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Scientific Article

Impact of land use change on nitrogen stocks in plinthosols of cerrado

Impacto da mudança de uso da terra nos estoques de nitrogênio em plintossolo de cerrado

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ABSTRACT - The land use changes and different management forms promote modifications in soil organic matter (SOM), which imply the yield and sustainability of agricultural systems. SOM provides essential elements for plants, such as Nitrogen (N), one of its main constituents, and is also an indicator of soil quality. This study aimed to evaluate the dynamics of N levels and stocks in the soil of Plinthosol in the state of Tocantins, Brazil, under different uses (eucalyptus, corn, and pasture) compared to a natural ecosystem of Cerrado *sensu stricto*. Therefore, six trenches were opened in each study area to collect soil samples at 0-10, 10-20, 20-30, 30-40, and 40-50 cm soil layers, determining the contents and stocks (0-50 cm) of total N in the soil by dry combustion. The means were compared by the Tukey test at a 5% error probability level. N-S contents and stocks of the evaluated systems did not differ statistically from the reference area, except the eucalyptus area, which presented a higher average content, specifically in the 0-10 cm layer, and a higher average stock, considering the entire layer evaluated (0- 50cm). N-S stocks decreased in the following order across different land uses: eucalyptus > corn = pasture = Cerrado, probably indicating the effectiveness of the arboreal component in incorporating N-S as well as the importance of adopting conservation management practices that prioritize greater input and stabilization of organic matter in the soil.

Keywords: Soil organic matter. Soil management. Biomass. Forestry. No-tillage.

RESUMO - As mudanças de uso da terra e as diferentes formas de manejo promovem alterações na matéria orgânica do solo (MOS), que implicam na produtividade e sustentabilidade dos sistemas agrários. A MOS é provedora de elementos essenciais às plantas como o Nitrogênio (N), um dos seus principais constituintes, sendo também um indicador da qualidade dos solos. Este estudo teve como objetivo avaliar a dinâmica dos teores e estoques de N no solo em um Plintossolo no estado do Tocantins, Brasil, sob diferentes usos (Eucalipto, Lavoura- Milho, Pastagem) tendo como referência um ecossistema natural de Cerrado sensu stricto. Para tanto, foram abertas seis trincheiras em cada área de estudo para coleta de amostras de solo nas camadas de 0-10, 10-20, 20-30, 30-40, 40-50 cm, determinando- se os teores e estoques (0-50 cm) de N total no solo por combustão a seco, sendo as médias comparadas pelo teste Tukey ao nível de 5% de probabilidade de erro. Os teores e estoques de N-S dos sistemas avaliados não diferiram daqueles da área de referência, com exceção da área de Eucalipto, que teve o maior teor médio, especificamente na camada de 0-10 cm e maior estoque médio, considerando toda a camada avaliada (0-50 cm). Os estoques de N-S decresceram na seguinte ordem nas diferentes coberturas: Eucalipto > Lavoura de Milho = Pastagem = Cerrado, possivelmente indicando a eficácia do componente arbóreo na incorporação de N-S, bem como a importância de adoção de práticas conservacionistas de manejo que favoreçam maior aporte e estabilização de matéria orgânica no solo.

Palavras-chave: Matéria orgânica do solo. Manejo do solo. Biomassa. Silvicultura. Sistema Plantio direto.

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INTRODUCTION

Natural ecosystems have a harmonious relationship between vegetation cover and soil attributes, promoting essential nutrient cycling processes through the accumulation and decomposition of organic matter (CERRI et al., 2017).

The uncontrolled exploitation of natural resources and land use changes have strongly threatened these environments. For this reason, it has been one of the focuses of the international political agenda for mitigating greenhouse gas emissions, as well as studies related to environmental impacts arising from land use and improving its quality, especially those aimed at research of Soil Organic Matter (SOM), considering its essential role in the sustainability of crop systems.

SOM is an important source of nutrients for plants, providing essential elements such as Nitrogen (N), considering that 97% of this element is found in organic forms, while only 3% of soil N is found in inorganic forms (GOUVEIA, 2020).

In tropical forests and savannahs, SOM acts as a component in the balance of the N cycle; however, changes in land use and management practices interfere with the dynamic balance of the soil and SOM itself (CERRI et al., 2017), which can maintain, reduce, or increase total N levels, depending on the use and the management applied (SOUZA et al., 2019).

Santos et al. (2022) point out that changes in soil N after the conversion of forests to agriculture and pasture have complex dynamics, and it can vary from one place to another, being affected by factors such as type and age of vegetation cover, physical attributes of the soil, climate, topography, management practices, amount of biomass and decomposition rates of crop residues due to the C/N ratio, lignin content, aggregation, and reduction of the physical protection of SOM.

Conventional agricultural systems cause greater soil disturbance and reduce its structural stability and aggregation, exposing SOM to the action of the microbiota and, consequently, reducing its levels in the soil, while conservation systems prioritize maintenance and less waste movement organic matter in the soil, so they have been more efficient in maintaining the soil N content (LOCATELLI et al., 2022).

