CHANGES IN YIELD AND CHEMICAL COMPOSITION OF THREE-YEAR-OLD SHORT-ROTATION PLANTATIONS OF *Dipteryx panamensis* IN COSTA RICA

Johana Gaitán-Alvarez[2], Lidier Tencio[2], Roger Moya[2*] and Dagoberto Arias-Aguilar[2]

[1] Received on 01.12.2018 accepted for publication on 03.02.2020.
[2] Instituto Tecnológico de Costa Rica, Escuela de Ingeniería Forestal, Cartago, Costa Rica. E-mail: <jgaitan@itcr.ac.cr> , <ltencio@itcr.ac.cr> ,<rmoya@itcr.ac.cr> and <darias@itcr.ac.cr>.
*Corresponding author.

ABSTRACT – Research and implementation of energy crops using short-rotation woody species (SRWC) are increasing in Latin America, especially for biomass production and use in bioenergy. For this purpose, one of the main factors to consider is species assessment. Therefore, the objective of the present study was to evaluate the growth characteristics, the production and distribution of biomass, and the chemical, physical, and energetic properties of the biomass of three-year-old *Dipteryx panamensis* plantations in SRWC in three different spacings (1.0x2.0 m, 1.0x0.5 m and 1.0x1.0 m) and establish the best spacing condition for this tropical species. The results showed that the production of biomass varies between 1.1 and 42.36 t.ha^{-1}, and that 33-44% of the production are concentrated in the leaves. At three years, the SRWC presented 50% mortality, with a diameter of 4.8 cm at 30 cm-height from the ground, with total tree heights ranging from 5.17 to 6.98 meters. The evaluation of the biomass showed a calorific value between 18.9 and 19.4 MJ/kg, less than 1.81% of ash content and 86% of volatile content. As for the effect of the spacing, the green density of the wood and the moisture content increased with increasing spacing, while spacings of 1.0x1.0 m and 1.0x0.5 m showed the best behaviour regarding annual biomass production.

Keywords: Tropical species; Woody crops; Energy crops.

*ALTERAÇÕES NO RENDIMENTO E NA COMPOSIÇÃO QUÍMICA DE PLANTAÇÕES DE TRÊS ANOS DE ROTAÇÃO CURTA DE **Dipteryx panamensis** NA COSTA RICA*

RESUMO – A pesquisa e a implementação de plantios energéticos usando espécies lenhosas de rotação curta (SRWC) estão aumentando na América Latina, especialmente para a produção de biomassa e uso na bioenergia. Para esse fim, um dos principais fatores a considerar é a avaliação de espécies. O objetivo do presente estudo foi avaliar as características de crescimento da árvore, a produção e distribuição de biomassa e as propriedades químicas, físicas e energéticas da biomassa de um plantio energético de ***Dipteryx panamensis*** *de três anos de idade em SRWC em três diferentes espaçamentos (1,0x2,0 m, 1,0x0,5 m e 1,0x1,0 m) e, assim estabelecer a melhor condição de espaçamento para esta espécie tropical. Os resultados mostraram que a produção de biomassa varia entre 1,1 e 42,36 t.ha^{-1} e que 33-44% dessa produção está concentrada nas folhas. Aos três anos, o SRWC apresentou 50% de mortalidade com um diâmetro de 4,8 cm a 30 cm de altura do solo e com alturas totais de árvores de 5,17 a 6,98 metros. A avaliação da biomassa mostrou um valor calorífico foi de 18,9 a 19,4 MJ/kg, 1,81% de cinzas e 86% de conteúdo volátil. A densidade verde da madeira e o teor de umidade aumentaram com o aumento do espaçamento. Os espaçamentos 1,0x1,0 m e 1,0x0,5 m apresentaram o melhor comportamento em relação à produção anual de biomassa.*

Palavras-Chave: Espécies tropicais; Plantios lenhosos; Plantios energéticos.

1.INTRODUCTION

High and variable cost of fossil fuels due to geopolitical factors, together with global warming (Hauk et al., 2014), have forced the creation of new environmental policies amongst which the promotion of renewable alternative energy sources stands out (Inglesi-Lotz, 2016). This type of energy source is one of the most abundant in the world (Pereira and Costa, 2017).

