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Stocks of elements in radicular biomasses in different coverages in the cerrado of tocantins, Brazil

Estoques de elementos em biomassas radiculares nas diferentes coberturas no cerrado tocantinense Brasil

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ABSTRACT - Root biomass plays a vital role in nutrient cycling for the maintenance and functioning of different ecosystems. In this context, this study aimed to determine the stocks of elements in root biomass under different covers in the Cerrado of Tocantins, Brazil. The research was conducted in different vegetal coverings: agriculture, pasture, Eucalyptus sp., and native Cerrado forest. Root biomass was collected in six trenches, 70 x 70 cm, and a depth of 50 cm through sieving. Macro and microelement stocks were determined in root biomass. Macros and microelements showed higher average values for the native forest. With the change in vegetation cover, N, P, and S were higher in agriculture, with stocks of 1.82 Mg ha^{-1}, 1.83 Mg ha^{-1}, and 9.6 Mg ha^{-1}. In a planted forest of Eucalyptus sp., macroelements K, Ca, and Mg were higher, with stock values of 16.06 Mg ha^{-1}, 25.91 Mg ha^{-1}, and 5.02 Mg ha^{-1}, and microelements, B, Cu, Fe, Mn, and Zn with values of 0.05 Mg ha^{-1}, 0.04 Mg ha^{-1}, 5 Mg ha^{-1}, 0.7 Mg ha^{-1}, and 0.08 Mg ha^{-1} in root biomass, respectively. Thus, the planted forest of Eucalyptus sp. promoted greater stocks and cycling of elements, with greater stability of the organic material.

Keywords: Macro and microelements. Underground biomass. Nutrient cycling.

RESUMO - As biomassas radiculares desempenham um papel importante na ciclagem de nutrientes, para manutenção e funcionamento dos diferentes ecossistemas. Diante desse contexto, o trabalho teve como objetivo determinar os estoques de elementos em biomassa radiculares sob diferentes coberturas no Cerrado em Tocantins, Brasil. A pesquisa foi conduzida em diferentes coberturas vegetais: agricultura, pastagem, *Eucalyptus sp.* e floresta nativa de cerrado. As biomassas radiculares foram coletadas em seis trincheiras com dimensões 70 x 70 cm, e profundidade de 50 cm através do peneiramento. Os estoques dos macros e microelementos foram determinados em biomassas radiculares. Os macros e microelementos apresentaram valores médios maiores para floresta nativa. Com a mudança de cobertura vegetal N, P, S, foram maiores em agricultura, com estoques de 1,82 Mg ha^{-1}, 1,83 Mg ha^{-1} e 9,6 Mg ha^{-1}. Em floresta plantada de *Eucalyptus sp.*, os macroelementos K, Ca e Mg foram maiores tendo valores de estoques respectivamente de 16,06 Mg ha^{-1}, 25,91 Mg ha^{-1} e 5,02 Mg ha^{-1} e microelementos B, Cu, Fe, Mn e Zn com valores de 0,05 Mg ha^{-1}, 0,04 Mg ha^{-1}, 5 Mg ha^{-1}, 0,7 Mg ha^{-1} e 0,08 Mg ha^{-1} em biomassas radiculares. Deste modo a floresta plantada de *Eucalyptus sp.* promoveu maiores estoques e ciclagem de elementos, com maior estabilidade do material orgânico.

Palavras-chave: Macro e microelementos. Biomassa subterrânea. Ciclagem de nutrientes.

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INTRODUCTION

The soils that make up the Cerrado have favorable conditions for crops of economic interest, with techniques that improve soil fertility, making cultivation possible (PES; GIACOMINI, 2017). In this way, the change of cover in the Cerrado leads to a greater susceptibility to soil loss by erosive processes and reduction of biomass and elements present in the soil due to the adoption of inadequate management techniques (OLIVEIRA et al., 2016).

The material deposited in the soil, for example, the shoot and root biomass, plays a key role in the cycling of nutrients since it releases elements for plants that they use as nutrients and energy transfers in the photosynthesis process (LABEGALINI et al., 2016). The content of elements deposited in the soil comes from the decomposition of surface and underground biomass, which is responsible for the entry of nutrients into the soil-plant system, positively altering the physical, chemical, and biological characteristics of the soil (MORAIS et al., 2019).

The underground biomass formed mainly by roots is composed of macro and microelements, being of fundamental importance for the maintenance and development of different ecosystems, as it influences the productivity and potential of the local vegetation (SANTOS et al., 2017). The change in vegetation cover can lead to a decrease in nutrients when performed without adequate management techniques, such as monocultures or unfertilized crops (BORDONAL et al., 2018).