Several studies have used total N stock to evaluate the sustainability of different agricultural soils of the Cerrado biome (ALMEIDA, 2017; ZEFERINO et al., 2021; LOCATELLI et al., 2022; SANTOS et al., 2022); however, similar studies in petric plinthosol class are scarce.

Petric plinthosols have characteristics such as the presence of gravel and low water retention, preventing a series of agricultural practices necessary for the development of cultivated plants. Furthermore, the lack of knowledge of appropriate management practices for these conditions causes damage to agriculture and the degradation of these soils (ALMEIDA et al., 2020).

Agricultural expansion in Brazil has led to the conversion of soil in natural areas, including lower valuable soils such as petric plinthosol (ALMEIDA et al., 2020), especially in the Cerrado biome, in the region of MATOPIBA, the new agricultural frontier of Brazil, represented by the states of Maranhão, Tocantins, Piauí, and Bahia.

Therefore, this study aimed to assess the dynamics of nitrogen (N) stocks in the soil in different agricultural systems implemented on petric plinthosols.

MATERIAL AND METHODS

Study Area

The study was conducted on the experimental farm of the Federal University of Tocantins, in the municipality of Gurupi, located in the southern Tocantins state, Brazil, at the central geographical coordinates of 11º46'25" S and 49º02'54" W (Figure 1).

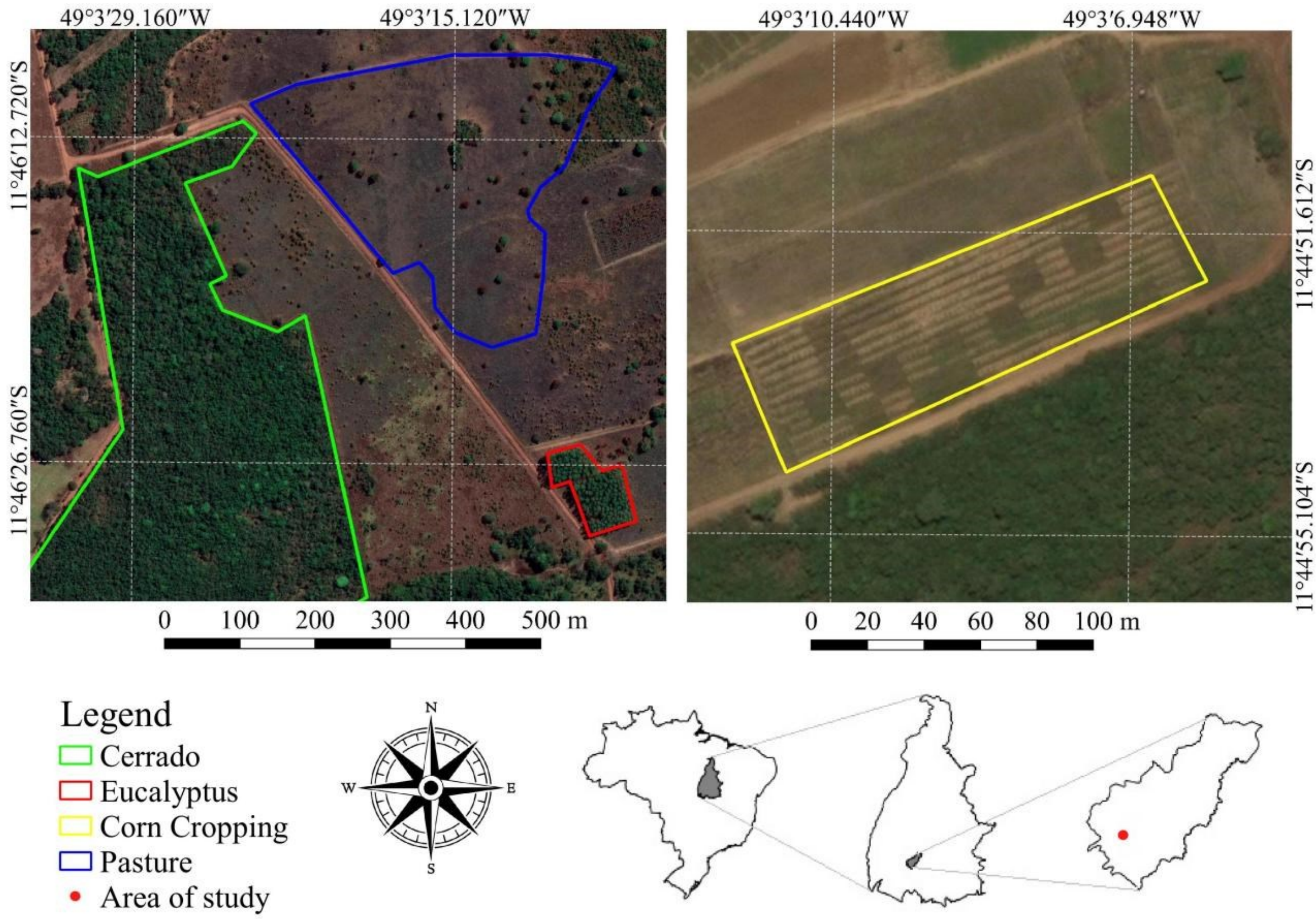

Figure 1. Location of the experimental areas in southern Gurupi, TO, Brazil.