Forest residues resulting from harvest and sawmill processing wastes area important for energy production, followed by agroforestry residues or short rotation woody crops (SRWC) (Moya et al., 2019). The latter have become increasingly important, since they are highly productive plantations whose purpose is to use the stem and branches for the production of energy (Zamora et al., 2015).

In general, SRWC are associated with planting densities higher than 5000 trees/ha (Dickmann, 2006). The first experiences in SRWC establishment used spacings oriented to wood production, that is, 3x3 m, 4x3 m and 4x4 m (Silva et al., 2015). Another advantage of using SRWC is that in addition to biomass production, SRWC provide other ecological benefits, such as carbon capture and habitat for various wild species (Volk et al., 2011). From the point of view of reproduction, these systems can use genetically improved and easy to propagate species, with short cutting cycles between 3 to 10 years (Vance et al., 2014).

Species selection, planting density, annual increments and rotation are important at the time of establishing a SRWC (Volk et al., 2011). Regarding the planting density, densities above 5000 trees/ha are necessary depending on the dimensions needed (Dickman, 2006). With respect to annual increments and rotations, some authors point out that, at the age of 3, production should be around 5 to 50 $t.ha^{-1}$ (Dickman, 2006; Acuña et al., 2017; Tenorio et al., 2016a, 2018).

Dipteryx panamensis, a native species that had not been studied in SWRC, was tested in the present study. *D. panamensis* is a dense wood that shows initial fast growth, with potential for reforestation for sawlog production in Costa Rica (Tenorio et al., 2016a). Harvesting this species is currently forbidden. *D. panamensis* is one of the endemic species of the region (Redondo-Brenes, 2007), with basic wood density above 0.7 (Tenorio et al., 2016a). Recent studies have shown that *D. panamensis* presents adequate properties for energy production, and that torrefaction processes increase its energy performance (Gaitán-Alvarez et al., 2017).

Although *D. panamensis* is used in reforestation for timber production (Redondo-Brenes, 2007), there is lack of information on its performance in SRWC systems for biomass production (Moya et al., 2019. Therefore, the objective of this study was to evaluate the growth characteristics of the tree, the production (tons) and distribution of biomass, and the chemical, physical and energy properties of the biomass of a three year-old *Dipteryx panamensis* plantations in SRWC at three different spacings (1.0x2.0 m, 1.0x0.5 m and 1.0x1.0 m) in Costa Rica and establish the best spacing condition for this tropical species

2.MATERIALS AND METHODS

2.1. Location and conditions of the plantation

The study was carried out within a trial of 3-year-old *Dipteryx panamensis* (Figure 1a-b), located in the northern zone of Costa Rica. The trial consisted of 3 different spacings: (i) 1.0 x 2.0 m (low density, 5000 trees/hectare), (ii) 1.0 x 1.0 m (medium density, 10000 trees/hectare) and (iii) 1.0 x 0.5 m (high density, 20,000 trees/hectare), thus obtaining 3 different treatments. Each of the planting spacings was represented in 3 blocks, resulting in 3 random repetitions with experimental units of 10 x 10 m of each spacing. Each repetition consisted of 100 m^2 plot (Figure 1a).

2.2. Tree sampling in the plantation and sampling in the tree

In each spacing, 15 trees in total were sampled (5 trees x 3 repetitions), making a total of 45 sampled trees for the whole study. Each tree was felled at ground level and its total height and diameter at 30 cm above the ground were measured (Figure 1c). This height was defined because the 1.3 m of tree height were not presented in all sampled trees. Following, the branches and the leaves were separated from the tree stem and each part was weighed separately. This was denominated as green weight. Then, 2 samples 10 cm long each were extracted from the stem free of leaves and branches, in three sections at different tree heights (at the base of the tree, at 50% height and at the total height) (Figure 1c). The sampling tree was applied according to previous researches published by Tenorio et al. (2016a; 2018)