The management of the production system, and agricultural practices, are one of the main factors that can determine the degree of impact on the soil, as well as the use of vegetation appropriate to the region, which can provide less soil degradation and greater environmental sustainability (FEITOSA et al., 2016).

The quantification and evaluation of the content of elements in root biomass are still little discussed in the Cerrado biome, especially concerning the influence of the change in vegetation cover; it can be observed by the scarcity of studies that provide information about the contribution of root biomass in nutrient cycling (SALOMÃO et al., 2020). In this context, this study aimed to determine the stocks of elements in root biomass under different covers in the Cerrado of Tocantins, Brazil.

MATERIALS AND METHODS

The research was conducted at the experimental farm of the Federal University of Tocantins, in Gurupi-TO, in May 2019, at the geographic coordinates 11º 46’ 25” S and 49º 02’ 54” W (Figure 1).

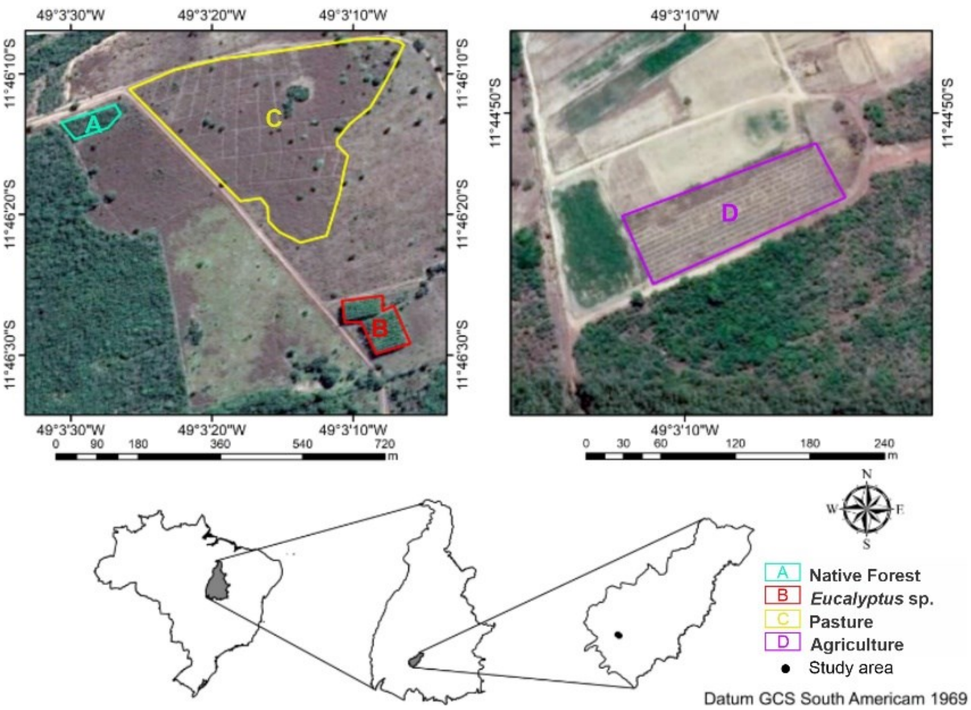

Figure 1. Location of experimental areas with native forest, Eucalyptus sp., pasture, and agriculture in Gurupi, Tocantins, Brazil.

The climate of the region, according to Thornthwaite, is of the B1wA'a' type, with two well-defined seasons, with about six months of drought, comprising the winter period and six months of rain that correspond to the summer. The average annual temperature is 27ºC, and the average annual precipitation is 1,500 mm (SEPLAN, 2017). The soil was classified as a Plintossolo Pétrico (SANTOS et al., 2018). The studied areas were *Eucalyptus sp*., Pasture, Agriculture, and Native Forest, the last one as a control treatment. Each area had the following characteristics:

Native forest: the area covers 22.82 ha, aged over 60 years, without recent burns or cuts of vegetation in the area. The ground cover had a large amount of litter, and the vegetation was characterized by five species of higher importance value, *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%) (BENDITO et al., 2018).

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

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

Agriculture: The area has 0.95 ha, and the soil preparation was done using a leveling harrow and disc plow, and the weeds were controlled by manual weeding associated with the use of full-action herbicides such as Glyphosate, operations adopted when necessary. Over the past six years, the corn crop was grown in the area, planted annually between February and March at an average spacing of 0.2 x 0.8 m. A manual planter-fertilizer was used for sowing, enabling fertilization in the sowing furrow. The nutrients applied at the time of corn sowing consisted of nitrogen in the form of ammonium sulfate (45% N), phosphorus in the form of triple superphosphate (42% P_2O_5), and potassium in the form of potassium chloride (58% of K_2O), 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 was carried out in the area, with corn stubble only covering the soil.

