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SOIL QUALITY AND GROWTH OF NATIVE PLANTS FERTILISED WITH SUGARCANE RESIDUE

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The aim of this study was to evaluate the growth of Cerrado seedlings and soil quality using byproducts of sugarcane in a degraded area. The experiment was implemented in the Northwest of Minas Gerais State, Brazil, with the following treatments: (T1) control, (T2) filter cake, (T3) sugarcane bagasse, (T4) filter cake + sugarcane bagasse and (T5) mineral fertiliser. After planting, three evaluations of plant height and diameter at ground level were carried out. The soil quality was evaluated 410 days after planting at 0–10 and 10–20 cm depths, where total and microbial carbon and nitrogen, basal and accumulated respiration, microbial and metabolic coefficient were determined. For *Anacardium humile* and *Hymenaea courbaril*, T2 and T3, respectively, favored their growth in diameter. The seedlings of *A. humile, Butia capitata* and *H. courbaril* showed the higher growth in height with filter cake and bagasse (T2, T3 and T4). Soil carbon and nitrogen contents were higher in T2 at 0–10 cm, and these variables were more responsive in T1, T2 and T3 at 10–20 cm. The use of sugarcane bagasse and filter cake residues promoted good growth of all the evaluated species and improved soil quality, as indicated in recovery projects for degraded areas.

Keywords: Plant growth, microbial activity, recovery of degraded areas, soil organic matter, industrial waste

INTRODUCTION

The Brazilian Cerrado biome occupies approximately 204 million ha, being one of the most important areas in South America, encompassing recharge areas of important aquifers and rivers, and corresponding to 24% of the Brazilian territory (Medrado and Lima 2014). It is recognised as the 'cradle of Brazilian waters', and has high commercial potential for fruit, wood and medicinal species (Lima 2011, Soares et al. 2017). In addition, the Cerrado is one of the 25 biodiversity hotspots in the world, with high biological and endemic diversity. However, this biome has lost vegetation due to the expansion of agriculture and pasture, which resulted in a large number of endangered species (Silva et al. 2006. Therefore, it is necessary to work on the protection, recovery and production of species from these environments.

Extensive areas of the Cerrado have been replaced by sugarcane. This generates a mosaic of vegetation fragments of different sizes and conservation degree (Silvano et al. 2005). Sugarcane is one of the most important Brazilian crops for national economy.

Brazil is the world's largest producer of sugarcane, with about 642.7 million tons processed in the 2019/2020 crop (CONAB 2020). The increased world demand for ethanol from renewable sources, combined with soil and climate conditions, favored the expansion of this crop in Brazilian fields. The State of Minas Gerais represents 10.7% of Brazilian production (SEAPA-MG 2020).

Rovere et al. (2009) reported that the main issues in the sector are biodiversity changes, soil loss and water availability. Thus, one of the challenges of the sustainable production of this crop in the state is to maintain productive capacity with adequate land use, meeting the established criteria for preservation and/or environmental conservation areas and aiming at biodiversity maintenance (Teófilo et al. 2015).

Permanent preservation areas (PPA) subjected to some exploration process, as well as agricultural areas with inadequate management, can trigger the removal or erosion loss of the surface horizon of the soil and of organic matter, causing serious physical, chemical and biological problems to the remaining substrate (Lara et al. 2017). In this way, soil degradation compromises the growth and survival of plants as well as the maintenance of ecosystems.

One of the ways to recover these areas is the use of revegetation with the planting of native species that aims to create conditions similar to the original forest. The use of organic residues to recover degraded areas is a promising practice that improves the soil properties when their composition and potential for releasing nutrients are known. As the industrial process of ethanol production generates large amounts of solid, liquid and gaseous residues, the management of these wastes is essential to avoid negative environmental impacts (Borrero 2003). Thus, the use of sugarcane byproducts can be a source of nutrients and organic matter, depending on the characteristics of the added residue (Modesto et al. 2009).

Successful projects to improve soil quality and to promote species growth require monitoring through the evaluation of growth and productivity parameters over time (Fonseca et al. 2002). It is also important to monitor soil quality, as its recovery favors the reestablishment of degraded environments, especially when there is an input of organic waste, which is essential to maintain and/or improve soil structure (Mendonça et al. 2013, Stefanoski et al. 2013).

Considering the above, it was hypothesised that the use of sugarcane byproducts can improve soil quality and promote good establishment of the native plants of Cerrado. Thus, the objective of this study was to evaluate the growth of Cerrado seedlings and soil quality after the application of filter cake and bagasse in a degraded area.

