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Tree species' growth in a silvipastoral system in Amazon

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This research aimed to evaluate the dendrometric development of four tree species (*Carapa guianensis* Aubl. (Meliaceae); *Dipteryx odorata* (Aubl.) Willd (Fabaceae), *Swietenia macrophylla* King (Meliaceae) and *Handroanthus chrysotrichus* (Mart ex A. DC.) Mattos (Bignoniaceae)) in a silvopastoral system in Santarém, Pará, Brazil. Productive activities in the forest sector create a demand for technical capacity to promote sustainable management, with the silvipastoral system presented as one of the paths to sustainability. Three permanent plots of 1 ha each were established on the 240-hectare Diamantino Farm, and stem DBH 1.30 m from the soil surface, total height and crown diameter data were obtained for all individuals. In addition to the quantitative data, crown regularity and bole tortuosity parameters were measured. *S. macrophylla* achieved better performance in almost all parameters. *C. guianensis* and *D. odorata,* respectively showed greater uniformity in growth. The species, *H. chrysotrichus* had the smallest crown diameter; however it was still able to provide enough shade for animal thermal comfort.

Key words: Dendrometry, forest management, reforestation.

INTRODUCTION

The growth of the Brazilian forestry sector contrasts with the low level of investments in replanting and forest formation. In order to avoid market retention in the medium and long term, it is important to invest in reforestation (Juvenal and Matos, 2002).

In addition to the traditional planting systems, integrated crop-livestock-forest (ICLF) systems represent a new method developed for the cultivation of tree species which aim to diversify production, integrating different productive systems such as agriculture, livestock and forestry, simultaneous or consecutively (Guimarães, 2015). When trees and pastures are in the same system, a silvipastoral model is formed, characterized by the combination of the use of trees, pastures and cattle in the same area concomitantly, being managed in an integrated way aiming to increase productivity per unit

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area (Nair, 1984).

Agroforestry practices encompass a range of products to be achieved, both to meet the demands of wood and its multiple uses in the industry, such as forage, fruit and vegetable production, as well as benefits such as improved physical, chemical and biological, improve the productivity of the components, economic stability and income increase with the diversification of activities, reduction of costs in the medium and long term, and reduction of vulnerability to risks, including susceptibility to pests (Cordeiro et al., 2015). In this area of Brazilian livestock raising, problems caused by pasture degradation, poor pasture formation, inadequate management and maintenance, and extensive stocking of animals are still present, and these are the main agents of the soil compaction process, and also of negative changes in soil and climatic properties (Peron and Evangelista, 2004; Macedo, 2005). In view of this problem, the integration of tree species with pastures in the ILPF system is presented as an option in order to recover the productive capacity of pastures (Rozados-Lorenzo et al., 2007; Paciullo et al., 2011), besides being essential to improve the quality of the pasture, and to contribute to the thermal comfort of the animals, resulting in better meat and milk production and also an increase in the nutritive value of the pasture (Dias-Filho, 2006). In addition, other types of animals such as buffaloes, sheep and goats can also be integrated into the silvipastoral system (Garcia et al., 2011; Campanha and Araújo, 2010). In the Amazon region, there are still few studies that deal with silviculture in forest plantations in ICLF systems, and there is a need for these systems to be developed in agricultural regions in Brazil areas so that in the coming decades, Brazilian agriculture and cattle raising can be promoted as an example of sustainability in the international market, in addition to offering healthy products, in line with new concepts regarding the timber market and land use systems (Silva, 2009). Among some tree species that could be chosen in the implantation of a silvopastoral system, Andiroba - *Carapa guianensis* Aubl. (Meliaceae), is highlighted for its high demand in the municipality of Santarem due to its multiple uses, such as wood and oil supply (Souza et al., 2006). Another multipurpose species that also provides wood, bark and oil, is Cumaru - *Dipteryx odorata (*Aubl.) Willd (Fabaceae). It is a species that adapts well to different types of soil. From the seed, an oil rich in coumarin is extracted, for which there is great demand in the international cosmetics and perfumery market (Carvalho, 2009). Mahogany- *Swietenia macrophylla* King (Meliaceae) is another species of interest to the markets, which is currently banned from being cut in natural forest, and can only be commercialized if its origin is reforestation. It is a species that adapts to hydromorphic, podzolic, medium to high fertility soils (Lamb, 1966; Brasil, 2003). The species, ipê-amarelo- (*Handroanthus chrysotrichus* (Mart. ex A.DC) Mattos) (Bignoniaceae) is also recommended as species for the recovery of degraded areas, landscaping, as well as providing good quality wood for the construction of bridges, boards for general use, frames and other purposes (Lorenzi, 2002). Thus, measuring dendrometric parameters of a stand is important to evaluate the arrangement and estimate the forest production, helping to make a productive comparison of different locations, besides defining guidelines for forest management practices establishing harvest goals (Pinto et al., 2005). In this sense, the objective of this work was to evaluate the dendrometric development of four forest species, seven years in age, in a silvipastoral system.