The roots were collected in six trenches with dimensions of 70 x 70 cm and a depth of 50 cm, selected in randomized blocks in each study area. The soil of each layer was passed through a 4 mm mesh sieve, and all underground biomass that was retained was collected by manual collection. The collected roots were stored in identified plastic bags and sprayed with 70% alcohol to inhibit microbial activity. The roots were not distinguished between dead and alive, nor specific for species. The collected root biomasses were packed in paper packages and dried in an air-forced circulation oven at 65°C until reaching constant weight.

After drying, the samples were ground in a laboratory mill with a 30 mesh sieve, and an aliquot was removed and placed in plastic containers for chemical analysis. Analyzes were performed in aqueous extract after sulfuric or nitric-perchloric digestion. The concentrations of macro and microelements were determined by atomic absorption spectrometry (TEIXEIRA et al., 2017).

The element stocks were calculated by the product of the element concentrations and the root biomass stocks in Mg ha^{-1} for each sampled depth. The total stock of elements at a depth of 0-50 cm was calculated by obtaining the sum of the stocks in each soil layer. Data were submitted to the Shapiro and Wilk normality tests, after which the analysis of variance (ANOVA) was performed. The comparison of means was performed using the Tukey test at 5% significance and using the SISVAR statistical software (FERREIRA, 2011).

RESULTS AND DISCUSSION

Analyzing the stock of macroelements (N, P, and K) in root biomass, it was observed that the area with native forest obtained higher significant values (Figure 2).

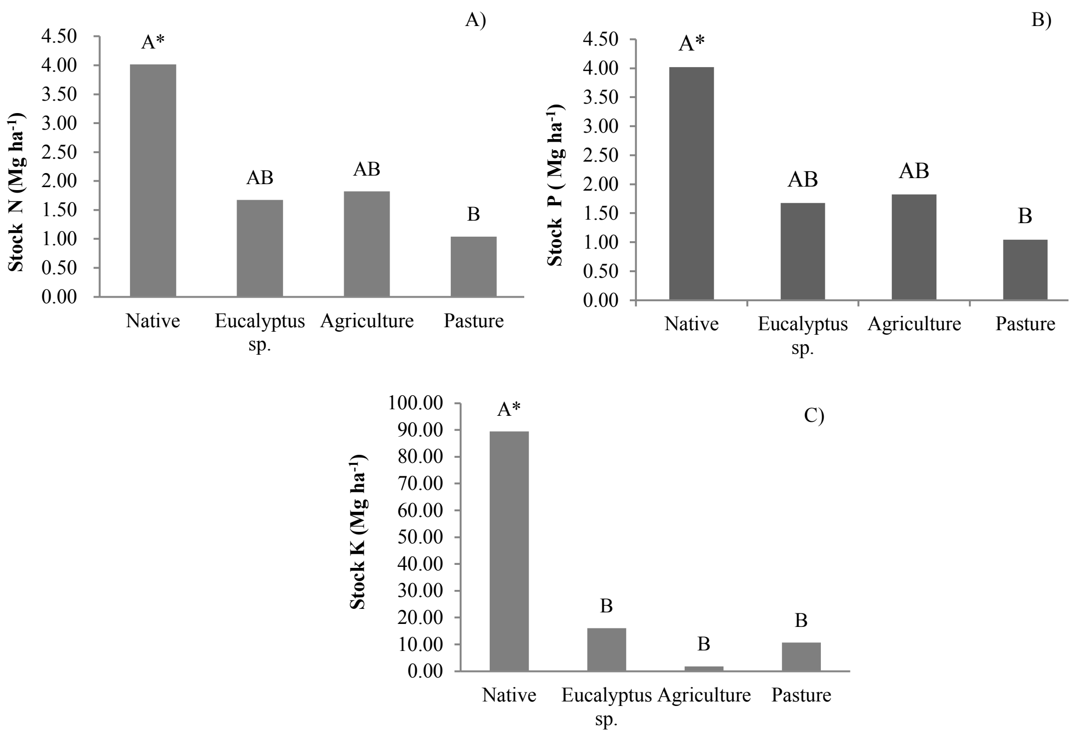

Figure 2. Nitrogen (A), phosphorus (B), and potassium (C) stocks in root biomass according to different soil covering.
*Different capital letters indicate differences by the Tukey test at 5% significance.

In the native Cerrado, large amounts of leguminous species occur, which is known for its biological fixation capacity, where the association of bacteria and roots can absorb large amounts of nitrogen from the soil and convert it into compounds assimilable by the plant, receiving in exchange sugars and other organic nutrients in the root system, thus explaining higher nutrient stocks in root biomass (TAIZ et al., 2017).

