occupied with Eucalyptus sp., Pasture, Agriculture and Native

Forest as control. Each area had the following characteristics:

Native forest: the area aged over 60 years covers 22.82 ha, without recent vegetation burns or cuts with the following species: *Myrcia splendens* (Sw.) DC. (13.04%), *Qualea multiflora* Mart. (9.87%), *Protium heptaphyllum* (Aubl.) Marchand (7.53%), *Magonia pubescens* A.St.-Hil. (5.35%), *Qualea grandiflora* Mart. (5.02%) (Bertazzini et al, 2018).

Eucalyptus sp.: the area aged 11 years covers 0.65 ha and its implementation was carried out through deforestation with bulldozer and front shovel, followed by plowing and harrowing. Seedlings of 25 cm in height were planted in pits of dimensions of 0.4 x 0.4 x 0.4 m with the help of excavators and 3 x 2 m spacing. Fertilization was carried out with 100 g of simple superphosphate at the bottom of the pit and partially buried, then 150 g per pit-1 of NPK were added in the 5-25-15 formulation. After implementation, thinning was not carried out on trees and ground cover was composed of leaves and small *Eucalyptus* sp. branches. Manual weeding was also carried out in the area to control weeds.

Pasture: the area covers 11.25 ha with native pasture and predominance of *Andropogon* grass aged over 40 years, without the presence of animals. Other poaceas species such as *Spalum notatum*, *Eragrostis bahiensis*, *Axonopus affinis*, *Bothriochloa laguroides*, *Schizachyrium microstachyum*, *Paspalum dilatatum*, *Sporobolus indicus*, *Rhynchospora* sp., *Andropogon ternatus*, *Panpalumis* sp. have been recorded.

Agriculture: The area covers 0.95 ha and soil preparation was performed using leveling harrow and disc plow, and weeds were controlled by manual weeding associated with the use of full-action herbicides such as Glyphosate, operations adopted when necessary. Over the past 6 years, corn was grown in the area, annually planted in the period between February and March with average spacing of 0.2 x 0.8 m. For sowing, manual planter-fertilizer was used, which enabled basic fertilization. The nutrients applied at the time of corn sowing consists of nitrogen in the form of ammonium sulphate (45% N), phosphorus in the form of triple superphosphate (42% P₂O₅) and potassium in the form of potassium chloride (58% of K₂O), corresponding to 120, 170 and 140 kg ha⁻¹, respectively of N, P and K, with N applied 50% at 25 days and 50% at 45 days after sowing. At other times of the year, no cultivation of any kind was carried out in the area, with corn stubble being the only soil coverage.

Roots were collected in six trenches with dimensions of 0.7 x 0.7 m, at depths of 0-10, 10-20, 20-30, 30-40 and 40-50 cm, in each study area. The soil of each layer was passed through a 4 mm mesh sieve, and all retained underground biomass was manually collected. Collected roots were stored in identified plastic bags and sprinkled with 70% alcohol to inhibit microbial activity. Roots were separated into two diameter classes, fine roots ≤ 5 mm and coarse roots > 5 mm, with the aid of a caliper. Roots were not distinguished between dead and alive, nor separated by species. The collected root biomass was placed in paper containers and dried in a forced circulation oven at 65°C until reaching constant weight. Subsequently, samples were weighed to obtain the dry mass of plant components.

Root biomass stocks were calculated in Mg ha⁻¹ for each depth sampled as follows (Barbosa et al, 2012):