MATERIALS AND METHODS

Study area

The research was developed at Diamantino Farm (Figure 1), located on the left bank of the Santarem/Curuá-Una Highway, km 11 (02° 30' 57,7"S e 54° 39' 36,2"W) covering an area of 240 ha, with annual average temperature between 25 and 28°C, relative air humidity of about 86% and average annual precipitation of 1920 mm. According to Köeppen's classification, the tropical monsoon subclimate (Ami) of the region presents the traditional climate of Tropical Forests, hot and humid, having a period of 3 months (August to October) with rainfall less than 50 mm monthly, with periods of drought (4 to 6 months) and well defined rainfall, directly influencing the seasonal changes in the water level of the rivers. According to IDESP (2014), the soils of the study area are yellow Oxisols of medium, clayey and very clayey texture in association with concretionary lateritic and dystrophic indiscriminately textured soils and rocky outcrops.

Main characteristics and area history

Diamantino Farm belongs to the Congregation of the Brothers of Santa Cruz, Diocese of Santarém, PA. Historically, there was cutting of timber in the area and introduction of annual crops. Over time, the area became abandoned, and in 2008, the pasture was planted with *Panicum maximum* Jacq, and the forest species were introduced. The planting of the seedlings was done manually, in pits of 40 cm x 40 cm x 40 cm, and spacing of 7 m x 7 m between trees. Organic manure from cattle was used with terra preta (black earth) as fertilizer. Subsequently, after the pasture grew substantially, it was cut using a tractor. After this first cutting, in order to reduce the costs and control pasture growth, cattle were introduced in a rotating system. The silvicultural treatments consisted of pruning and cleaning two to three times a year in order to minimize competition from invasive plants, especially in the first two years. The vegetation of the area is secondary vegetation composed by sparse grasses and shrubs, popularly called "capoeira" vegetation in Brazil. The physical-chemical properties of the soils are shown in Table 1.

Data collection

The 2008 planting area was 17 ha wherein in 2015, three plots of 100 m × 100 m (1 ha) were installed. The trees planted in these plots were *Carapa guianensis* (Aubl.) (Meliaceae), *D. odorata*

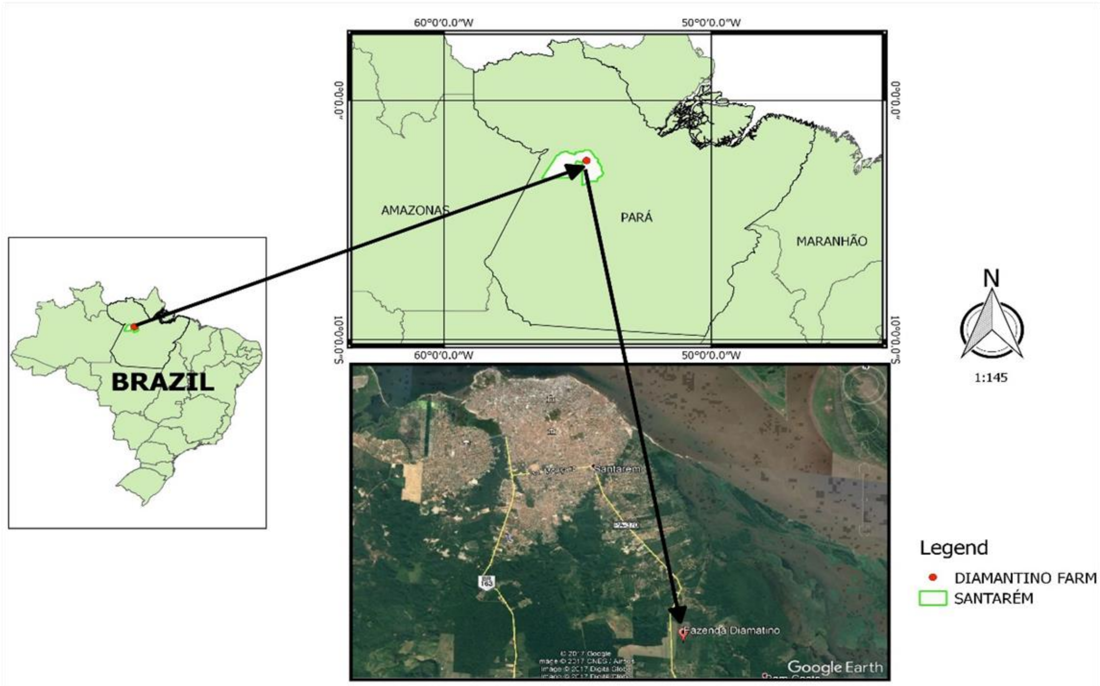

Figure 1. Map of location of the Diamantino Farm in Santarém, Pará, Brazil.

Table 1. Physical-chemical characteristics of soil in the experimental area (0-20 cm).

Depth	OM*	pH	P	K	Na	Ca	Ca+Mg	Al	H+Al	CTC		Saturation	
(cm)	(g/kg)	(water)	(mg/dm³)			(cmol$_c$/dm³)				Total	Effective	Base	Al
										(cmol$_c$/dm³)		V (%)	m (%)
0-20	40-70	5.8	583	22	7	7.2	8.7	0.1	7.10	15.88	8.88	55.28	1.13

*OM = Organic matter.

(Aubl.) Wild (Fabaceae), *H. chrysotrichus* (Mart. Ex A.DC) Mattos) (Bignoniaceae) and *S. macrophylla* King (Meliaceae) among other species (Figure 2).