In a study carried out by Teodoro (2014) on biomass and nutrient stocks in the Cerrado, they found similar results for (N, P, and K), values that exceeded, respectively, 5.0 Mg ha^{-1}, 5.5 Mg ha^{-1}, and 35.0 Mg ha^{-1}.

Assessing nitrogen stocks in root biomass in areas with a change in vegetation cover, it was observed that the area with agriculture presented higher average values (Figure 2A). This greater stock of nitrogen in root biomass in the agricultural area may be linked to fertilization and soil preparation at the beginning of planting, as most areas exploited with agriculture are found in tropical regions, with a high degree of weathering and low levels of nutrients, requiring fertilization (FARIAS et al., 2017).

In a study carried out by Silva et al. (2008), who evaluated the nutrient stock in root biomass in different cover crops in the Cerrado, showed higher nitrogen content in root biomass in corn agriculture than in this study, in which the average nitrogen stock was 7.5 Mg ha^{-1}.

The pasture area had lower average values of nitrogen stock in the root biomass (Figure 2A). The state of degradation of unmanaged pasture tends to have lower nutrient content due to the fast cycling of nutrients and their loss, due to greater exposure of biomass to degrading agents, leaving soils poorer, and consequently, there is a deficiency of this element in plants (ROSSET et al., 2016).

In a study carried out by Rosendo and Rosa (2018) on factors influencing nutrient stock in root biomass, they observed that in the system in which cattle graze throughout the year, the proportion of biomass is lower due to their consumption of grass leaves, which decreases its photosynthetic rate, hindering the renewal of the root system and consequently the nutrient supply present in it.

Phosphorus stocks in root biomass showed higher average values in the agricultural area than in other soil covers that underwent alteration (Figure 2B).

The phosphate fertilization can explain the higher levels of phosphorus carried out at the beginning of planting, together with the cultural remains of previous crops, contributing to greater availability and storage of this nutrient in the soil and shoot and root system biomass (RESENDE et al., 2018).

Another point that can be used to explain the higher P stocks in root biomass in agricultural areas is the type of fibrous root system of corn, formed by several axes, usually with diameters below 0.2 mm, which facilitates the absorption and nutrient storage in it, since fine roots have greater efficiency in the absorption of water and nutrients (ASSEFA et al., 2017).

In a study conducted by Marcolan (2006), uptake and stock of phosphorus in soil and biomass in different coverings showed higher values of phosphorus stock in root biomass in agricultural areas than in this study, with an average value of 3.00 Mg ha^{-1}.

The lowest average values of phosphorus stocks in root biomass were found in the pasture area concerning the other vegetation covers that underwent alteration (Figure 2B). This can be explained by the intensity of grazing, reducing the leaf area to capture solar radiation, consequently decreasing plant growth, both in the shoot and root system, and, therefore, the nutrient stock in the biomass was affected (LUZ, 2016).

Another point that reduced the phosphorus and other nutrients stock is the degree of exposure of the organic material to degrading agents since pasture degrades have greater soil exposure, causing higher rates of biomass mineralization, releasing nutrients faster, that is, spending less time stored in the biomass (CAMPOS et al., 2016).

In a study by Diniz et al. (2015), who evaluated the nutrient stock in biomass in different vegetation covers in the Cerrado, showed similar values of phosphorus stock in root biomass in degraded pasture area, with an average value of 1.17 Mg ha^{-1}.

Potassium stock in root biomass in the area of *Eucalyptus* sp. was higher when compared to areas that showed changes in vegetation cover (Figure 2C). This higher value in root biomass may be linked to fertilization performed at the beginning of planting in the area of *Eucalyptus* sp. (FARIAS et al., 2017).

Another point is the greater capacity of forests, whether planted or natural, to store biomass and nutrients for longer due to greater protection from degrading agents (GUIMARAES et al., 2015).

With increasing age of the eucalyptus forest, through physiological strategies, the plant uses much of its energy to increase the production of roots; thus, there is an increase in density and specific root area, and consequently, there is greater absorption and water and nutrient stock in the root system (DICK, 2018). Costa et al. (2014) found in their study on biomass and nutrient stocks in planted forests the approximate value of this study concerning the potassium stock in root biomass, in which the average value was 12.75 Mg ha^{-1}.

On the other hand, the lowest values of potassium stock in root biomass were in the agricultural area (Figure 2C). Tropical soils naturally have low levels of K even when this element enters via fertilization since the passage of K from the exchangeable to the non-exchangeable form can be fast, depending on the concentration of the nutrient in the soil solution, making it possible for the occurrence of losses by leaching, due to the natural tendency of the soil balance, thus the absorption and storage of this nutrient in the biomass, whether aerial or underground, is affected (BATISTA et al., 2018).