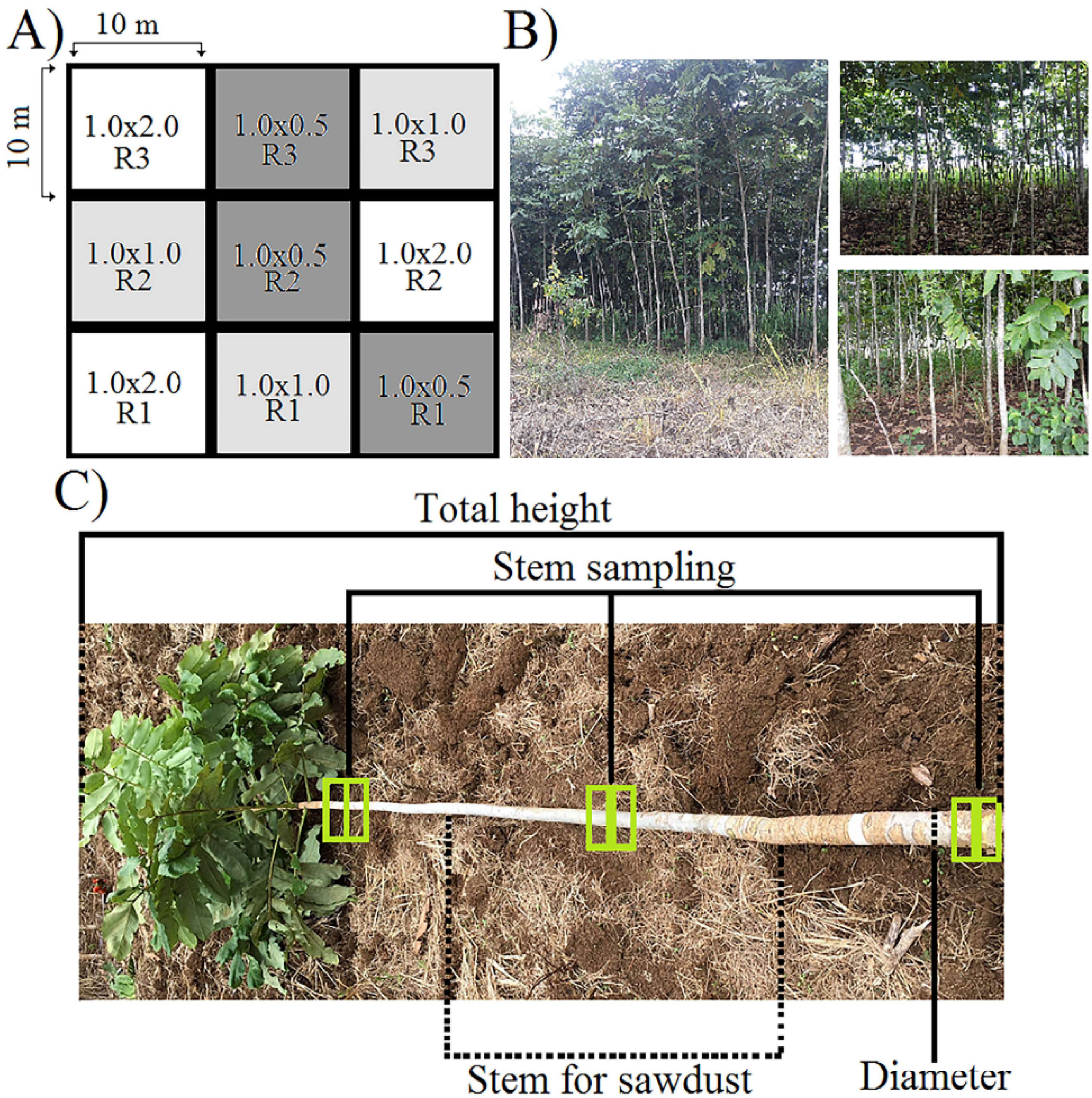

Figure 1 – Distribution of the spacing and the repetitions (a), the energy plantation tested (b) and the tree sampling variables (c) of *Dipteryx panamensis* in Costa Rica.
Figura 1 *– Distribuição do espaçamento e repetições (a), plantio energético testado (b) e variáveis de amostragem arbórea (c) de* ***Dipteryx panamensis*** *na Costa Rica.*

2.3. Determination of moisture content and biomass production

The biomass moisture content (MC) was determined for each part of the tree (leaves, branches and stem). A sample approximately 150 g of leaves and branches was collected and dried at 60 °C for 72 hours and then weighed to obtain the dry weight. As for the stem MC, one of the 3 samples cut from three different heights of the stem was used. Each sample was removed the bark, each of these parts (bark and stem) was weighed in green condition and then dried for 72 hours at 60 °C avoiding the material degradation, to obtain the dry weight of the stem and the bark. With green and dry weights of stem, bark, leaves and branches we proceeded to calculate the MC.