MATERIALS AND METHODS

Experimental area location and characterisation

This study was conducted at Tapera farm in the municipality of João Pinheiro (17º 44' L and 45º 49' N), Minas Gerais State, Brazil (Figure 1). The area has a flat relief, with ridges and furrows, and a mosaic of slope and grove pathways (palm swamps), which end in three contiguous pathways within an area of approximately 2,785.98 hectares. Sugarcane crops for ethanol production are the main economic activity in the farm, with 1,088.80 hectares planted. The selected experimental area was degraded, and

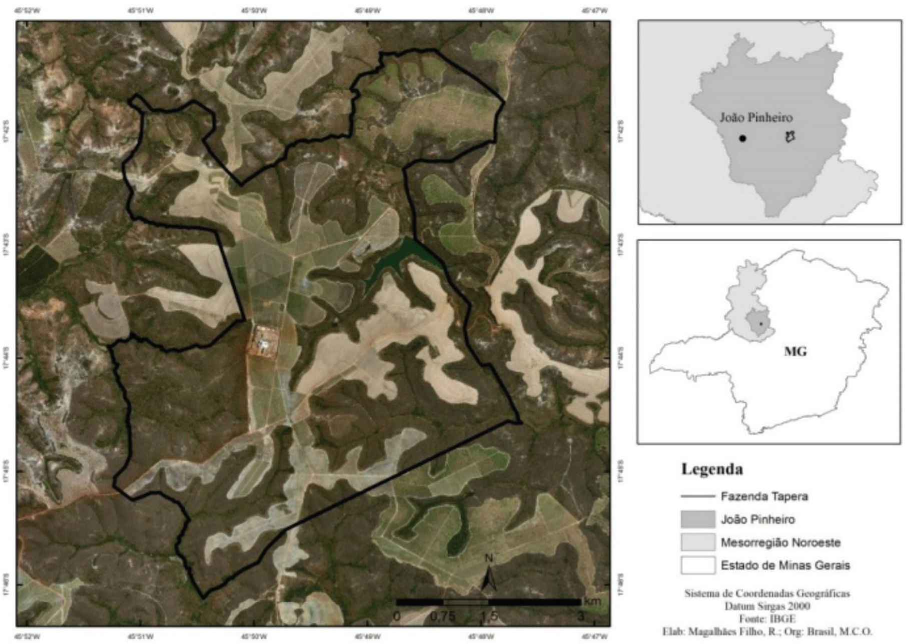

Figure 1 Location of Tapera Farm, located at the municipality of João Pinheiro, Minas Gerais State, Brazil

the sequence of land use after deforestation was cultivation of sugarcane and later pasture, that remained without management and replacement of nutrients.

Phytogeographically, the region is in the Cerrado domain (Rizzini 1997). According to Köppen classification, the climate is tropical wet Aw and sub-humid, with four to five dry months. The average annual rainfall is 1,500 mm, ranging between 750 and 2,000 mm (Alvares et al. 2013). The average annual temperature is 22.5 °C.

Experiment implementation

The eight species used were found in the area. They were selected from a floristic study of the arboreal stratum of areas within the same hydrographic sub-basin. They are *Handroanthus impetiginosus*, *Myracrodruon urundeuva*, *Butia capitata*, *Handroanthus heptaphyllus*, *Jacaranda brasiliana*, *Magonia pubescens*, *Anacardium humile* and *Hymenaea courbaril.* Chemical and physical properties of the soil were defined to characterise the experimental area (Table 1), which was classified as Typic Quartzipisamment with 84% sand, 6% silt and 10% clay.

Table 1 Soil chemical and textural characterisation (0–20 cm) before experiment implementation

Soil chemical analysis		
Soil attribute	Level	
pH (água)	6.00	B
P (mg dm^{-3})	46.53	
K (mg dm^{-3})	25.00	Bx
Ca (cmolc dm^{-3})	1.10	Bx
Mg (cmolc dm^{-3})	0.46	M
Al (cmolc dm^{-3})	0	MBx
H+Al (cmolc dm^{-3})	1.07	Bx
SB (cmolc dm^{-3})	1.62	Bx
t (cmolc dm^{-3})	1.62	Bx
T (cmolc dm^{-3})	2.69	Bx
m (%)	0	MBx
V (%)	60.00	B
Soil particle size analysis		
Areia (dag kg^{-1})	84.00	
Silte (dag kg^{-1})	6.00	
Argila (dag kg^{-1})	10.00 Ar	

MBx - very low, Bx - low, M - medium, B - good, MB - very good, A - high, MA - very high, Ar - sandy, Tme - medium texture, Arg - clayey, Marg - very clayey

The experiment had a randomised block design, with five replications and five treatments: (T1) control, without addition of residue or fertiliser, (T2) addition of filter cake, with 3,500 g per hole (equivalent to 8 g of N), (T3) addition of sugarcane bagasse, 300 g per hole, (T4) addition of filter cake (1,750 g) + sugarcane bagasse (150 g) per hole (equivalent to 4 g of N) and (T5) addition of mineral fertiliser, 200 g per hole (formulated NPK 4:14:8, equivalent to 8 g of N, 28 g of P_2O_5, and 16 g of K_2O). The filter cake is a residue composed of the mixture of ground bagasse and decantation sludge, coming from the filtration of sugarcane juice, extracted from the mills.