Potassium is one of the elements that present a high rate of internal translocation in plants, mainly for grains, with 26% to 43% of the absorbed potassium being translocated (GUILHERME et al., 2020). When corn is harvested, in addition to the grains, the vegetative part is also removed, with a consequent high extraction and export of potassium leading to a continuous reduction in the stock of this element in the soil and the aboveground and underground biomass over time (PANTANO et al., 2016).

In a study carried out by Guareschi et al. (2019), the amount of potassium that is exported by grains is approximately 4 kg ha^{-1} to 7 kg ha^{-1} for each ton of corn produced, thus leading to a decrease in this nutrient in the soil and consequently the availability for plants to absorb and store in their biomass.

In a study carried out by Wolschick et al. (2016) on nutrient contents in underground biomass, they showed potassium stock values in root biomass in agricultural areas above 24 kg ha^{-1}, which were higher than those found in this study. The same authors attribute the high K stocks in root biomass in agricultural areas to intercropping with cover crops since these can recycle the element K.

Calcium and magnesium stocks showed higher average values in root biomass in an area of *Eucalyptus* sp. compared to areas with a change in vegetation cover (Figures 3A and 3B). The greater stocks of calcium and magnesium in root biomass in eucalyptus areas can be explained by the age of the forest and continuous cycling since forests over ten years old manage to maintain nutrients for longer through the decomposition of controlled organic matter; in addition to that, the elements Ca and Mg are structural elements, mainly Ca, which is commonly found in the literature as an immobile element, remaining in the plant structure for a longer time (ALVES et al., 2017).

According to Valente et al. (2016), the distribution of nutrients in forest biomass varies over time. With the dynamics of the ecosystem in the juvenile stage, the process is more accelerated, stabilizing when the forest reaches ages greater than ten years, as is the case of the area with *Eucalyptus* sp., which is 11 years old.

In a study carried out by Consensa (2017) on nutrient stocks in biomass in a eucalyptus stand, they showed lower values of Ca and Mg stocks in root biomass than the values found in this study, with average values of 7.82 Mg ha^{-1} and 2.44 Mg ha^{-1}, respectively.

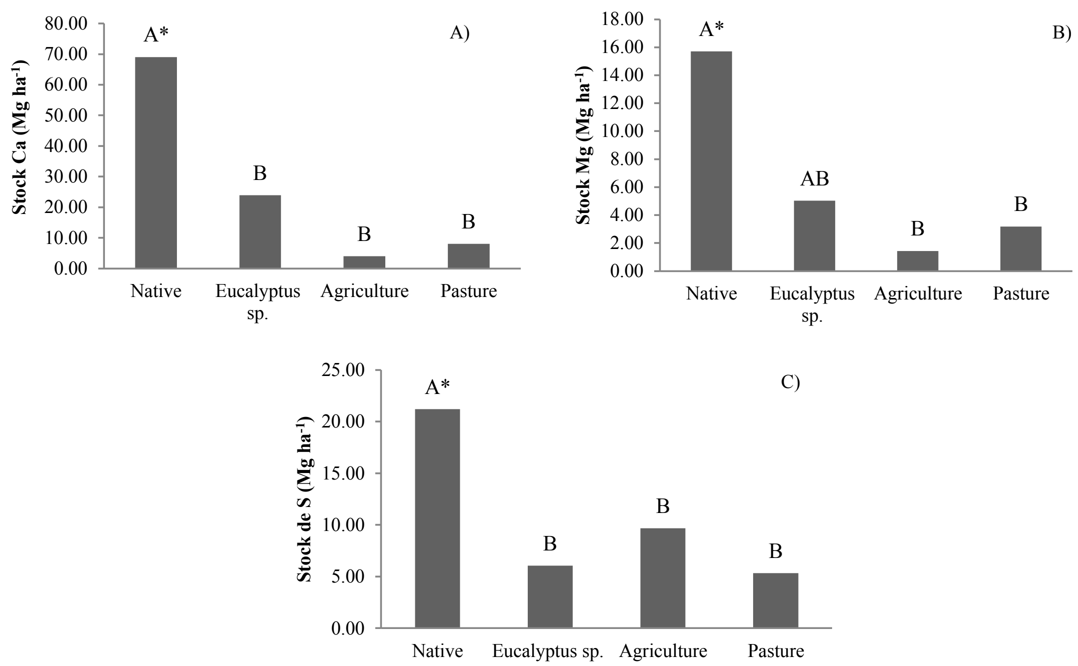

Figure 3. Calcium - Ca (A), magnesium – Mg (B), and sulfur – S (C) stocks in root biomass in different vegetation covers. *Different capital letters indicate significant differences by the Tukey test at 5% significance.