The climate of the region is Aw-type according to the Koppen classification (Tropical with dry season), with an average annual temperature of 26.1 ºC and an average annual rainfall of 1,776 mm (ALVARES et al., 2013). The soil in the area was classified as Plintossolo Pétrico (Petric Plinthosol) (CODEVASF, 2021).

The study areas correspond to three different agricultural systems and one area with native vegetation cover (reference area), according to the characteristics shown in Table 1 below:

Table 1. Characteristics of the study areas.

Study Area	Characteristics
Native Vegetation (reference area)	Area of 22.82 ha occupied with Cerrado *sensu stricto* cover and over 60 years old (MARINHO JÚNIOR et al., 2021). According to Bendito et al. (2018), the main forest species on the site concerning the absolute dominance parameter were *Protium heptaphyllum* (Aubl.) Marchand, *Tapirira guianensis* Aubl., *Magonia pubescens* A.St.-Hil., *Myrcia splendens* (Sw.) DC., *Qualea multiflora* Mart., and *Antonia ovata* Pohl.
Eucalyptus	Area of 0.65 ha occupied by an 11-year-old *Eucalyptus urophylla* S. T. Blake, planted after the native vegetation had been removed using a crawler tractor with a front blade attached, with subsequent plowing and harrowing of the soil. The eucalyptus seedlings were planted in pits measuring 40 x 40 x 40 cm, which were dug using hand-held diggers at a 3.0 x 2.0 m spacing. The fertilization per pit was 100 g of simple superphosphate placed at the bottom of the pit, plus 150 g of the 5-25-15 NPK formulation (MARINHO JÚNIOR et al., 2021).
Pasture	Area of 11.25 ha occupied with degraded and abandoned pastures over 40 years, composed predominantly of *Andropogon* sp., as well as other species such as *Paspalum notatum Flügge, Eragrostis bahiensis Schrad, Axonopus affinis Chase, Bothriochloa laguroides* (DC.) *Herter, Schizachyrium microstachyum* (Desv. ex Ham) Roseng, *Paspalum dilatatum* Poir, *Sporobolus indicus* P.Beauv., *Rhynchospora* sp., *Andropogon ternatus* (Spreng.), and *Panpalumis* sp. (MARINHO JÚNIOR et al., 2021).
Corn	Area of 0.95 ha, with initial coverage of Cerrado, had subsequently been used for six consecutive years to cultivate corn (Zea mays L.). The soil has been prepared with a disc harrow and disc plow. Weeds were controlled by manual weeding associated with total action herbicides, such as Glyphosate, when necessary. Cultivation occurred once a year, with an average spacing of 0.20 x 0.80m. The sowing was conducted using a manual seeder. The fertilization with N was conducted with ammonium sulfate (45% N), phosphorus in the form of triple superphosphate (42% P2O5), and potassium in the form of potassium chloride (58% K2O), corresponding to 120, 170, and 140 kg ha-1 of N, P, and K respectively, with the N applied 50% at 25 days and 50% at 45 days after sowing. Harvesting was done manually, with the crop remains kept on the soil

Soil sampling and determination of N stocks

For soil sampling, six trenches measuring 70x70 cm and 50 cm deep were opened in each study area, with the first trench selected at random and the others spaced approximately 30 m apart. The soil samples were taken during the dry season at layers of 0-10, 10-20, 20-30, 30-40, and 40-50 cm, the latter considered the impeding layer.

The disturbed soil samples were air-dried at room temperature and passed through a 2 mm sieve for chemical analysis. The undisturbed samples were extracted to determine soil density using the volumetric cylinder method described by Teixeira et al. (2017).

For the soil chemical analysis, the disturbed soil samples were macerated in a porcelain mortar and pestle until they formed a fine powder and then passed through a 150 µm mesh sieve. The total N content in the soil (N-S) was determined using this material, by the dry combustion method, using an elemental analyzer (Model PE-2400 Series II Perkin Elmer).

Based on the N contents obtained above, the N stock in the soil in Mg ha^{-1} was determined at each layer sampled using the equation EstN = TN x Ds x e. EstN = N stock in the soil layer, in Mg ha^{-1}; TN = N content in the soil fraction sampled, in g kg^{-1}; Ds = soil density, in g cm^{-3}; e = layer thickness, in cm.

After calculating the N stock in each layer, the N stock was corrected, considering the differences in soil mass (SISTI et al., 2004). The total stock of N in the soil at the 0-50 cm soil layer resulted from the sum of the values obtained in each layer sampled. Finally, the parameters evaluated were subjected to the Shapiro-Wilk normality tests and analyzed by the analysis of variance to assess the differences in N content between the different land uses at 0-10, 10-20, 20-30, 30-40, and 40-50 cm soil layers, as well as the accumulated N stocks in the 0-50 cm layer. The means were compared using the Tukey test at a 5% ($P<0.05$) significance level using the SISVAR statistical software (FERREIRA, 2011).

RESULTS AND DISCUSSION

Total N content and stocks in the soil

Differences were found between the land uses concerning the N-S contents in the 0-10 cm layer, and from this layer onwards, the contents were statistically equal between the areas (Table 2).