Residues and fertiliser were directly placed into the planting hole with the dimension of 40 x 40 x 40 cm, within the 50 x 50 m (2000 m^2) area. The quantity of filter cake per hole was calculated based on the chemical analysis of the filter cake (Table 2). Sugarcane bagasse was not analysed as it is an inert material, basically composed of lignocellulose.

Table 2 Chemical characterisation of the filter cake used in the experiment

Attributes	Unit	Content
Total nitrogen	g Kg^{-1}	23.56
N-ammoniac	g Kg^{-1}	1.66
N-nitrate	g Kg^{-1}	0.69
Organic carbon	%	48.51
Calcium	g Kg^{-1}	16.79
Magnesium	g Kg^{-1}	1.56
Phosphor	g Kg^{-1}	0.51
Potassium	g Kg^{-1}	0.48
Sodium	g Kg^{-1}	0.06
Iron	g Kg^{-1}	2.62
Manganese	g Kg^{-1}	0.43
Copper	g Kg^{-1}	0.03
Zinc	g Kg^{-1}	0.14
Nickel	g Kg^{-1}	0.0
Chrome	g Kg^{-1}	0.0
Lead	g Kg^{-1}	0.03

Thus, five blocks of five plots were plotted at different points in the selected area, totaling 25 plots, with an experimental area of five ha. The respective treatments were applied directly in the planting hole. The seedlings of the eight species used (*H. impetiginosus*, *M. urundeuva*, *B.*

capitata, *H. heptaphyllus*, *J. brasiliana*, *M. pubescent*, *A. humile* and *H. courbaril*), were planted in rows at a distance of three meters in the same row and three meters between rows. Then, the seedlings were identified with numbered plates. Before planting, the entire area was mowed, and the crowning (manual weeding of the surrounding vegetation to reduce competition for nutrients and light) was maintained throughout the experiment to ensure good performance of the plants.

Variables used to assess the initial growth of the seedlings

The experimental arrangement was performed in a split-plot model (considering different evaluation time), which was used to assess the initial growth of the seedlings. The plants were evaluated for 13 months. There were three evaluations (40, 200 and 410 days after planting) to measure diameter at soil (DAS) level and total height (H). The height was measured with a wooden metric scale and the diameter with a digital caliper.

Variables used to assess soil quality

Soil quality was evaluated at 0–10 and 10–20 cm depth, with the determination of total organic carbon (TOC) and total nitrogen (TN), microbial biomass carbon (MBC) and nitrogen (MBN), basal (BSR) and accumulated soil respiration (ASR) and metabolic (qCO_2) and microbial quotient (qMic), 410 days after planting. Soil samples were collected from the different treatments in mini-trenches using five replications arranged in the center of the plots at 0–10 and 10–20 cm depths. To verify the effect of the treatments, the mini-trenches were opened in the root influence zone, where the treatments were applied.

To determine soil TOC and TN contents, the samples were air-dried, passed through 2 mm sieves, homogenised, ground and sieved at 0.150 mm. The TOC contents were determined by wet oxidation according to Yeomans and Bremner (1988), and the semi-micro Kjeldahl steam drag distillation method was used to determine TN contents (Tedesco et al. 1995). The MBC and MBN were analysed using the fumigation-extraction method proposed by Vance et al. (1987) and Silva et al. (2007).

Soil basal respiration was measured by the quantification of mineralisable C through the release of CO_2 (C–CO_2) captured in a 0.5 mol L^{-1} NaOH solution, according to the method described by Anderson (1982) and adapted by Silva et al. (2007). The C–CO_2 was quantified at intervals of 24, 48, 72, 96 and 120 hours. The respiration rate per biomass unit, or qCO_2, was obtained by the relationship between BSR, which is the measurement of CO_2 production resulting from metabolic activity in the soil and microbial biomass (Anderson and Domsch 1989). The qMic was calculated from MBC and TOC levels, according to Sparling (1992).

Statistical analysis

The data for each variable were analysed by the Shapiro-Wilk and Bartlett tests ($p < 0.05$) to verify normality and homogeneity of variance. As for variables related to seedling performance, the split-plot model was used and statistical analysis was performed for each species, three times. The results were subjected to analysis of variance and, when significant, the effects of the treatments. The means were compared by the Tukey's test at a 5% significance level ($p \leq 0.05$). Subsequently, regression equations were adjusted at a level of 5% probability to analyse the behavior of the variables as a function of the evaluation periods.