On the other hand, the lowest average values of calcium and magnesium stocks in root biomass were in the agricultural area compared to areas with a change in vegetation cover (Figures 3A and 3B).

Lower Ca and Mg stocks in root biomass were due to greater soil interference, with faster nutrient cycling and greater decomposition, reducing the nutrients stored in organic matter (BORDONAL et al., 2018).

Another point that may explain the lower Ca and Mg stocks in root biomass in agriculture, according to Primieri et al. (2017), is a large amount of these nutrients in grains, having from 7 to 35 kg ha^{-1} of Ca and 10 to 33 kg ha^{-1} of Mg. When these grains are harvested, most of these nutrients are taken, not returning to the soil, thus reducing the amounts of these nutrients for absorption and storage in the root biomass.

In the study by Galvão et al. (2009) on root dry mass and nutrient stock in different cover crops in the Cerrado, they showed lower values of Ca stored in root biomass with 3.8 Mg ha^{-1} and higher values of Mg with 2.6 Mg ha^{-1} compared to this study.

Analyzing the macroelements, higher average values of sulfur stocks in the agricultural area were observed compared to the areas with a change in vegetation cover (Figure 3C). The higher sulfur stocks in root biomass in agriculture can be explained by the management and application of fertilizers at the beginning of planting (CAMPOS et al., 2016; CASSOL et al., 2019).

Another point that may explain the greater stock of sulfur in root biomass in agriculture is the greater release of this element through the decomposition of crop residues from previous plantations, thus allowing greater amounts of sulfur to be absorbed and stored in shoot and root biomass (ANDRADE et al., 2019).

According to Barbosa et al. (2017), the corn crop has a fibrous root system, with a predominance of fine roots that stimulates the activities of the plasma membrane H+-ATPase together with humic substances from previous crops, favoring the emission of new roots on thin sides, thus increasing the surface area of the root system and, consequently, the nutrients stored in it.

In a study carried out by Teixeira and Trivein (2004) on sulfur stocks in biomass in different soil covers in the Cerrado, they showed S stock values in agricultural root biomass (corn), higher than those found in this study, with an average value of 13.3 Mg ha^{-1}.

On the other hand, the lowest average values of sulfur stock in root biomass were in the pasture area compared to areas with a change in vegetation cover (Figure 3C). Sulfur is found mainly in the composition of proteins and participates in the formation of some essential amino acids for energy metabolism; it intervenes in the synthesis of organic compounds, especially vitamins and enzymes, being an immobile nutrient that justifies its higher concentration in the leaf compartment and lower concentrations in roots, mainly in degraded areas (ANDRADE et al., 2019).

Another point used to explain the lower sulfur stocks in root biomass in pasture areas is that sulfate is immediately available for use by plants; however, as this form is very mobile in the soil, its supply may be interrupted due to leaching mainly in areas with potential degradation (VILELA et al., 2017).

In a study carried out by Teodoro (2014) on biomass, nutrient stocks in different vegetation covers in the Cerrado, they showed values of sulfur stored in the root biomass in a pasture area lower than those found in this study, with an average value of 10 Mg ha^{-1}.

The area of the native forest presented higher average values of microelements stocks in the root biomass (Figure 4).

These higher microelement stocks in forest areas can be explained by the time the organic material remains in the area before being decomposed since forests tend to maintain and protect their biomass from degrading agents for a longer time and consequently keeps the nutrients stored in it (SCHUMACHER et al., 2019).

Another explanation for the higher microelement stocks in native forest areas is the variability of root systems in Cerrado areas, adapted to dry and poor soils with the capacity to store nutrients in their roots (CARVALHO et al., 2016).

Although the Cerrado has an abundance of light, on the other hand, the low availability of water and nutrients are factors that limit the growth of vegetation, causing greater investment in root formation to explore the deep layers of soil, thus increasing the amount of root biomass and consequently the nutrient stocks present in them (DÓRIA et al., 2016).

In a study carried out by Caldeira (2003) on the determination of biomass and nutrients in the Cerrado, they showed microelement stocks in root biomass greater than those found in this study, where the average values stored in the root biomass of B were 0.96 Mg ha^{-1}, Cu 0.87 Mg ha^{-1}, Fe 58.26 Mg ha^{-1}, Mn 15.17 Mg ha^{-1}, and Zn 1.25 Mg ha^{-1}.

In an area with *Eucalyptus* sp. forest, where there was a change in vegetation cover, they presented higher average values in microelements stocks compared to the other covers (Figure 4). According to Taylor et al. (2016), the largest stocks of microelements in root biomass in eucalyptus areas were due to the efficiency of nutrient use since monocropping has greater availability of nutrients in the soil and root biomass due to more uniform cycling and release, thus reducing leaching losses.