In general, there was a gradual decrease in the average N-S concentrations along the 0-50 cm profile in all land uses (Table 2). Between the surface layer (0-10 cm) and the last layer (40-50 cm), there was a decrease in N-S contents of 70%, 46%, 44%, and 51% in the areas with eucalyptus, corn, pasture, and Cerrado, respectively.

Table 2. Total N contents (N-S) in a petric plinthosol in southern Tocantins, Brazil, at different soil layers (0-10, 10-20, 20-30, 30-40, and 40-50 cm), in areas with eucalyptus, corn, pasture, and Cerrado *sensu stricto*.

Land use	N-S (g kg^{-1})
	0-10 cm layer
Eucalyptus	1.952 Aa
Corn	1.528 Aba
Pasture	1.175 Ba
Cerrado	1.170 Ba
	10-20 cm layer
Eucalyptus	1.527 Aab
Corn	1.357 Aab
Pasture	0.997 Aa
Cerrado	1.003 Aab
	20-30 cm layer
Eucalyptus	1.047 Abc
Corn	0.995 Aab
Pasture	0.837 Aa
Cerrado	0.763 Aab
	30-40 cm layer
Eucalyptus	0.835 Ac
Corn	0.911 Ab
Pasture	0.757 Aa
Cerrado	0.660 Aab
	40-50 cm layer
Eucalyptus	0.535 Ac
Corn	0.808 Ab
Pasture	0.655 Aa
Cerrado	0.570 Ab

Means followed by the same letter do not differ according to the Tukey test at 5% error probability. Uppercase letters refer to comparing the different land uses in the same soil layer, and lowercase letters refer to comparing the soil layers in the same land use.

This is mainly linked to the higher concentration of organic matter in the topsoil due to the deposition of plant biomass (SANTANA et al., 2019), as well as the higher density of fine roots in the first layers (MEDEIROS et al., 2018).

Considering that the total N in the soil is predominantly organic (GOUVEIA, 2020), the variations seen in its levels are largely due to changes in the SOM. In this regard, some studies have reported a reduction in N reserves with changes in land use (SANTANA et al., 2019; LOCATELLI et al., 2022). However, the behavior of the N-S contents in the present study indicated that in most layers and land uses, the total N contents in the soil remained stable or showed increases concerning the contents of the reference ecosystem.

The eucalyptus area stood out concerning the land uses, with the highest significant average N-S value in the 0-10 cm layer, with differences concerning the averages of the pasture and Cerrado areas, which had the lowest significant average values (Table 2). On the other hand, the average N-S values of the corn area and the other uses were similar in this layer.

When compared to the reference area, the eucalyptus area showed an increase in the average N-S concentrations, which ranged from 27% to 67% over the 0-40 cm layers, while in the 40-50 cm layer, there was a 6% reduction in the average content (Figure 2).

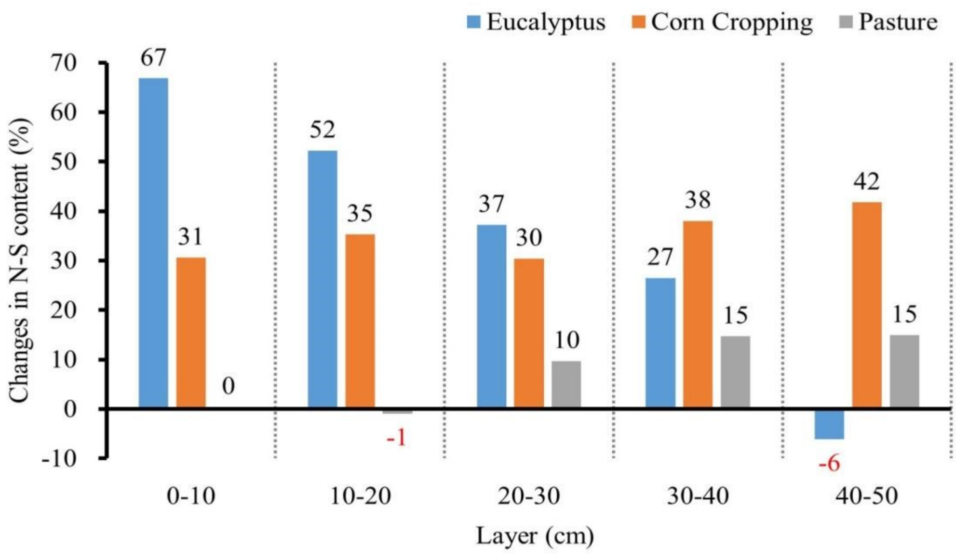

Figure 2. Balance of losses and gains (%) in soil N content (N-S) in a petric plinthosol, at different layers (0-10, 10-20, 20-30, 30-40, and 40-50 cm), after the conversion of Cerrado sensu stricto into eucalyptus cultivation, corn cultivation, and pasture.

In the corn area, there was an increase in the average N-S content, ranging between 30% and 42% over the assessed profile when compared to the reference area (Figure 2).

In the Pasture area, the average N-S content was stable in the 0-10 cm layer, fell slightly (1%) in the 10-20 cm layer, and increased by 10% and 15% in the 30-50 cm layers (Figure 2).