Multivariate analysis of variance (MANOVA) was used for soil variables to check the grouping of different soil properties using the MANOVA function of the Stats package and the Pillai test at 5% significance. After confirming the absence of multicollinearity, the data were subjected to canonical variable (CV) analysis using the candisc package. Statistical procedures were performed using the R software (R Core Team 2016).

RESULTS

Initial growth of the seedlings

There was no significant effect of treatments and interaction between treatments within the evaluated period ($p \leq 0,05$) for DAS variable in six of the eight species studied (*H. impetiginosus*, *M. urundeuva*, *B. capitata*, *H. Heptaphyllus*, *J. brasiliana* and *M. pubescens*) (Table 3), with growth in diameter as a function of the evaluation periods (Figure 2). The species *A. humile* and *H. courbaril* showed a significant effect of this interaction (Table 3), with growth in diameter (Figure 2) for each treatment as a function of the evaluation period. The species *H. impetiginosus*, *M. urundeuva*, *B. capitata*, *H. Heptaphyllus*, *J. Brazilian* and *M. Pubescens* showed diameter growth during the entire period of evaluation, with *A. humile* and *H. courbaril* presenting different growth behavior for each treatment (Figure 2).

The growth in diameter for species *A. humile* and *H. courbaril* was statistically different at 410 days after planting (Table 3). The addition of filter cake (T2) significantly favored the performance of *A. humile*, as the plants in this treatment showed greater growth in diameter than the others. However, for *H. courbaril*, the same treatment did not favor growth in diameter, with bagasse (T3) providing the best result for this species, with a higher average (Table 4 and Figure 2).

As for the total height variable, four of the eight species studied (*M. urundeuva*, *H. Heptaphyllus, J. brasiliana* and *M. pubescens*) showed no significant effect of treatments and interaction between treatments within the evaluated period, and the species *B. capitata* showed an isolated effect of treatments within the period of evaluation. Therefore, height growth is shown as a function of the evaluation periods (Figure 3). The other species (*H. impetiginosus, A. humile* and *H. courbaril*) showed a significant effect of the interactions, with growth in diameter for each treatment as a function of the evaluation periods (Figure 3).

The five species (*M. urundeuva*, *B. capitata, H. Heptaphyllus*, *J. brasiliana* and *M. Pubescens*) showed linear height growth throughout the evaluation period (410 days). *H. impetiginosus, A. humile* and *H. courbaril* presented different growth behavior for each treatment (Figure 3).

The total height of *H. impetiginosus, A. humile* and *H. courbaril* seedlings showed the effect of the treatments, 410 days after planting, with the mean total height showing statistical difference (Table 5), and isolated effect of the treatments for *B. capitata* (Table 5).

In *H. impetiginosus* seedlings, it was observed that the non-addition of residue or fertiliser (T1) provided greater growth (Table 5 and Figure 3), however there is no statistical difference between averages with addition of filter cake (T2) and mineral fertiliser (T5) (Table 5). For *A. humile* and *B. capitata* seedlings, the addition of filter

Table 3 P value for the mean diameter at soil and total height of plants of the eight species evaluated

		Mean diameter at soil	Total height
Handroanthus impetiginosos	Treatment	0.35^{ns}	0.13^{ns}
	Treatment x Era	0.93^{ns}	0.04*
Myracrodruon urundeuva	Treatment	0.29^{ns}	0.41^{ns}
	Treatment x Era	0.21^{ns}	0.86^{ns}
Anacardium humile	Treatment	0.031*	0.28^{ns}
	Treatment x Era	0.005*	0.01*
Butia capitata	Treatment	0.14^{ns}	0.04*
	Treatment x Era	0.72^{ns}	0.09^{ns}
Handroanthus heptaphyllus	Treatment	0.57^{ns}	0.62^{ns}
	Treatment x Era	0.49^{ns}	0.77^{ns}
Hymenaea courbaril	Treatment	0.48^{ns}	0.004*
	Treatment x Era	0.02*	0.0005*
Jacaranda brasiliana	Treatment	0.66^{ns}	0.72^{ns}
	Treatment x Era	0.24^{ns}	0.61^{ns}
Magonia pubescens	Treatment	0.06^{ns}	0.38^{ns}
	Treatment x Era	0.24^{ns}	0.12^{ns}

^{ns} Non-significant effect, * significant effect at 5% ($p < 0.05$)

Table 4 Mean diameter at soil (DAS, in mm) of native Cerrado species planted without residue or fertiliser (T1), with filter cake (T2), sugarcane bagasse (T3), filter cake + sugarcane bagasse (T4) and with the addition of 200 g of mineral NPK 4:14:8 fertiliser (T5) 410 days after planting

Species	Treatment	DAS (mm) at 410 days after planting
	T1	9.46 b
	T2	18.42 a
Anacardium humile	T3	8.74 b
	T4	6.69 b
	T5	3.82 b
	T1	6.95 ab
	T2	5.24 b
Hymenaea courbaril	T3	8.71 a
	T4	6.29 ab
	T5	7.07 ab

Means followed by the same letter do not differ statistically from each other by Tukey test ($p < 0.05$)

cake and bagasse (T2 and T3) provided greater growth in height, and for the species *H. courbaril*, the treatment that provided better performance was the bagasse (T3) (Table 5).