Once the MC for each part of the tree was obtained, dry biomass production was calculated using as a reference the MC and the weight in green condition of each part of the tree at the time of sampling (Equation 1). Then with these data the percentage of each of the parts (stem, leaves and branches) was calculated as the ratio of the weight of each part and the dry biomass of the whole tree, expressed as a percentage. These data were extrapolated to hectares in the different planting spacings.

$$Biomass = weight\ x\ \left(1 - \frac{moisture\ content}{100}\right)$$

2.4. Determination of specific gravity and green density

The specific gravity (SG) represents the biomass relative to the green weight of the sample. It was calculated only for the stem, using the other section of the sample extracted from 3 different tree heights. The bark was removed, weighed and the volume by water displacement was determined. The pieces were then placed in an oven for 24 h at 103 °C, and the weight was recorded before and after drying. SG was determined according to ASTM D-4442 (ASTM, 2007), while the density was determined in freshly cut condition (green mass and volume).

2.5. Determination of the chemical and energy characteristics of the biomass

The percentage of carbon (C), hydrogen (H) and nitrogen (N), lignin, cellulose were determined only to stem part of trees. The stem from 3 different tree heights from the five trees per each sampled block and spacing was used to get milled material, these milled material were air dry until it reached 12% moisture content. The material was then sieved through 40-60 meshes (425 and 250 μm). Regarding the chemical characteristics, the percentage of C, H and N were determined utilizing the Elemental Analyser , model Vario Micro Cube. Also the cellulose and lignin percentage of the material were obtained; the lignin were calculated using three samples of 2 mg of the milled material according to norm TAPPI T222 om-02 (TAPPI, 2002), and the cellulose were calculated using three samples of 2 mg of the milled material according to the procedure describe by Seifert (1960). Regarding the energy characteristics, the gross calorific value (GCV) and the percentages of ash and volatile material were determined. As for the GCV, a portion of 10 g of the milled material was brought to a humidity condition of 0%. Then, a sample of each repetition of 2 grams was selected and the GVC was determined by means of the Parr's Calorific Test, in accordance with ASTM D-5865 (ASTM, 2004). These tests were performed on a 6725 Micro-Parr model calorimeter pump at a temperature of 20 °C. The percentage of ashes was determined by ASTM D-1102 (ASTM, 2013a). For volatiles percentage 3 random samples of 2 g each were selected again and determinations were performed following the procedure described in ASTM D-1762 (ASTM, 2013b). For chemical and energy characteristics, three samples of approximately 2 g of the previously sieved material were used for each of the blocks studied (3 samples x 3 blocks x 3 spacings = 27 samples).

2.6. Statistical analysis

The statistical analysis consisted of, firstly, the determination of the normality and homoscedasticity of the variance analysis model for all the measured variables. Next, the descriptive statistics were determined for each of the variables, and then the characterization of the variables. An analysis of variance was conducted to determine the effect of the plantation spacing, followed by Tukey's multiple comparison analysis to verify significant differences between the spacings, using the averages of the measured variables. The SAS program (SAS Institute Inc., Cary, NC) with α=0.05 confidence level was utilized to perform these analyses.

Table 1 – Characteristics of short rotation energy plantations of *Dipteryx panamensis* with three different spacing in Costa Rica.
Tabela 1 *– Características de plantios energéticos de curta rotação de* ***Dipteryx panamensis*** *em três diferentes espaçamentos na Costa Rica.*

Spacing(m)	Initial density (Tree/ha)	Density at 3-yr-old (Tree/ha)	Mortality rate/ha (%)	Diameter (mm)	Total height (m)
1.0x2.0	5000	2500	50.00	47.08 (6.09)^{A}	5.17 (24.16)^{B}
1.0x1.0	10000	4733	52.67	48.94 (5.92)^{A}	5.96 (12.56)^{B}
1.0x0.5	20000	10200	49.00	47.73 (0.70)^{A}	6.98 (3.72)^{A}

Legend: the mortality is determined in relation to the initial density.
Different letters in diameter and total height mean that there is a statistical difference at 95% confidence between spacings.
Lengenda: a mortalidade é calculada em relacao com a densidade inicial
Letras diferentes no diâmetro e na altura total significam que há uma diferença estatística com 95% de confiança entre os espaçamentos

3.RESULTS

3.1. Plantation characteristics

Table 1 shows the initial density, the density at the time of sampling and the mortality rate of the plantations at the different spacings. Table 1 shows that the highest mortality at 3 years of age is approximately 50%, being higher in spacing 1.0 x 1.0 m. In relation to the morphological dimensions of the tree, the diameter at 30 cm-height from the ground at 3 years of age, in each spacing, registered values between 47 and 48 mm, with no significant differences between the three spacings (Table 1). As for the total height, *D. panamensis* trees in spacing 1.0 x 0.5 m were statistically higher close to 7 m (Table 1).