The increases in these levels in the eucalyptus area may be related to the continuous supply of plant residues (leaves, branches, and bark) produced by eucalyptus cultivation, the maintenance of these residues on the surface, less soil disturbance compared to conventional soil management, reducing the exposure of SOM stored in the deeper layers to attack by microorganisms, as well as soil aggregation promoted over time, leading to greater protection and resistance of SOM to erosion and leaching processes. Almeida (2017) and Medeiros et al. (2018) found similar results in latosols with eucalyptus plantations managed similarly to the present study in the Cerrado and Atlantic Forest regions.

Attention should also be paid to the large amount of plant residues returned to the soil and the high C/N ratio and lignin and cellulose content of the material deposited by eucalyptus, which leads to the slow decomposition of these residues (BARBOSA et al., 2017; BIELUCZYK et al., 2020). In this regard, Barbosa et al. (2017) found a stock of accumulated litter on the ground of 13.1 Mg ha^{-1} in plantations of the same species and age, which is equivalent to a total N stock of 83.6 kg ha^{-1}, with a C/N ratio ≈ 67:1.

In addition, the microclimate and soil protection provided by eucalyptus trees and litter reduces the direct incidence of sunlight and rain on the soil, maintains humidity and temperature at more uniform levels, and contributes to water infiltration in the profile, which benefits the root development and the regulation of soil microbial activity, reducing the mineralization rates of SOM (VALADÃO et al., 2019) and, consequently, the organic N.

Medeiros et al. (2018) found similar results concerning the reduction in the N-S content in the deeper layer (40-50 cm), attributing this to the deep disturbance of the soil at the eucalyptus planting stage and the slow replacement of plants with the change of use. However, these authors also suggested a possible recovery of these contents over time.

This reduction may also be related to the probable reduction in root biomass at this depth, as it coincides with the soil impediment layer in petric plinthosols, possibly reducing the amount of organic material in the roots at this depth.

Despite increases in the average N-S content in the corn area, many studies suggest a tendency for total N to be lower in agricultural areas than native areas, especially when managed conventionally, due to soil exposure and disturbance, short crop cycle, export of production, among other factors (SANTANA et al., 2019; LOCATELLI et al., 2022).

These results may be related to the constant application of nitrogen fertilizers to the corn crop (SANTANA et al., 2019; SANTOS et al., 2022). Studies by Santana et al. (2019) also suggested a possible increase in N-S due to evidence of biological fixation of atmospheric N by endophytic bacteria in symbiosis with some plants from the Poaceae family, such as corn.

Moreover, the conservation practice of maintaining straw after harvesting corn has several benefits such as protecting the soil and biodiversity and cycling organic matter, promoting the return of N to the soil, also considering the significant supply of plant residues generated by this species. In this regard, Redin et al. (2018) measured the production of dry biomass from the shoot of corn plants in Argissolos in a subtropical humid region with hot summers. They found a production of 6.55 Mg ha^{-1} at harvest time, with a total N content of 4.4 g kg^{-1} in the material collected, with a C/N ratio of 105:1. The high C/N ratio of this crop's waste increases the time needed for the organic material to decompose, slowly releasing nutrients.

Regarding the results in the pasture area, studies by Zeferino et al. (2021) demonstrated that the establishment of pastures in the region of Cerrado transition maintains the N stocks and can also exceed the original contents of native areas, but when these are well-managed.

These authors highlighted the role of soil management and texture in maintaining soil N stocks, including in petric plinthosol. Due to the low clay content of Petric plinthosols, the protection capacity of SOM becomes lower than other soil classes, reducing the capacity to fix N to the soil. Considering this natural limitation, the pasture renewal by soil plowing hinders the formation and stability of macroaggregates, exposing the physically protected SOM; therefore, this management is not recommended for these soils. The no soil disturbance in the pasture area may have contributed to these results.

The close average N-S values between the Pasture and Cerrado areas may also be related to the great biomass production potential of the grasses (SANTANA et al., 2019). In this regard, Flores et al. (2014) found a dry biomass production of 9.37 Mg ha^{-1} in an experiment with *Andropogon gayanus* in the same region as the present study, subjected to nitrogen fertilization. Despite the high biomass production, Guimarães, Pinto and Fortes (2010) found a C/N ratio in pasture litter ranging from 32:1 to 49:1, which indicates a greater lability of this residue compared to other land uses and the reference area.

Much of the SOM in pasture areas originates from the grass roots, which are well distributed in the soil and are continuously renewed and decomposed by microorganisms (CERRI et al., 2017) and can reach deep layers, which may explain the increase in N-S levels found in the layers between 20-50 cm, as also suggested by Giácomo et al. (2015). This can also be related to the supply of N through animal excreta during grazing and the fact that these soils have not been disturbed (ZEFERINO et al., 2021; RACHWAL et al., 2022).

Vegetation cover has different characteristics regarding the amount of biomass produced and its distribution patterns in ecosystems, affecting stocks of N in soil.

Therefore, litter is the main form of the return of mineral constituents from vegetation to the soil, and its production and the respective content of N incorporated into the soil also depend on soil and climate characteristics and the characteristics of the plant species used ages, and spacing between the plants (VALADÃO et al., 2019).