Soil properties

The simultaneous effect of treatments on soil variables at each depth underwent CV analysis. The eigenvector matrix shows the proportion of the total variance explained by different CV and their correlations with analysed characteristics (Figure 4). The 0–10 cm graph shows that the first two CVs (CV1, CV2) explained 85.66% of the total variation observed, with CV1 explaining 63.03% and CV2 explaining 22.63% (Figure 4A). In the 10–20 cm graph, CV1 and CV2 explained 88.47% of the total variation observed, with CV1 explaining 70.36% and CV2 explaining 18.11% (Figure 4B).

Positive correlations are responsible for the discrimination of treatments located to the right of CV1 and in the upper part of CV2. Negative correlations, on the other hand, are responsible for discriminating treatments located to the left of CV1 and at the bottom of CV2 (Figure 4). Treatment proximity with the respective variable correlation vectors suggests the characteristics in which they improve the respective soil attribute according to the residue used (filter cake and sugarcane bagasse).

At 0–10 cm depth, TOC, NT and MBN were the variables that most correlated with filter cake addition (T2). The T4 (filter cake + sugarcane bagasse) showed a good correlation with BSR and qMic. The T1, T3 and T5 (no residue or fertiliser, addition of bagasse, addition of mineral fertiliser, respectively) showed a negative correlation with the evaluated soil properties (Figure 4A).

At 10–20 cm depth, the variables responded well to treatments T1, T2 and T3 (no residue or fertiliser, addition of filter cake, addition of sugarcane bagasse, respectively). The variables TOC, MBC and BSR were higher in treatment T1 (without addition of residue and fertiliser), and qMic, MBN and ASR had a greater relationship with treatment T2 (addition of filter cake) (Figure 4B).

DISCUSSIONS

Initial growth of the seedlings

The addition of filter cake and sugarcane bagasse (T2 and T3) significantly improved the performance of *A. humile* and *B. capitata* in diameter and height 410 days after planting. For *H. courbaril*, sugarcane bagasse (T3) was the treatment that provided the best result (Table 4 and Figure 2). This result may be associated with increased organic matter in these treatments. Improvements in chemical, physical and biological soil quality are related to organic matter content since it has important functions in substance complexation, and in the supply and storage of nutrients and water for the plants (Pezarico et al. 2013, Han et al. 2016).

Filter cake has important functions for the soil, as it increases the water retention capacity, forming aggregates that can increase the absorption capacity and the cation exchange capacity of the soil (Façanha et al. 2002). All of these functions have a direct effect on plant growth (Ulukam 2008, Rima et al. 2011). Increased plant growth can also be explained by the increased soil fertility provided by the addition of filter cake, which has high levels of N and other nutrients in its composition (Table 2).

Being a basically organic compound, filter cake has a variable chemical composition and high levels of organic matter, phosphorus, nitrogen and calcium, also presenting