In total, 133 individuals of *S. macrophylla*, 104 of *D. odorata*, 101 of *H. chrysotrichus*, and 82 *C. guianensis* were recorded. To obtain the dendrometric data, a diametric tape was used to measure the diameter at a height of 1.30 m (DBH), a hypsometer was used to measure total height (HT) and a 30 m line was used to measure crown diameter (CD). In addition, the quality of the trunk (QT) was classified as straight, bifurcated or tortuous, and crown quality (CQ), classified as regular or irregular, was evaluated in order to determine the ability of the forest cover to provide thermal comfort to animals in the silvipastoral system. Measurements were performed in the period from May to July 2015, wherein the data of all the inventoried individuals were collected.

Data processing

The diametric distribution is an important tool applied in the description of the diametric structure of forest populations. It is also possible to describe changes in the structure of the stands, as well as hypsometric relationships and mortality rates, all of which are possible to study in certain periods, stand growth (Schikowski et al., 2016).

The diametric distribution of the planting was analyzed considering a 2 cm diameter class amplitude, followed by application of the non-parametric Komolgorov-Smirnov T test at the level of ($\boldsymbol{\alpha}$) 0.05% significance. Comparison of each individual of a species with another of the same species was done for all possible comparisons, for example, individual 1 when compared with individual 2, then 3 and 4, and subsequently repeating this pairwise comparison for all possible combinations with the objective of finding the largest difference value (*D*) between them from the relative frequency of distributions, obtained by dividing the cumulative frequency (*F*) by the number of observations (n), and subsequently comparing the critical value ($\boldsymbol{D\alpha}$), as presented by Sokal and Rohlf (1995) and used by Werneck et al. (2000), where:

$$D = \left|\frac{F1}{n1} - \frac{F2}{n2}\right|$$

$$D\alpha = K\alpha\sqrt{\frac{n1+n2}{n1.n2}}$$

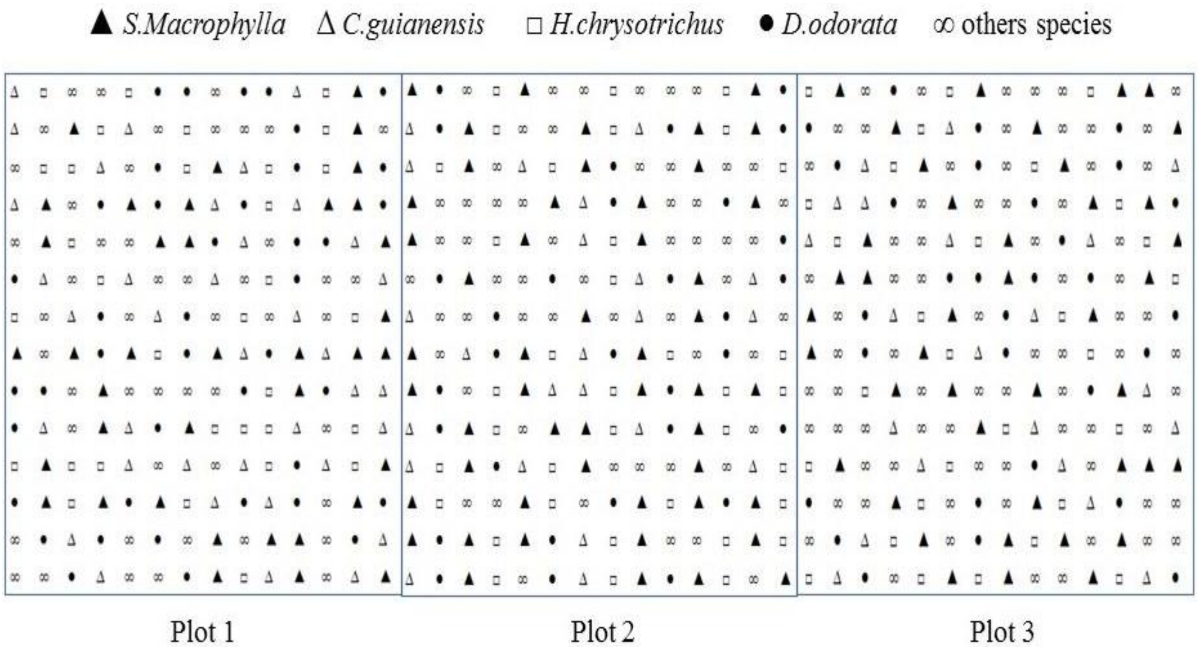

Figure 2. Sketch of the installed plots of the 7-year-old planting in 7 x 7 m spacing, in Diamantino Farm, Santarém, PA.

$$K\alpha = \sqrt{\frac{1}{2}\left[-ln\left(\frac{\alpha}{2}\right)\right]}$$

The qualitative analyses of the stem (straight or tortuous) and canopy (regular or irregular) were described by means of percentage (%). The individual canopy area was calculated using the ellipse area formula that uses the largest longitudinal and perpendicular measurement of the canopy.

$$A\ canopy = \pi[(L1+L2)/2)^2/4]$$

Where, A canopy = individual area of canopy (m²); L1 = length of the largest longitudinal measurement of the canopy (m); L2 = length of the largest perpendicular measurement of the canopy (m). All statistical analyses and graphs were done using the software Excel 2010.