Due to the high floristic diversity, including atmospheric N-fixing species, the litter of tropical forests becomes highly heterogeneous, which implies the diversification of the soil microorganism community, making the permanence time of N in the litter of native areas shorter due to the higher mineralization rate (BARBOSA et al., 2017).

Areas of Cerrado *sensu stricto* provide soil with easily decomposable residues and a greater release of N when compared to other Cerrado biome physiognomies, verified by the lower C/N ratio of these materials (GIÁCOMO et al., 2015). Studies by Almeida (2017) found that the C/N ratio of the litter in this physiognomy is around 50:1.

Related to this, Teixeira et al. (2016) investigated the annual litter production in the same Cerrado area as this study. They found a production of 1349.01 kg ha^{-1}, representing a total N stock in the residues of 13.5 kg ha^{-1}, which is considered low compared to other forest areas. This result may be a strong reason for the lower N-S levels in the reference area and the higher N-S levels in the eucalyptus, corn, and Pasture areas.

The probable reason for this is that the Cerrado area is semi-open vegetation, considering the spacing between trees and the small shoot size of the forest structure, which is subject to the occurrence of fire through natural processes (SANTANA et al., 2019).

On the other hand, Paiva and Faria (2007) suggested that the lower amount of residues from the shoot of plants in Cerrado *sensu stricto* is probably related to the strategy of applying part of the photosimilates produced to form a thicker and deeper root system, ensuring the absorption of water and nutrients to meet the demand of the vegetation, especially during the dry season. Thus, like leaf litter, root residues also have a major influence on N stocks in the soil.

Studies conducted in the same areas and at the same depths as the present study assessed the stock of root biomass (LIMA et al., 2022) and the stock of N present in these roots (LIMA et al., 2023), with the highest stock of root biomass being found in the Cerrado area (≈ 12.0 Mg ha^{-1}), followed by the eucalyptus (≈ 4.0 Mg ha^{-1}), pasture (≈ 2.0 Mg ha^{-1}), and corn (1.18 Mg ha^{-1}) areas, while the stock of N present in the roots was higher in the Cerrado area, due to the biological fixation of N by the leguminous species, then in the corn area, due to the frequency of N fertilization, followed by the Eucalyptus and Pasture areas.

Bieluczyk et al. (2020) found a lower C/N ratio in corn roots (C/N ≈ 34:1) and pasture (C/N ≈ 73:1) and a higher C/N ratio in eucalyptus roots (C/N ≈ 103:1), which slows down the N mineralization in these residues, probably contributing to the results obtained in this study.

Regarding the average stocks of N in the soil (EstN-S) accumulated for the entire layer between 0-50 cm deep, there were significant differences between the eucalyptus (8.944 Mg ha^{-1}) and Cerrado (6.402 Mg ha^{-1}) areas, which had, respectively, the highest and lowest average values for EstN-S among the areas evaluated (Figure 3). On the other hand, the averages in the corn (8.346 Mg ha^{-1}) and pasture (7.111 Mg ha^{-1}) areas showed intermediate EstN-S values compared to the other covers. The statistical results indicated that the averages for these areas and the other land uses were similar (Figure 3).

Although no significant differences were identified among the areas with corn, pasture, and other land uses, the average EstN-S values numerically were in the following order: eucalyptus > corn = pasture = Cerrado. Therefore, when compared to the reference area, the variations in EstN-S in the areas with eucalyptus, corn, and Pasture areas were positive, which indicates that the land uses evaluated promoted an increase in the average values of the stocks of 40% (2.592 Mg ha^{-1}), 30% (1.944 Mg ha^{-1}), and 11% (0.709 Mg ha^{-1}), respectively, considering the entire soil profile (0-50 cm).

The results of this study point to a strong relationship between N-S stocks and the results found for Carbon (C) stocks in the same areas and depths studied by Marinho Júnior et al. (2021), who highlighted the potential of eucalyptus to store C in the soil. This is because organic C and N are coupled to each other, so the maintenance of the C stock depends on the amount of N in the soil, although the land use change impacts C levels more than N levels (SANTANA et al., 2019; LOCATELLI et al., 2022).