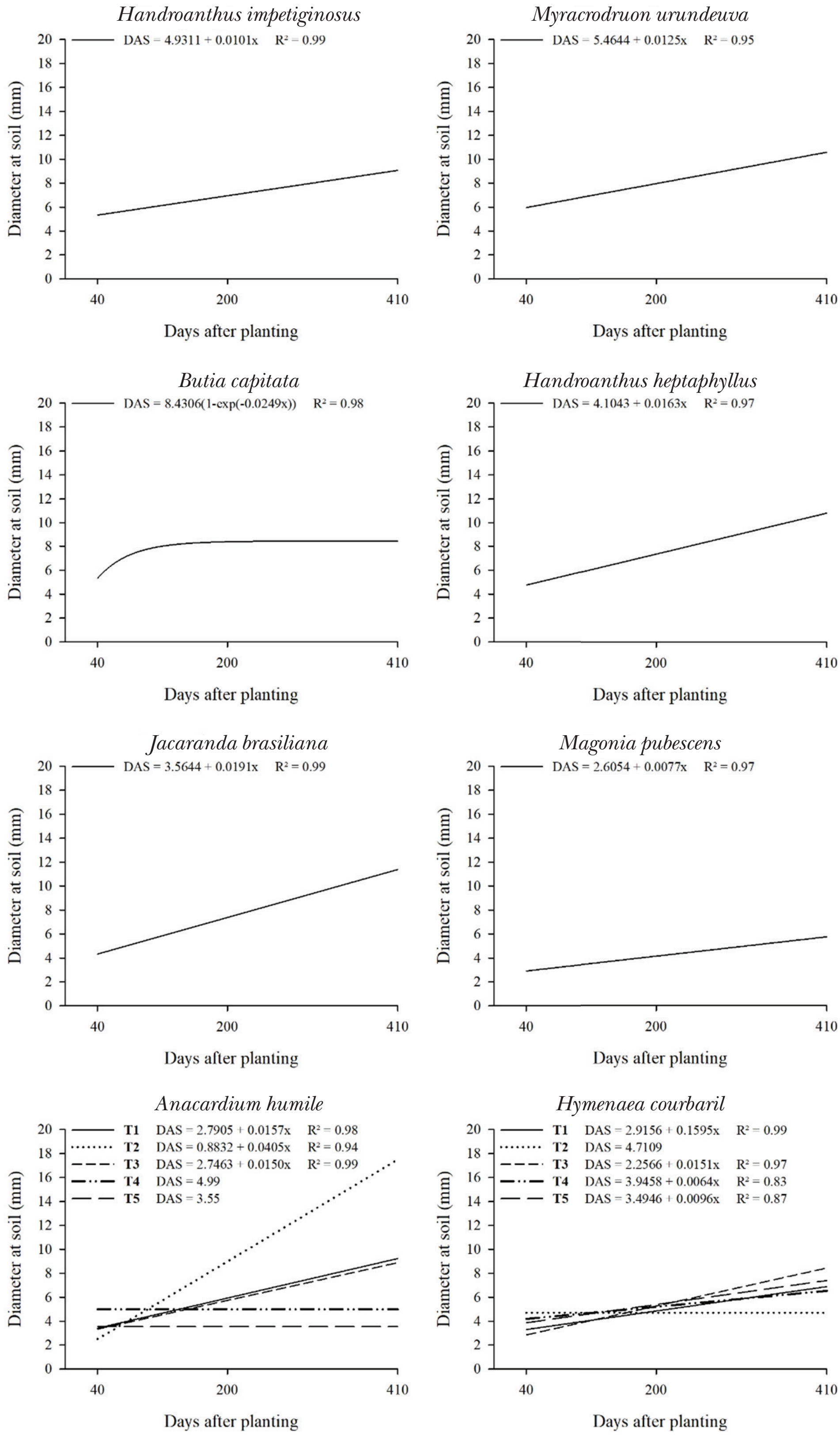

Figure 2 Diameter at soil (DAS) of native Cerrado species (Handroanthus impetiginosus, Myracrodruon urundeuva, Butia capitata, Handroanthus heptaphyllus, Jacaranda brasiliana., Magonia pubescens, Anacardium humile and Hymenaea courbaril) as a function of the evaluation periods (40, 200 and 410 days); Treatments: T1 - without addition of residue or fertiliser, T2 - with addition of filter cake, T3 - with addition of sugarcane bagasse, T4 - with addition of filter cake + sugarcane bagasse, and T5 - with addition of 200 g of mineral NPK 4:14:8 fertiliser