$$ESTBR = BR \times Ds \times VPA$$

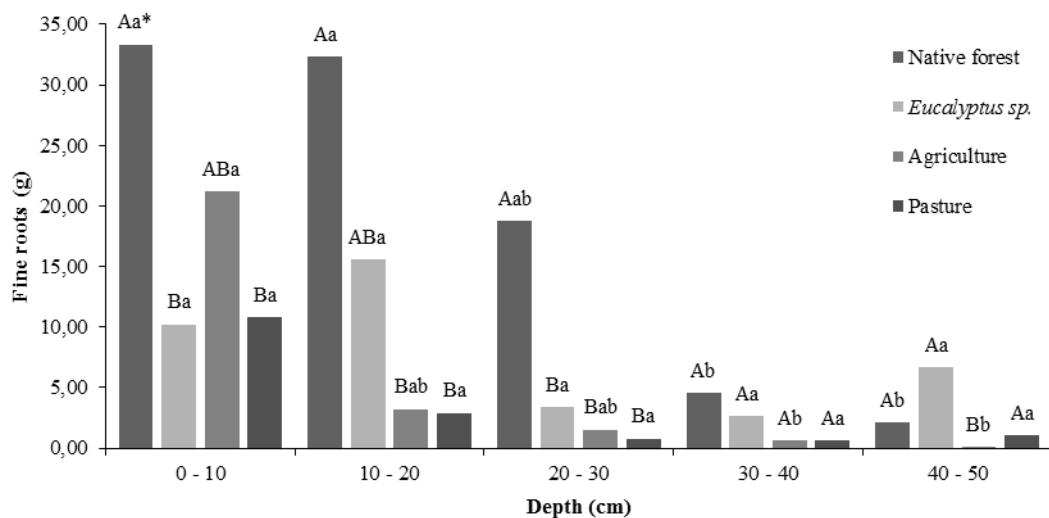
Where ESTBR is the root biomass stock in the soil layer, in Mg ha⁻¹; BR is the root biomass concentration, in kg Mg⁻¹; Ds is the soil density in the layer, in Mg m⁻³ and VPA is the volume of the sampled depth, in m³.

Data were submitted to Shapiro and Wilk normality tests and then analysis of variance (ANOVA) was performed to evaluate differences between vegetative coverages at soil depths of 0-10, 10-20, 20-30, 30-40 and 40-50 cm, with application of the F test. Comparison of means was performed using the Tukey test at 5% significance and the SISVAR statistical software (Ferreira, 2011).

3. Results and Discussion

Fine root amount showed the highest average values, between vegetation coverage and surface layers in all land uses, and in *Eucalyptus* sp., greater amounts were observed, ranging from 2.66 to 15.56 g, in comparison with the other areas under study, except for native forest considered as control (Figure 2).

Figure 2. Amount of fine roots as a function of different land uses and depths in Gurupi, Tocantins, Brazil.



*Significant differences are indicated by different letters by the Tukey test at 5% significance ($P \leq 0.05$). Uppercase letters indicate differences between vegetation coverages and lowercase letters indicate differences between soil depths. Source: Authors (2021).

In areas where land use changes were observed, in area of *Eucalyptus* sp., the highest values may be linked to greater conservation of organic material, since the forest area has greater soil and root biomass protection from degrading agents when compared to areas without vegetation coverage, or in state of degradation (Nascimento et al., 2019). In a survey of fine root biomass and organic matter constituents in different areas, Barbosa et al. (2017) found values of fine roots not exceeding 3.96 g in eucalyptus area. In another work on the dynamics of fine roots in different areas, Mendes et al., (2018) found values around 11.00 g, similar to those found in this work.

Another point to be highlighted is that in the layer of 0-10, the agriculture area presented values of fine roots significantly higher than the other areas where change in vegetation coverage was observed, exceeding 20 g. These higher values of fine roots in the first layer in the agriculture area can be explained by the type of corn root system, as corn is monocotyledonous, its roots are thinner, with uniform thickness, receiving the name of fasciculate root system, which are located more superficially on the soil (Assefa et al., 2017).

The distribution of nutrients on the surface, as is the case in the agriculture area, where fertilizers were applied, leads to greater concentration of roots at this depth (Roquette, 2018).