RESULTS AND DISCUSSION

Quantitative analysis: Height and diameter

The mean values of the variables measured at 7 years in relation to DBH, total height and their respective annual mean increments, in addition to the crown area, are listed in Table 2. The species that obtained the best performance in all these variables was *S. macrophylla*. At 7 years of age in the silvipastoral system, it reached a maximum height of 14 m and 23.81 cm of DBH. In studies by Matos et al. (1996) and Sousa et al. (2010), performed in other types of Agroforestry Systems of the same age, the maximum height and DBH recorded for *S. macrophylla* was 10.2 m and 12.3 cm, respectively. Castro et al. (2008) in a silvipastoral system of the same age at Embrapa Rondônia, found values of growth in height of 12 m and diameter of 22 cm, suggesting, therefore, that the best performance of the species manifests itself with the presence of the animals in the planting area.

C. guianensis presented superior results in relation to DBH and height when compared with *D. odorata* and *H. chrysotrichus*. Souza et al. (2010), working in the city of Manaus, showed that *C. guianensis* obtained better results when compared with *S. macrophylla* of the present study in all variables, being similar only in height growth ($m.year^{-1}$); however, the spacing used by the authors was 3 m x 3 m, in an area of 225 m². In order to evaluate the growth of *C. guianensis* in a planting of mixed tree species of the same age, Tonini et al. (2005), reported a similar result of 10.5 cm in DBH, but with an additional 2 m in height as compared to the present study.

Among the averages of height, *H. chrysotrichus* obtained the lowest value (5.64 m). However, for mean DBH (8.88 cm), *H. chrysotrichus* had the third best performance in relation to the other species. The growth of *H. chrysotrichus* occurs slowly, being able to reach a height of 4 m to 35 m in the adult phase (Carvalho, 2006). Lorenzi (2002) reported, for DBH of this species, values between 30 and 130 cm in the adult phase. There are few studies on the behavior of this species in silvipastoral systems. In an agroforestry system in Mato Grosso do Sul, Salomão et al. (2012), estimated a mean height of 7.99 m for this species at the age of seven years in a 1.5 m x 1.5 m spacing model in a consortium between different tree types and agricultural species.

Table 2. Dendrometric performance by species in the full sun trial at 7 years of age.

Species	DBH (cm)	TH (m)	Canopy area (m²)	MAI DBH (cm.year^{-1})	MAI TH (m.year^{-1})
S. macrophylla	16.01	7.99	17.87	2.29	1.14
C. guianensis	10,32	7.00	8.92	1.47	1.0
H. chrysotrichus	8.88	5.64	6.26	1.27	0.81
D. odorata	7.60	6.31	10.71	1.09	0.90

DBH = diameter measured at 1.30 m from the soil, TH = total height, and MAI = mean annual increment.

The Komolgorov-Smirnov non-parametric T Test yielded a higher value (D) between the populations of *D. odorata* and *H. chrysotrichus*, and the diameter distribution of *S. macrophylla* had a higher concentration in the 19 cm DBH class (Figure 3); *H. chrysotrichus* was the only other species that had an individual in this class. However, although it is present in the largest class, *S. macrophylla* was one of the species that presented the greatest heterogeneity as a result of this distribution, which is not a desirable type of behavior for a plantation forest in terms of planning criteria.

D. odorata had superior development to *H. chrysotrichus* in all measurements except DBH. Galeão et al. (2003), in a pure planting of the species with spacing of 6 m x 1.3 m in the same city (Santarém), obtained an average growth rate of 2.91 m in height and 6.41 cm of DBH at 7 years. Souza et al. (2010), in a silvicultural plantation in full sun with multiple arboreal species, in a spacing of 3 m x 3 m obtained averages of 6.61 in height and 6.12 in DBH. These behaviors in different types of systems indicate good performance of the species in a silvipastoral system.

In addition, *C. guianensis* is the species that presented the second lowest coefficient of variation in DBH (CV% 44.65) and after *S. macrophylla*, had a higher frequency of trees in classes 9 and 11. Most *D. odorata* individuals were included in the 9 cm class, and none of the individuals reached a diameter greater than 12 cm. However, although it did not reach larger diameters, it presented the highest homogeneity pattern in DBH with the lowest CV% (44.45), and it was possible to establish objective predictions and targets for the cultivation of this species, based on this parameter. However, the species *H. chrysotrichus* was the most heterogeneous with the highest coefficient of variation in DBH (CV% = 45.12), registering the presence of individuals in all the classes with majority (30.7%) of the population centered around the 7cm diameter class.

It is important to mention the aptitude that other species have in integrating the silvipastoril system. Martínez et al. (2010) and Tonini et al. (2016), present as possibilities, the species, *Schizolobium amazonicum*, common in the Amazon region, and the exotic species, *E. grandis* and *E. urophylla.* Results of the dendrometric performance of these species under the same conditions of age as the system adopted in this work was not available in the current literature. However, in research carried out by Tonini et al. (2016), in a silvipastoril system in West-Central Brazil, the species of *E. grandis* and *E. urophylla* at 3 years of age showed average DBH of 10.4 cm, and height of 10.5 m in 3.5 x 3 m spacing, and this is a result that exceeds the performance of the best species studied in this research. Maneschy et al. (2009), evaluating growth of *S. amazonicum* in an Amazonian silvipastoril system in 5 x 3 m spacing, registered average results of 17.81 and 19.25 m in height, and DBH of 16.83 and 19.72 cm, measured in different years. In the current research, the result of average height and diameter of *S. amazonicum* also presented results significantly higher than the species with better performance in this research, despite being one year younger.