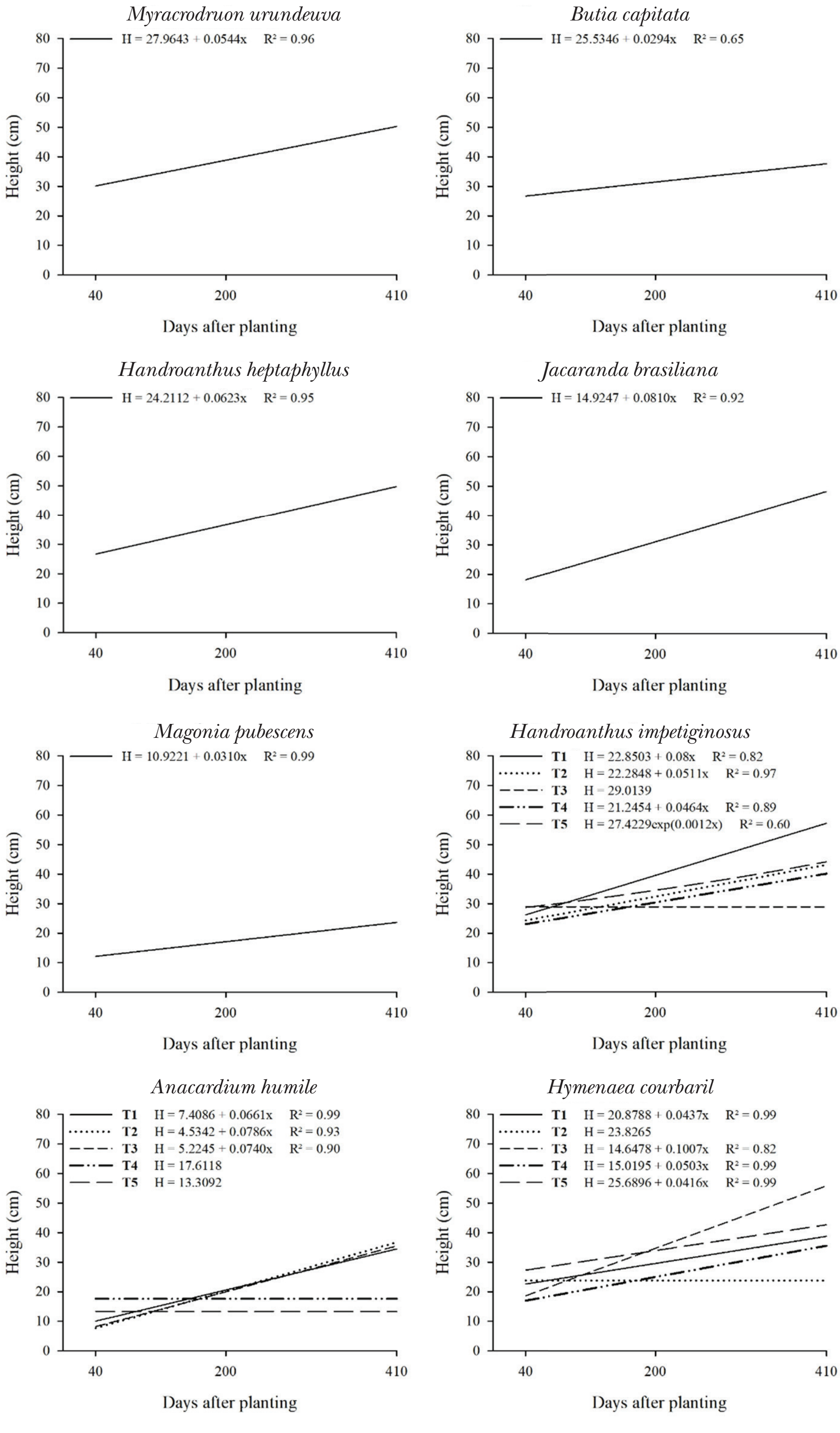

Figure 3 Height growth of native Cerrado species (Handroanthus impetiginosus, Myracrodruon urundeuva, Butia capitata, Handroanthus heptaphyllus, Jacaranda brasiliana, Magonia pubescens, Anacardium humile and Hymenaea courbaril) as a function of the evaluation periods (40, 200 and 410 days); Treatments: T1 - without addition of residue or fertiliser, T2 - with addition of filter cake, T3 - with addition of sugarcane bagasse, T4 - with addition of filter cake + sugarcane bagasse, and T5 - with addition of 200 g of mineral NPK 4:14:8 fertiliser

considerable levels of potassium and magnesium, and significant amounts of Fe, Mn, Zn and Cu (Cerri et al. 1988, Nunes Júnior 2005). Thus, this product is already used as a partial replacement for mineral fertilisation in several countries, including Brazil, India, Cuba, Pakistan and Australia (Santos et al. 2010, González et al. 2016, Liu et al. 2018).

High plant performance in the treatment added with bagasse can be related to its water retention capacity of up to 68%, since it is basically composed of lignocellulose (Santos et al. 2012, Diel et al. 2018). Mizobata et al. (2017) studied the growth of *Dipteryx* and *Astronium fraxinifolium* seedlings in degraded soil supplemented with residue, and reported good height growth with the addition of sugarcane bagasse.

As for *H. impetiginosus,* not adding residue or fertiliser (T1) provided greater growth (Table 5), however, the addition of filter cake (T2) and mineral fertiliser (T5) showed no statistical difference in the means. *Handroanthus impetiginosus* is considered a nutrient-demanding species (Cunha et al. 2006, Souza et al. 2006). However, the results of the present study contradicted this statement, showing the species as robust and tolerant to degraded conditions. The species used in the present study are typical of the Brazilian Cerrado and may present adaptation to the environment, since, normally, the Cerrado vegetation occurs in dystrophic soils, poor in calcium and magnesium and with high availability of aluminum (Alves Júnior et al. 2015).

The current findings showed good adaptation of the Cerrado species, even when exposed to degraded soil, due their mechanisms of adaptation to low-fertility soils. Marques et al. (2014) also reported the good performance of Cerrado species for recovery of degraded areas, compared to exotic species.

Soil properties

The results showed the potential of organic residues derived from sugarcane for improving soil quality, especially at 0–10 cm depth. The high TOC increase in the 0–10 cm depth with treatments added with residues confirmed the powerful contribution of organic matter to the soil through sugarcane industry residues. Rosset et al. (2014) reported similar results, where higher TOC levels were found in soils managed with sugarcane residues, similar to those of native vegetation. The loss of soil organic matter under some conditions can be compensated with the use of residues. Additionally, this result can be also attributed to the increase of root activities (Obidike-Ugwu et al. 2023).