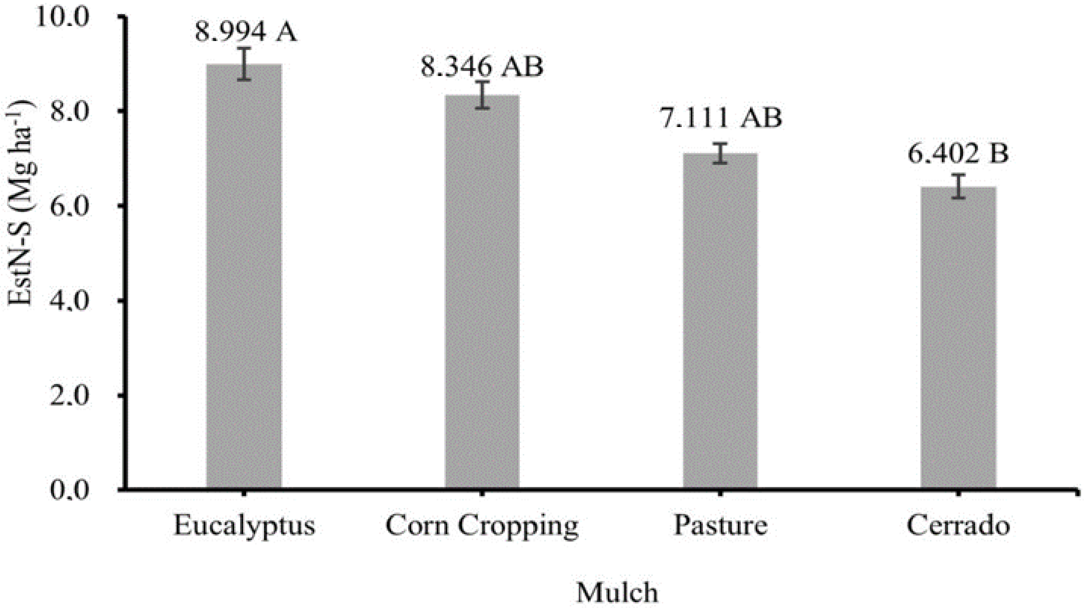

Figure 3. Stocks (Mg ha^{-1}) of N in the soil (EstN-S) in petric plinthosol, in the 0-50 cm layer, in areas with eucalyptus, corn, pasture, and Cerrado *sensu stricto*. Means followed by the same letter do not differ by the Tukey test at 5% probability.

The difference between the periods of use and management of cultivation areas must be highlighted, considering that the average value obtained in the eucalyptus area refers to the EstN-S after 11 years of use of the area for forestry activities. The EstN-S obtained in the area with corn cultivation refers to a period of six years, while in the pasture area, the EstN-S refers to the use of the area for livestock for more than 40 years.

It should also be considered that the eucalyptus area is a perennial plant system that has not yet been subjected to cutting cycles for timber, which has meant greater soil protection and the supply of litter by the crop, probably contributing to the greater stock of N in the soil.

Despite this, McMahon et al. (2019) pointed out in their studies that the aerial productivity of eucalyptus plantations managed for charcoal in latosols was higher than the native vegetation of Cerrado, even in successive crop rotations, which is a positive point for the sustainability of eucalyptus cultivation in the Cerrado region, resulting in increases in N stocks in the soil. It should be emphasized, however, how important it is for the litter and plant residues (bark, leaves, and branches) to remain in the harvest area to maintain the N stock in the soil and supply the nutritional demand of subsequent plantations (ALMEIDA, 2017; MCMAHON et al., 2019).

The positive results found in the eucalyptus area probably indicate the viability of this system in terms of soil conservation, in addition to the increase in N-S stocks. This also suggests that, when possible, introducing a tree component combined with crops and/or pastures (integrated crop-forest system – ICFS and integrated livestock-forest system - ILFS) can be an alternative to intensive monoculture production.

Thus, given the lower gains in N-S stocks observed in pasture and agricultural systems, new use and management options must be found to make land use compatible with soil quality and the maintenance and/or increase of N stocks in the soil (ZEFERINO et al., 2021), such as those that prioritize a greater supply and stabilization of organic matter in the soil, such as the no-tillage soil management practice, as well as agroforestry systems and integrated production systems, as integrated crop-livestock-forestry systems.

CONCLUSION

In all the land uses evaluated, the N-S contents were higher in the surface layers, decreasing in the subsequent layers.

N-S contents and stocks of the systems evaluated did not differ from the reference area, except for the eucalyptus area, which had the highest average content, specifically in the 0-10 cm layer and the highest average stock, considering the entire layer evaluated (0-50 cm).

N-S stocks were in the following decreasing order in the different land uses: eucalyptus > corn = pasture = Cerrado, probably indicating the effectiveness of the arboreal component in incorporating N-S, as well as the importance of adopting conservation management practices that prioritize greater input and stabilization of the soil organic matter.

Future studies about the quality and forms of N in organic matter added to soils may be interesting to understand the dynamics of N in petric plinthosols in different land uses.

REFERENCES

ALMEIDA, R. E. M. et al. Expansão agrícola em áreas de difícil manejo: cultivo em solos com cascalho. In: PINAZZA, L. A. et al. (Eds.). **Anuário Brasileiro de Tecnologia em Nutrição Vegetal**, São Paulo, SP: Abisolo, 2020, v. 1, cap. 1, p. 71-75.

ALMEIDA, R. F. **Estoque de carbono, nitrogênio e enxofre**

em plantio de Eucalyptus grandis sob diferentes manejos de resíduos florestais. 2017. 107 f. Dissertação (Mestrado em Ciências: Área de Concentração em Química na Agricultura e no Ambiente) - Universidade de São Paulo, Piracicaba, 2017.

ALVARES, C. A. et al. Köppen's climate classification map for Brazil. **Meteorologische Zeitschrift**, 22: 711-728, 2013.

BARBOSA, V. et al. Biomassa, Carbono e Nitrogênio na Serapilheira Acumulada de Florestas Plantadas e Nativa. **Floresta e Ambiente**, 24: 20150243, 2017.