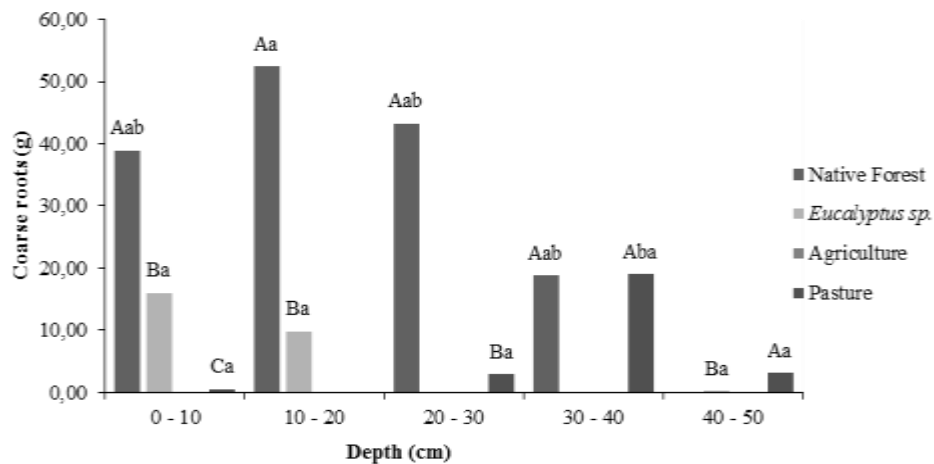
In work on fine root dynamics in different land uses, Rosa (2018) showed that more than 50% of fine roots were concentrated mainly in the superficial layer (0-10 cm), and in the agriculture area, the first layer presented approximately 0.5 Mg ha⁻¹ of stored fine roots.

The smallest amounts of fine roots were found in the pasture area, and as the depth increased, the mean values of fine roots decreased Figure 2. These lower values can be explained by the degree of degradation in the area, as with the reduction of vegetation coverage, the amounts of roots also decreased (Premrov et al., 2017). According to Andrade et al., (2020), the amount of fine roots in pasture area ranged from 5.33 to 25.83 g, which are within values found in this study. The same authors

also reported that the results found in their work in relation to the behavior of fine root biomass are inversely proportional to depth, and the amounts of roots decreased around 36% in the layer of 5-30 cm.

The significant mean values of coarse roots were higher in *Eucalyptus* sp. with values ranging from 9.77 to 16.04 g in the superficial layers of 0-10 and 10-20 cm, except for native forest considered as control Figure 3.

Figure 3. Amount of coarse roots as a function of different land uses and depths in Gurupi, Tocantins, Brazil.



*Significant differences are indicated by different letters by the Tukey test at 5% significance ($P \leq 0.05$). Uppercase letters indicate differences between vegetation coverages and lowercase letters indicate differences between soil depths. Source: Authors (2021).

Areas with forest monocultures such as *Eucalyptus* sp. tend to present high biomass increase rates, both aboveground and underground, due to its homogeneity and high degree of development (Miccolis et al., 2016). Another explanation is that the larger amounts of coarse roots in eucalyptus areas are related to the C/N ratio of the organic material, as the higher, the longer it takes for the material to be decomposed, remaining stocked in the soil (Colatto et al., 2019).

In the work carried out by Dias et al., (2017) on the distribution and morphology of the root system, the authors found values of coarse roots in an eucalyptus area that exceed 15 g in the layer of 0-10, values similar to those found in this work.