The microelement content in planted forest stands is a consequence of the nutrient levels in the soil and the decomposition of biomass. According to Silva et al. (2017), the decomposition of biomass in an area of eucalyptus occurred slowly due to its high C/N ratio, presenting itself as an excellent strategy in the cycling process of nutrients, allowing them to be slowly released, absorbed, and stored in the biomass for more time.

Barichello et al. (2005) found in their study on microelement stock in planted forest biomass in the Cerrado lower microelement stock values than those found in this study in root biomass in the eucalyptus area, in which the average value of B was 0 .46 Mg ha^{-1}, Cu 0.03 Mg ha^{-1}, Fe 1.79 Mg ha^{-1}, Mn 0.35 Mg ha^{-1}, and Zn 0.08 Mg ha^{-1}.

In a study on the amount of nutrients in the root biomass of *Eucalyptus* sp. at seven years of age carried out by Salvador and Schumacher (2015), they found values higher than this study, ranging from 3.83 to 5.40 Mg ha^{-1} of boron stored in root biomass.

In the agricultural area, boron stocks had lower average values (Figure 4A). Albers et al. (2019) showed in their study that B is a microelement that does not have a priority function in the roots, in which it participates in addition to cell formation, in the transport of carbohydrates, causing it to accumulate in the leaves, especially in annual crops such as the case of corn.

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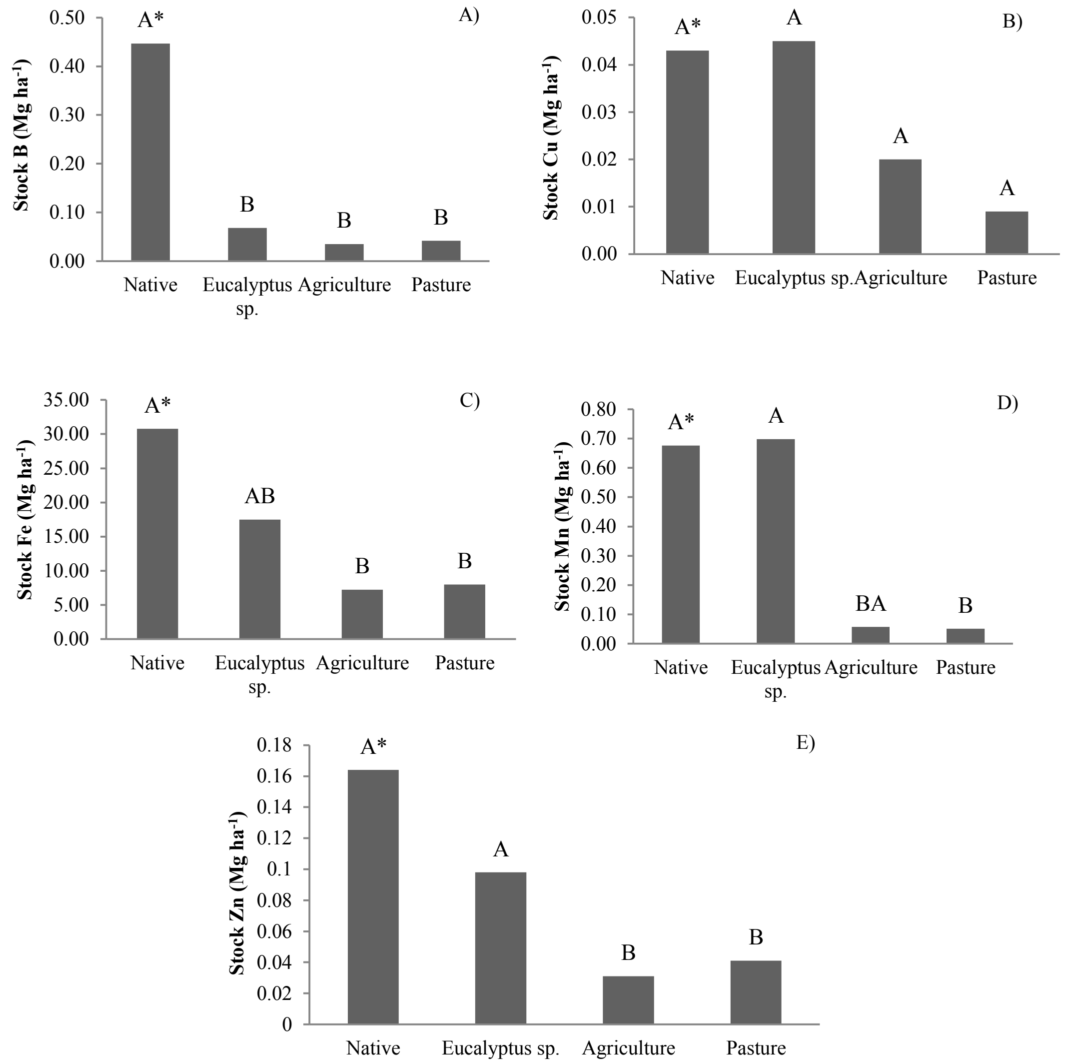