3.2. Biomass production

The lowest biomass production, with and without leaves, was observed in spacing 1.0 x 2.0 m, followed by spacing 1.0 x 1.0 m, with the highest biomass production in spacing 1.0 x 0.5 m (Table 2). Regarding the stem biomass production, spacing 1.0 x 2.0 m presented the statistically lower biomass production with respect to the other two spacings (Table 2). In relation to the biomass from the leaves and branches, the highest yield was obtained with the density 1.0 x 0.5 m, this being statistically different from the other spacings, which did not show statistical differences in the production of leaves and branches (Table 2).

As regards to biomass distribution in the different parts of the tree, in spacing 1.0 x 2.0 the highest percentage of biomass production was in the leaves, followed by the stem, branches and bark (Figure 2). In spacings 1.0 x 1.0 m and 1.0 x 0.5 m, most biomass production came from the stem, followed by the leaves, then the bark and lastly, the branches (Figure 2).

3.3. Chemical characteristics

Regarding the content of cellulose and lignin, no significant differences were found between the three spacings (Table 2).. Statistical differences in the percentages of N, C and the C/N ratio were observed. There were no statistical differences between the 1.0 x 1.0 and 1.0 x 0.5 m spacing, only in the 1.0 x 2.0 m (Table 2). The highest value of N percentage was obtained in spacing 1.0 x 2.0 m and 1.0 x 1.0 m, whereas in spacing 1.0 x 2.0 m the N percentage was statistically different from spacing 1.0 x 0.5 m (Table 2). The lowest percentage of C was obtained by trees planted at a distance of 1.0 x 2.0 m, being statistically different from the other two densities, which did not present statistical differences (Table 2). In relation to the C/N ratio, the highest value was shown by the spacing 1.0 x 0.5 m, being statistically different from the other spacings, which did not show differences between them (Table 2).

Table 2 – Biomass production and chemical properties of stem part of tree from short rotation energy plantations of *Dipteryx panamensis* with three different spacings in Costa Rica.

Tabela 2 – *Produção de biomassa e propriedades químicas de plantios energéticos de curta rotação de **Dipteryx panamensis** em três diferentes espaçamentos na Costa Rica.*

Biomass production	Spacing (m)		
(t.ha^{-1})	1.0 x 2.0	1.0 x 1.0	1.0 x 0.5
Total with leaves	10.83	20.06	42.36
Total without leaves	6.18	12.09	28.40
Stem	5.08^{B}	10.93^{B}	24.87^{A}
Branches	1.11^{B}	1.16^{B}	3.53^{A}
Leaves	4.64^{B}	7.98^{B}	13.96^{A}
Cellulose	52.83^{A}	52.09^{A}	51.85^{A}
Lignin	21.74^{A}	22.94^{A}	22.04^{A}
N	0.22^{A}	0.19A^{B}	0.18^{B}
C	45.11^{A}	45.15^{B}	45.50^{B}
H	6.30^{A}	6.26^{A}	6.16^{A}
C/N	212.35^{A}	232.46^{B}	253.39^{B}

Legend: Different letters in biomass from steam, branches and leaves and chemical compositions mean that there is a statistical difference at 95% confidence between spacings.

Legenda: Letras diferentes na biomassa de vapor, ramos e folhas e composições químicas significam que existe uma diferença estatística com 95% de confiança entre os espaçamentos.

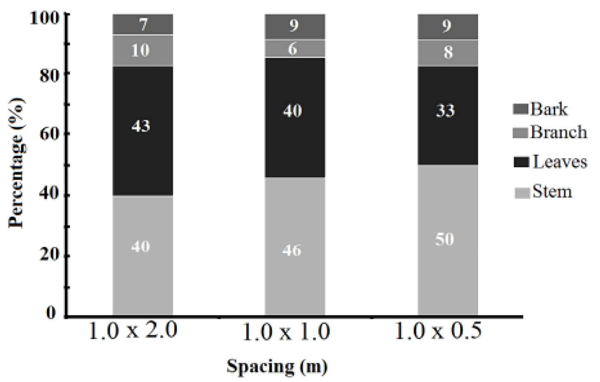

Figure 2 – Biomass distribution in trees from short rotation energy plantations of *Dipteryx panamensis* with three different spacings in Costa Rica.