Qualitative analysis of trunk and crown

For trees with a straight trunk (Figure 4), the highest contribution was from *S. macrophylla*, with 93.23% of its individuals, followed by *C. guianensis*, *D. Odorata* and *H. chrysotrichus*. Only 1.92% of the *D. odorata* species were classified as bifurcated. With respect to trunk tortuosity, the species *H. chrysotrichus* (57.42%) and *D. odorata* (36.53%) had the highest proportions of individuals. One of the techniques used to reduce the coefficient of variation (CV %) is selective thinning, a forest activity that has as objective, removal of trees of inferior quality, favoring the growth of others with larger diameters. For this, it is necessary to monitor the growth of the plantation in order to determine the best time for intervention (Maestri and Scolforo, 1997). For the analysis of trunk straightness, more than 72.61% of the total individuals presented straight boles, indicating that there was good performance in relation to the silvicultural treatments in the maintenance stage of the planting. The high degree of tortuosity of the *H. chrysotrichus* trunks is explained by Carvalho (2006), as characteristic of this species.

For the canopy evaluation, Figure 4 shows that 89.04% of the individuals presented a regular shape, with insignificant differences between the species *C. guianensis* and *D. odorata,* and there was low crown regularity in the *H. chrysotrichus* population. In relation to fruit and seed production, Grogan (2001) reported that

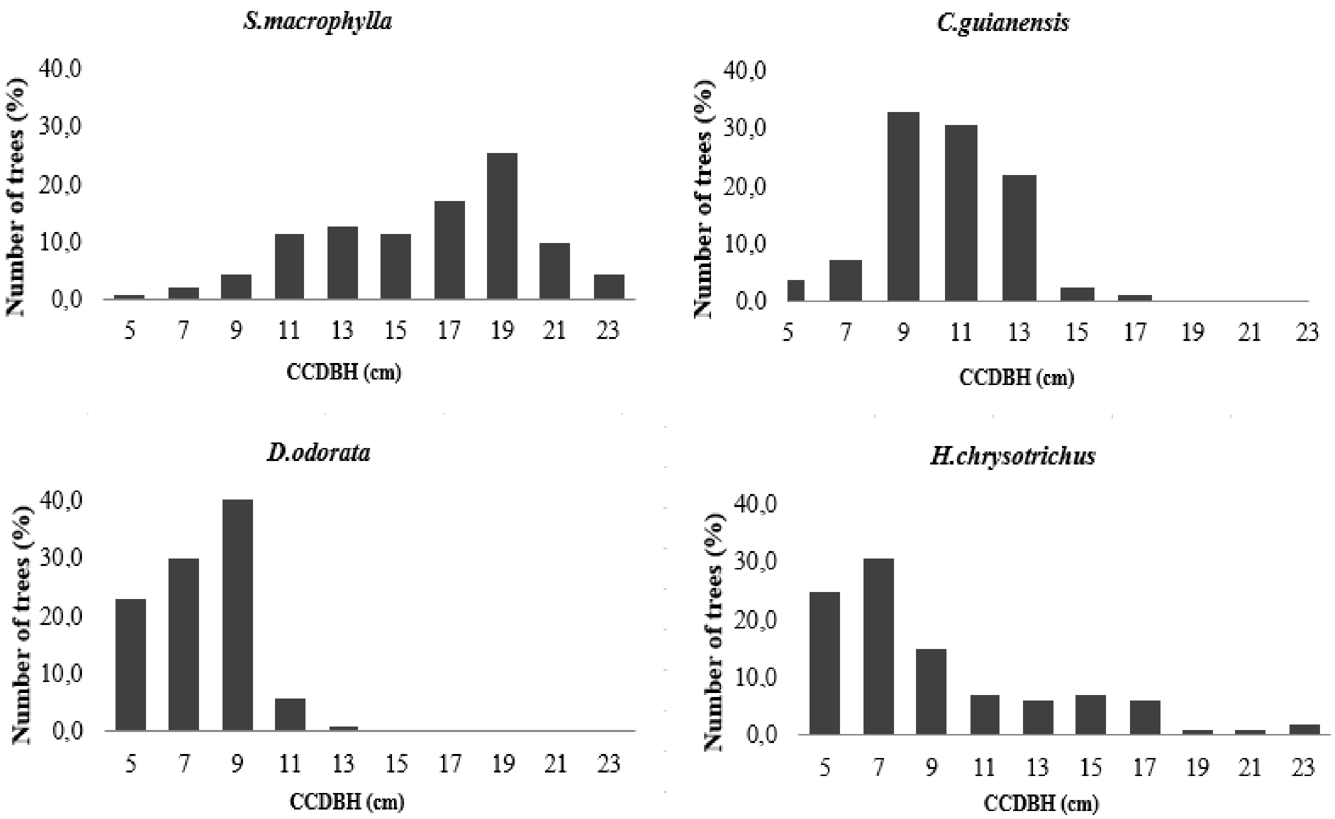

Figure 3. Diametric distribution by species (amplitude 2 cm), Diamantino Farm, Santarém, Pará in which: CCDBH = Center class diameter at breast height.

individuals of *S. macrophylla* with DBH ≥ 30cm produce approximately 50 seed pods, each, having on average, 60 seeds. Thus, if the DBH growth rate presented in this work continues for further six years, this species will be producing seeds for commercialization. According to IBF (2013), one of the benefits of commercializing the seed of this species is its great economic value. It is noted that after *S. macrophylla*, *C. guianensis* is the species that grew the most in diameter, confirming the study by Souza et al. (2006), which concludes that this species, in fertile soils, has rapid development with high increase in volume.