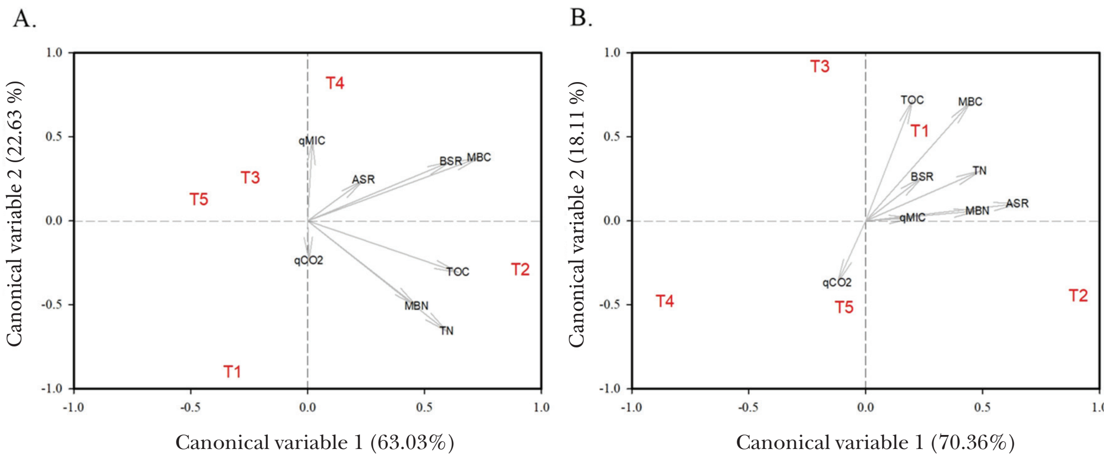

Figure 4 Graphic dispersion of canonical variables CV1 and CV2 in the study of soil quality at 0–10 (A) and 10–20 (B) cm depths; Treatments: T1 - without addition of residue or fertiliser, T2 - with addition of filter cake, T3 - with addition of sugarcane bagasse, T4 - with addition of filter cake + sugarcane bagasse, and T5 - with addition of 200 g of mineral NPK 4:14:8 fertiliser; TOC - total organic carbon, TN - total nitrogen, MBC - microbial biomass carbon, MBN - microbial biomass nitrogen, BSR – basal soil respiration, ASR - accumulated soil respiration, qMIC - microbial quotient and qCO2 metabolic quotient

Nitrogen stands out among the nutrients present in residues, byproducts and compounds. The correlation of TN with treatments added with residue corroborate the increased soil organic matter content (Pardon et al. 2017). The low correlation of TN with the treatment of mineral fertiliser (T5) was due to the fact that these fertilisers provide nutrients readily available to the plants, and soil analysis was performed on samples collected 410 days after application. Therefore, the slow decomposition of residues favors the permanence of N in the soil-plant system for longer periods (Antonkiewicz et al. 2019).

As for MBC and MBN contents at a depth of 0–10 cm, several studies reported improved soil biology when organic matter is increased. Li et al. (2019) reported that soil TOC and TN maintained microbial biomass. Beutler et al. (2015) described that increased organic matter provided better conditions for the establishment and maintenance of microbial populations. The increasing in BSR, ASR, qMic and qCO_2 after application of sugarcane byproducts imply greater biological activity, which is directly related to the availability of soil carbon and/or microbial biomass (Allen et al. 2011).

The current findings indicated high microbial activity in the area. These data are important for providing information about the soil recovery capacity. Microorganisms represent the richest repertoire of chemical and molecular diversity in nature, providing the basis for ecological processes such as biogeochemical cycles, being fundamental for soil quality as they can change the physicochemical characteristics of the environment, directly participating in nitrogen and phosphorus transformations (Messenssini et al. 2015, Panizzon et al. 2015).

CONCLUSIONS

The use of filter cake and sugarcane bagasse improved soil quality and the initial growth of the *A. humile, H. courbaril, H. impetiginosus* and *B. capitata*.

The soil quality indicators such as TOC, TN, MBC, MBN, BSR, ASR, qCO_2 and qMic showed that the use of sugarcane residues during the establishment of seedlings promotes positive changes in the soil biological activity.

Treatments T2 (addition of filter cake), T3 (addition of sugarcane bagasse) and T4 (addition of filter cake + sugarcane bagasse) increased the initial growth of seedlings of *A. humile, H. courbaril, H. impetiginosus and B. capitata*, and improved soil quality, being indicated in recovery projects for degraded areas.

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