Figura 2 – *Distribuição de biomassa em árvores provenientes de plantios energéticos de curta rotação de **Dipteryx panamensis** em três diferentes espaçamentos na Costa Rica.*

3.4. Physical and energy characteristics

With regard to the physical properties of the trees, the density of recently felled wood was higher in spacings 1.0 x 2.0 m and 1.0 x 1.0 m, with no statistical differences between those spacings, while spacing 1.0 x 1.0 m showed no differences with 1.0 x 0.5 m (Figure 3a). The trees in the three spacings were on average statistically similar regarding the specific gravity (Figure 3b).

Regarding the energy properties of the biomass, spacings 1.0 x 0.5 m and 1.0 x 1.0 m did not show statistical differences in MC, while spacing 1.0 x 0.5 m presented statistically lower MC than the previous spacings (Figure 3c). The highest value of GCV was obtained in the spacings 1.0x1.0 m and 1.0 x 0.5 m, without differences between them, while the spacing 1.0 x 1.0 m presented GCV value statistically different to the spacing 1.0 x 2.0 m (Figure 3d). As for the ash content, the highest value was obtained with biomass from the spacing 1.0 x 2.0 m, which was statistically different from the other planting densities, which shows the lower ash content value (1.0 x 1.0 and 1.0 x 1.5 m) (Figure 3e). The percentage of volatile materials was higher in the biomass planted at 1.0 x 1.0 m, while the remaining spacings were statistically lower, showing no statistical difference (Figure 3f).

4. DISCUSSION

4.1. Plantation characteristics and biomass production

Firstly, *D. panamensis* is catalogued as a slow growing species in plantations (Piotto et al., 2003), according to the results in diameter growth