For the canopy cover analysis, an extremely favorable result in relation to the planting prospects is given by Melo et al. (2007), in a study on reforestation that showed a positive correlation between canopy cover and the age of planting; however, the authors suggested that better equations could be obtained if the whole range of ages and site variation are considered.

Considering the silvicultural treatments used in the area (pruning of the branches and crowning), even with the great extension of the property and low number of workers, the planting presented trees with trunks and crowns of satisfactory quality. According to Sena (2013), it is worth noting that in plantation of forestry for commercial purposes, whether seedlings or seeds, some of the factors that should be given special attention are size and shape of the crown, besides the volume and quality of the fruits produced. Figure 5 shows the performance per species in average crown diameter, considering the average of the greatest longitudinal and perpendicular measurement of the crown.

Planting, because it is young, is still in the process of growth, and its capacity of effective canopy cover at the age of seven years covers 2.796 m². That is, of the 2 ha study area, 27.96% is covered by 240 individuals from the plantation, tending to increase its reach until reaching maturity. In this way, the species, through this component, are already providing some types of thermal comfort to the animals.

Silva (2009) underlines the importance of shade for cattle, given the growing concern for animal welfare. On the other hand, if there is excessive shade for grazing, there may be a reduction in storage capacity and a negative influence on soil carbon. The author stated that there is still little information on the size of the shade area adequate to meet the needs of the animals, with values varying from 1.8 to 10 m² per animal. Garcia (2013) emphasized the importance of determining the appropriate shade design for

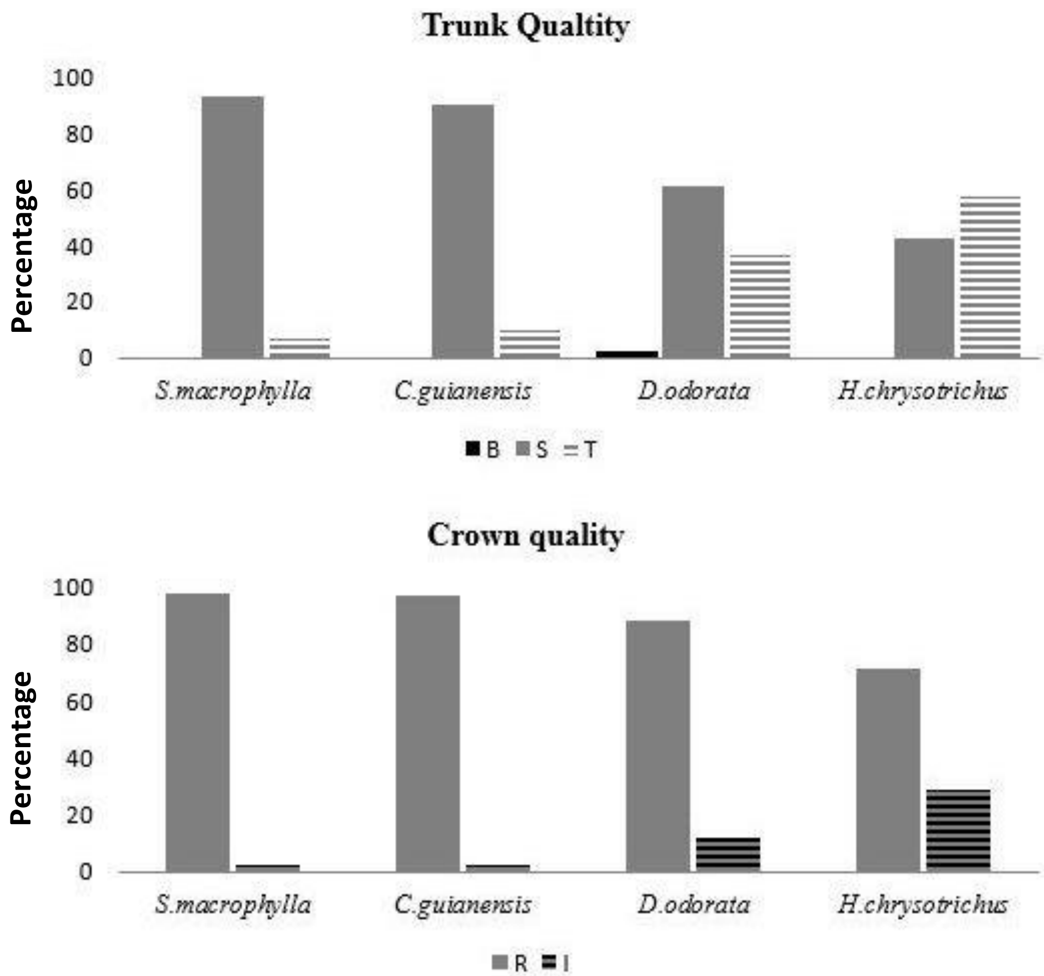

Figure 4. Qualitative evaluation of trunk (TQ) and crown (QC), Diamantino Farm, Santarém, Pará. Where: TQ (B = bifurcated, S = straight, T = tortuous); QC (R = regular, I = irregular).