Figure 4. Boron – B (A), copper - Cu (B), iron - Fe (C), manganese – Mn (D), and zinc - Zn (E) stocks in root biomass in different vegetation covers.
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A study by Chisté et al. (2019) showed a negative interaction between boron and calcium since higher doses of Ca provide lower B levels in the roots due to the similar functions of B and Ca in cell wall synthesis. Thus, lower boron stocks in root biomass in the agricultural area since this area received the application of lime in the soil at the beginning of planting, causing more Ca to be absorbed by the plants than B.

The lowest average values in copper stocks in root biomass were in the pasture area (Figure 4B). A considerable amount of copper in tissues is linked to plastocyanin and some protein fraction with a tendency to accumulate in reproductive organs and new plant leaves; on the other hand, in roots, the stock of this microelement is low (MOREIRA, 2017).

One point that can be used to explain the lower copper stocks in root biomass in pasture areas is the high content of Fe absorbed and stored in this area due to Cerrado soils naturally possessing iron and aluminum toxicity characteristics. The presence of metallic ions such as Fe reduces the availability of Cu to plants through competition for the same active site, thus reducing the stock of this element both in the shoot and root (HANSEL; OLIVEIRA, 2016) (MOREIRA, 2017).

In a study by Brun (2004) on biomass and nutrients in a pasture in the Cerrado, they showed values of copper stored in root biomass in pasture areas greater than those found in this study varied from 0.08 and 0.25 mg ha^{-1}.

Assessing iron stocks in root biomass, the agricultural area presented lower average values (Figure 4C). One point that may explain this lower iron stock in root biomass in agriculture is the phosphate fertilization at the beginning of planting, increasing the phosphorus content in this area, which can cause iron precipitation, leading to reduced absorption and active concentration of this microelement in the plant, even in soils rich in iron and acids (LUENGO et al., 2018).

Mielki et al. (2014) highlight in their study that the low availability of Fe is accentuated in soils with high pH, in which they received liming, as well as phosphate fertilization in high doses, as is the case in the agricultural area, which can induce iron deficiency, as it reduces the capture and storage of plants in their biomass.

In a study carried out by Jucoski et al. (2016) on the iron stock in root biomass in agricultural areas in the Cerrado showed values close to those found in this study, values ranging from 6.32 to 7.82 Mg ha^{-1}.

The manganese stock in root biomass was lower in the pasture area, not exceeding 0.1 Mg ha^{-1} (Figure 4D). Rodrigues et al. (2016) reported a lower concentration of manganese in phloem exudate than in leaf tissues, concluding that the small transport of the element through the phloem is responsible for its low concentration in fruits, seeds, and root storage organs, especially in degraded areas where the quantities this nutrient is low, which explains the lower stocks of this element in roots in pasture areas.

In a study carried out by Caldeira (2003) on the determination of biomass and nutrients in different plant coverings, it showed higher Mn stocks in root biomass than in this study in an area with pasture, with an average value of 1.51 Mg ha^{-1}.

Finally, the lowest average values of zinc stock in root biomass were in the agricultural area (Figure 4E). In areas that received phosphate fertilization, there is low availability and absorption of zinc by plants due to the negative interaction P x Zn, thus explaining the lower zinc stocks in root biomass in agricultural areas since this area received phosphate fertilization (SOUSA, 2018).

Another point used to explain lower Zn stocks in root biomass in pasture areas may be associated with greater interventions in the area, leading to rapid nutrient cycling, which can lead to zinc loss by leaching, making it difficult for plants to absorb and store this microelement (HONGYU et al., 2016).

In a study by Jucoski et al. (2016) on nutrient stocks in root biomass in agricultural areas in the Cerrado, they showed Zn stock values in root biomass higher than those found in this study, with values ranging from 3.99 to 4.85 Mg ha^{-1}.

CONCLUSIONS

Macro and microelement stocks in root biomass were higher in the native forest area. In the area of *Eucalyptus* sp. K, Ca, Mg, Br, Cu, Fe, Mn, and Zn were the highest stocks among the areas with changes in soil cover. N, P, and S stocks were higher in the agricultural area. On the other hand, the pasture area, in general, had the lowest macroelement stocks in its root biomass. The area of *Eucalyptus sp*. is similar to the native forest in terms of the amount of nutrients stored in the root biomass, promoting nutrient cycling in a controlled manner.

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