BENDITO, B. P. C. et al. Espécies do cerrado com potencial para recuperação de áreas degradadas, Gurupi (TO). **Revista Agrogeoambiental**, 10: 99-110, 2018.

BIELUCZYK, W. et al. Integrated farming systems influence soil organic matter dynamics in southeastern Brazil. **Geoderma**, 371: 114368, 2020.

CERRI, C. C. et al. Estoques de carbono e nitrogênio no solo devido a mudança do uso da terra em áreas de cultivo de café em Minas Gerais. **Coffee Science**, 12: 30-41, 2017.

CODEVASF - Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba. **Caderno de caracterização do estado do Tocantins**. Brasília, DF: Codevasf, 2021. 75 p.

FERREIRA, D. F. Sisvar: a computer statistical analysis system. Ciência e **Agrotecnologia**, 35: 1039-1042, 2011.

FLORES, R. A. et al. Yield of *Andropogon gayanus* pasture intercropped with two kinds of legumes, amended with P fertilizer. **Journal of Biotechnology and Biodiversity**, 5: 50-62, 2014.

GIÁCOMO, R. G. et al. Atributos químicos e físicos do solo, estoques de carbono e nitrogênio e frações húmicas em diferentes formações vegetais. **Ciência Florestal**, 25: 617-631, 2015.

GOUVEIA, R. G. L. **Manejo eficiente do nitrogênio**. Uberlândia, MG: Clube de Autores, 2020. 70 p.

GUIMARÃES, A. K. V.; PINTO, J. C.; FORTES, C. A. Acúmulo e decomposição de serrapilheira em ecossistema de pastagem. **Pubvet**, 4: 725, 2010.

LIMA, D. S et al. Root biomass under different soil uses and native Cerrado in Tocantins, Brazil. **Research, Society and Development**, 11: e53811125333-e53811125333, 2022.

LIMA, D. S. et al. Stocks of elements in radicular biomasses in different coverages in the cerrado of Tocantins, Brazil. **Revista Caatinga**, 36: 124-134, 2023.

LOCATELLI, J. L. et al. Changes in soil organic matter fractions induced by cropland and pasture expansion in Brazil's new agricultural frontier. **Geoderma Regional**, 28: e00474, 2022.

MARINHO JÚNIOR, J. L. et al. Soil carbon stocks and labile organic matter fractions under differents vegetation covers in Gurupi – TO. **Floresta**, 51: 767-775, 2021.

MCMAHON, D. E. et al. Soil nutrient stocks are maintained over multiple rotations in Brazilian Eucalyptus plantations. **Forest Ecology and Management**, 448: 364-375, 2019.

MEDEIROS, A. S. et al. Organic carbon, nitrogen and the stability of soil Aggregates in areas converted from sugar cane to Eucalyptus in the state of Alagoas. **Revista Árvore**, 42: e420404, 2018.

PAIVA, A. O.; FARIA, G. E. Estoque de carbono do solo sob cerrado *sensu stricto* no Distrito Federal, Brasil. **Revista Trópica – Ciências Agrárias e Biológicas**, 1: 59-65, 2007.

RACHWAL, M. F. G. et al. Impacto de sistemas produtivos nos estoques de carbono e nitrogênio do solo na Região Noroeste do Paraná. **Pesquisa Florestal Brasileira**, 42: e202002172, 2022.

REDIN, M. et al. Root and shoot contribution to carbon and nitrogen inputs in the topsoil layer in no-tillage crop systems under subtropical conditions. **Revista Brasileira de Ciência do Solo**, 42: e0170355, 2018.

SANTANA, M. S. et al. Carbon and nitrogen stocks of soils under different land uses in Pernambuco state, Brazil. **Geoderma Regional**, 15: e00205, 2019.

SANTOS, R. F. et al. Conversion of Brazilian savannah to agricultural land affects quantity and quality of labile soil organic matter. **Geoderma**, 406: 115509, 2022.

SISTI, C. P. J. et al. Change in carbon and nitrogen stocks in soil under 13 years of conventional or zero tillage in southern Brazil. **Soil and Tillage Research**, 76: 39-58, 2004.

SOUZA, A. S. et al. Propriedades e estoque de carbono e nitrogênio do solo na amazônia oriental: um estudo de caso sobre os sistemas de manejo. **Revista Observatorio de la Economía Latinoamericana**, 4: 1-17, 2019.

TEIXEIRA, W. G. et al. Densidade do Solo. In: TEIXEIRA, P. C. et al. (Eds.). **Manual de métodos de análise de solo**. 3. ed. rev. e ampl. Brasília, DF: Embrapa, 2017. v. único, parte I, cap. 7, p. 65-75.

TEIXEIRA, P. R. et al. Variação temporal de nutrientes N P K na serapilheira de duas fisionomias do domínio cerrado, Gurupi - TO. **Revista Verde**, 11: 39-46, 2016.

VALADÃO, M. B. X. et al. Litterfall, litter layer and leaf decomposition in *Eucalyptus* stands on Cerrado soils. **Scientia Forestalis**, 47: 256-264, 2019.

ZEFERINO, L. B. et al. Simulation of changes in C and N stocks with land use and cover in Amazon Forest-Cerrado transition environment. **Geoderma**, 404: 115388, 2021.