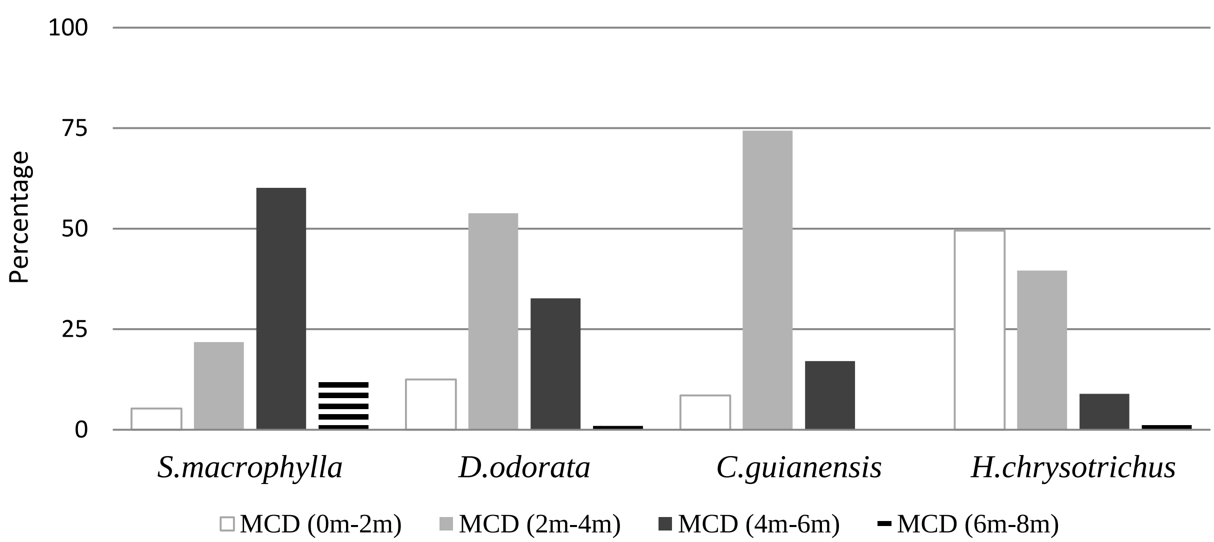

Figure 5. Mean crown diameter (MCD) by species, Diamantino Farm, Santarém, Pará, Brazil.

larger livestock groups in the plantation.

Conclusion

S. macrophylla had the best growth with regards to diameter and height. *C. guianensis* and *D. odorata* presented greater uniformity in diametric distribution. *H. chrysotrichus* provided a smaller crown area, however, sufficiently capable of offering thermal comfort to the animals in the silvipastoral system.

CONFLICTS OF INTERESTS

The authors declare that there is no conflict of interest.

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REFERENCES

Campanha M, Araújo F (2010). Árvores e Arbustos do Sistema Agrossilvipastoril Caprinos e Ovinos. Sobral: Embrapa Caprinos e Ovinos, ISSN. 1676-7659:32.

Carvalho P (2006). Brazilian tree species. Brasília: Embrapa Inform. Tecnol. 2:627.

Carvalho P (2009). Cumaru-ferro. *Dypterix Odorata*. Embrapa – Tech. Release 3:01-08.

Castro A, Lourenço J, Santos N.; Monteiro E, Aviz M, Garcia A (2008). Silvipastoral system in the Amazon: tool to raise the productive performance of Buffalo. Ciênc. Rural 38(8):2395-2402.

Cordeiro L, Vilela L, Marchão R, Kluthcouski J, Martha Júnior G (2015). Integrated crop-livestock and Integrated crop-livestock-forest. Cadernos Ciênc. Tecnol. 32(1/2):15-53.

Dias-Filho M (2006). Silvipastoral systems in the recovery of degraded tropical pastures. Rev. Bras. Zootec. 35(43):535-553.

Galeão R, Yared J, Carvalho J, Ferreira C, Guimarães N, Marques L, Costa-Filho P (2003). Diagnosis of replacement forestry projects in the state of Pará. Embrapa Amazônia Oriental Document 69:33.

Garcia A, Matos L, Lourenço Júnior J, Nahúm B, Araújo C, Santos A (2011) Variáveis fisiológicas de búfalas leiteiras criadas sob sombreamento em sistemas silvipastoris. Pesqui. Abropecu. Bras. 46(10):1409-1414.

Garcia, A (2013). Thermal comfort on reproductive processes of water buffaloes raised under tropical conditions. Rev. Bras. Reprod. Anim. 37(43):121-130.

Grogan J (2001). Bigleaf Mahogany (*Swietenia macrophylla* King) in Southeast Pará, Brazil: a life history study with management guidelines for sustained production from natural forests. Thesis - (Ph.D). Forestry Ecology, Yale University School of Forestry and Environmental Studies, New Haven 442p.

Guimarães L (2015). Ecological aspects and productivity in a Integrated Crop-Livestock-Forest system (ICLF) in Central Brazil. Final Project (Masters) Course of Agronomy, Federal University of Goiânia, Goiânia, Brazil.

Institute of Economic, Social and Environmental Development of Pará (IDESP) (2012). Territorial Analytical Report of the Lower Amazon – Pará. Available in: http://sit.mda.gov.br/download/ra/ra018.pdf

Instituto Brasileiro de Florestas (IBF) (2013). Brazilian Mahogany, *Swietenia macrophylla* – Seeds. https://www.ibflorestas.org.br/conteudo/blog/72-uncategorised/1019-ibf-recebe-sementes-de-mogno-africano.html

Juvenal T, Mattos R (2002). The Forest Sector in Brazil and the importance of Reforestation. BNDES Setorial, Rio de Janeiro 16:30.