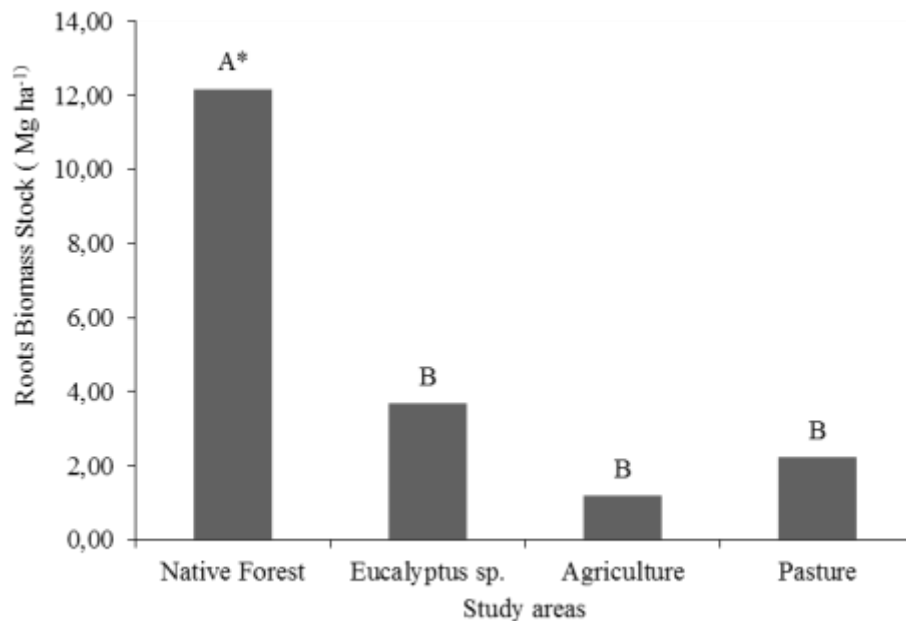
In layers of 20-30 and 40-50 cm, the amount of coarse roots was significantly higher in the pasture area compared to other areas, where change in vegetation coverage was observed, with the highest value above 15 g. These higher values of coarse roots in pasture area may be related to the deposition of weed roots over the years, accumulating in deeper layers, since the area was not submitted to weed removal (Favarin et al., 2019).

Another point that may explain this greater accumulation of coarse roots in deeper layers is the compaction in more superficial layers, due to the traffic of cattle, thus hindering the development of roots in these layers (Linhares et al., 2016). In work carried out by Rosa (2018) on vegetation coverage and biomass stock changes, the author found values of coarse root stocks in a pasture area between 12 and 13 g in the layer of 20-50 cm, values below those found in this work.

In the agriculture area, the occurrence of coarse roots was not observed Figure 3. The occurrence of annual crops, usually with superficial and thin roots in agriculture areas, directly influenced the amount of coarse roots in the soil, since most annual crops have roots that are divided into seminal and nodal, where roots have approximately the same diameter, and distinguishing the main root is not possible (Assefa et al., 2017).

Root biomass stocks were significantly higher in *Eucalyptus* sp. in relation to the other areas, except for native forest considered as control Figure 4.

Figure 4. Soil root biomass stocks as a function of different land uses and depths in Gurupi, Tocantins, Brazil.



*Significant differences are indicated by different letters by the Tukey test at 5% significance ($P \leq 0.05$). Capital letters indicate differences between vegetation coverages. Source: Authors (2021).

In soil with Eucalyptus sp., this greater root biomass stock may be directly linked to the size of the forest and its ability to maintain organic matter in the soil for longer time due to its high lignin content and high C/ N ratio (Klug et al., 2020). Ribeiro et al., (2017) found root biomass stock values close to those found in this work in eucalyptus area, with average value close to 2.00 mg ha⁻¹. In another work carried out by Garcia et al. (2019), the authors found in their work root biomass stock value in eucalyptus area much higher than that found in this work, 17.06 Mg ha⁻¹.

On the other hand, the root biomass stock was significantly smaller in the agriculture area, not exceeding 1.18 Mg ha⁻¹ (Figure 4). This lower value can be explained by the frequent soil disturbance, making the soil vulnerable due to exposure to external actions, impairing its protection from weather events, accelerating the decomposition of organic material such as, for example, roots (Salomão et al., 2019).

In work carried out by Albuquerque et al. (2016) on root biomass in areas with different land uses, the authors found values higher than those of this work in agriculture area, around 9.8 Mg ha⁻¹. In another work carried out by Wolschick et al. (2016) on root stock in different vegetation coverages, the authors found values close to those found in this work in the agriculture area, ranging from 1.35 to 4.53 Mg ha⁻¹.

4. Conclusion

Root biomass amounts and stocks in the Eucalyptus sp. area were higher in relation to other land uses such as agriculture and pasture. In general, the root biomass amount of the Eucalyptus sp. area was similar to that of native forest, since forests, whether planted or native, manage to keep the environment in balance, due to their long-term cycles, greater stability and low degree of disturbance.

Another very interesting point to be evaluated in future work is the effect of the change in land use on the amount of chemical elements present in root biomass, since they are of paramount importance in making the decision on which management to adopt.

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