Lamb F (1966). Mahogany in tropical America: Its ecology and management. University of Michigan Press. Mahogany 220p.

Lorenzi H (2002). Brazilian trees: identification and cultivation of tree plants of Brazil. Inst. Plant. 1(2):368.

Macedo M (2005). Livestock production and the focus on agribusiness. In: Annual meeting of the Brazilian Society of Animal Science. Goiânia, GO. 42:56-84.

Maestri R, Scolforo J (1997). The management of planted forests In: Scolforo, J.R.S. Forestry Management. Lavras, MG. Federal University of Lavras/FAEPE. 8:313-379.

Maneschy R, Da Veiga J, De Santana A (2009). Evaluation of growth of parica (*Schizolobium amazonicum* Huber) and teca (Tectona grandis l. f.) in silvipastoral systems in northeastern Pará.Luziânia, GO. Dialogue and Integration of Knowledge in Agroforestry Systems for Sustainable Societies. Manaus: SBSAF. Available in: http://www.sct.embrapa.br/cdagro/tema01/01tema15.pdf

Martínez G, Junior M, Junior S (2010). Selection of multipurpose forest species ideotypes of the floodplains in the Low Amazon Basin, Pará. Acta Amazôn. 40(1):65-74.

Matos J, Perin R, Souza S, Wandelli E, Arcoverde M, Fernandez E (1996). Fertility changes in yellow latosol under different agroforestry systems in Manaus. In: Brazilian meeting of soil fertility and Plant Nutrition, Manaus, AM. pp. 682-683.

Melo A, Miranda D, Durigan G (2007). Canopies covers as an indicator of structural development of reforestation of riparian forest restoration in the Middle Paranapanema Valley, SP, Brazil. Rev. Árvore 31(2):321-328.

Nair P, Fernandes E, Wangubu P (1984). Multipurpose leguminous trees and shrubs for agroforestry. Pesqui. Agropecu. Bras. 19:295-313.

Paciullo DSC, Gomide CAM, Castro CRT, Fernandes PB, Muller MD, Pires MFA, Fernandes E, Xavier DF (2011). Production and nutritional characteristics of pasture in agrossilvipastoril system, as the distance of the trees. Pesqui. Agropecu. Bras. 46(10):1176-1183.

Peron A, Evangelista A (2004). Degradation of pastureland in areas of the landscape cerrado. Ciênc. Agrotecnol. 28(3):655-661.

Pinto J, Encinas I, Silva G (2005). Age and growth of trees. Brasília: Universidade de Brasília. Department of Forest Engineering. Tech. For. Commun. 7(1):43. http://repositorio.unb.br/handle/10482/10018

Rozados-Lorenzo M, Gonzalez-Hernandez M, Silva-Pando F (2007). Pasture production under different tree species and densities in an Atlantic silvopastoral system. Agrofor. Syst. 70:53-62.

Salomão G, Fernandes S, Pereira S, Pereira Z, Moitinho M, Silva M, Padovan M (2012). Phytosociology and performance of tree species in an agroforestry system under agroecological foundations in. Embrapa West Agricultural. 4th Seminar of Agroecology of Mato Grosso do Sul, 2. Dourados, MS.

Schikowski A, Martins A, Schiavo B, Stang M, Corte A, Péllico-Neto S, Sanquetta C (2016). Diameter distribution of the dynamics of Araucaria angustifolia in a Mixed Ombrophilous forest fragment in Paraná. Rev. Bras. Biomed. 34(1):163-182.

Sena S (2013). Forest Seed - Collection, Processing and Storage. Available at:

http://www.remade.com.br/br/revistadamadeira_materia.php?num=1728&subject=Sementes&title=Sementes%20Florestais%20%20Colheita,%20Beneficiamento,%20Armazenamento

Silva V (2009). The silvipastoral system and its benefits for the sustainability of livestock. 2009. In: Symposium ABCZ-CNPC sustainable livestock. Lecture. Uberaba, MG. ExpoZebu 11p.

Sokal R, Rohlf F (1995). Biometry. Freeman and Company. New York, 3ed. P 850.

Souza C, Azevedo C, Lima R, Rossi L (2010). Behavior of forest species in plantations in full sun and in “capoeira” enrichment tracks on Amazon. Rev. Acta Amazôn 40(1):127-134.

Souza C, Lima R, Azevedo C, Rossi L (2006). Andiroba (Carapa guianensis Aubl.) Manaus. Embrapa Ocidental Amazon 48:10-21.

Tonini H, Arcoverde M, Sá S (2005). Dendrometry of native species in homogeneous plantations in the State of Roraima, Andiroba. (Carapa guianensis Aubl), Chestnut-of-Brazil (*Bertholetia excelsa* Bonpl.), Ipê-roxo (Tabebuia avellanedae Lorentz ex Griseb) and Jatoba (*Hymenae coubaril* L). Acta Amazôn 35(3):353-362.

Tonini H, Sartori W, Anjos A, Morales M, da Silva V (2016). Performance and quality of wood in a clone of *Eucalyptus* in monoculture and silvipastoral system. Nativa 4(2):77-81.

Werneck M, Pedralli G, Koening R, Giseke L (2000). Floristic and structure of three excerpts from a semideciduous forest in forest ecological station of Tripuí. Rev. Bras. 23(1):97-106.