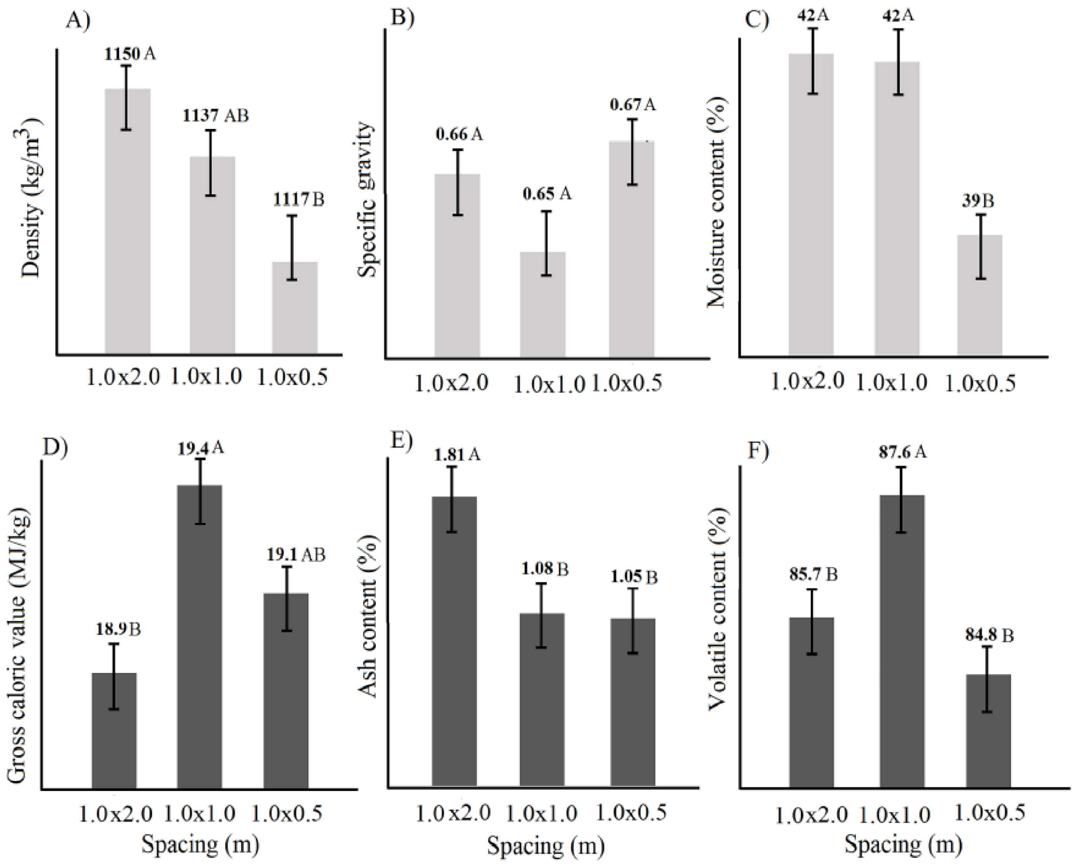

Figure 3 – Physical and energy properties of the biomass of stem of trees growing short rotation energy plantations of *Dipteryx panamensis* with three different spacings in Costa Rica.
Figura 3 – *Propriedades físicas e energéticas da biomassa de árvores provenientes de plantios energéticos de curta rotação de* ***Dipteryx panamensis*** *em três diferentes espaçamentos na Costa Rica.*

if compared with other woody trees growing under plantation conditions. For example, Tenorio et al. (2018) report a diameter of 72.43 mm for *Gmelina arborea* in 3-year-old SRWC plantations, for the same densities, which surpasses the diameter of 47.08 mm found in *D. panamensis*.

It is expected that the higher the planting density (narrow spacings), the smaller the diameter of the trees, due to the competition between neighbouring trees (Gspaltl et al., 2013). However, this did not occur in the densities of the plantations studied, where the diameters at the base of the trees in the different spacings showed no significant differences (Table 1). This lack of difference is probably because in *D. panamensis*, with high density and slow growth rates), the levels of competition among 3-year-old trees is still low as to produce differences in the diameter of the trees (Redondo-Brenes, 2007). At early ages, as in *D. panamensis* in this study, crown intertwining among trees (the visible evidence that competition begins) barely started, therefore competition was low (Li et al., 2017).

However, although no differences in the diameters were observed (Table 1), tree height showed differences in the spacing 1.0x0.5 m. Physiologically, the tree will focus its development mainly on stability and subsistence in the first years of age, in order to survive (Li et al., 2013), so that at early ages growth will be greater in height (Table 1) in those spacings that produce greater competition, such as 1.0x0.5 m.

Another significant aspect in the first 3 years of development of the plantation of *D. panamensis* under the SRWC system, is the high mortality occurring in the 3 spacings studied, from 49.00 to 52.67% (Table 1), which is common in *D. panamensis* plantations for wood production (Piotto et al., 2003). Therefore, the high mortality obtained in *D. panamensis* SRC was influenced by lack of weed management during the first year of establishment, which in these biomass production systems is highly important (Dickmann, 2006).

The variation of the biomass values (1.11 to 42.36 $t.ha^{-1}$) in the 3 spacings studied (Table 2) is lower than found by Tenorio et al. (2016a, 2018) in SRWC of 3-year-old *Gmelina arborea* in Costa Rica, *Populus* sp SRWC in Chile (Carmona et al., 2015). These differences appear mostly because *D. panamensis* is a slow growing species (Piotto et al., 2003). However, despite its low biomass production, *D. panamensis* exhibits high SG in planted trees (Tenorio et al., 2016b), thus concentrating the biomass in less volume, which is important during processing, densification and biomass transportation (Dickmann, 2006). Added to this, the potential of this species for energy production or biomass thermochemical processes has been demonstrated (Gaitán-Alvarez et al., 2017).

Despite the high leaf percentage (Table 2, Figure 2) and its physiological importance (Pleguezuelo et al., 2015), the stem sections (bark and branches) concentrate a high percentage of the total biomass, with differences occurring between spacings (Table 2, Figure 2). In general, in the SRWC systems, a high percentage of the biomass is expected to be concentrated in the stem and branches (Dickmann, 2006). An increase in biomass production in the stem reduces maintenance costs, since the canopy closes faster, preventing weed growth in the plantation (Hauk et al., 2014). Therefore, the spacings with the highest percentage of biomass in the tree stem and branches are the most appropriate. The spacing 1.0x2.0 m, with the highest percentage of leaf production (Figure 2), is inconvenient for biomass production, while the spacings 1.0x1.0 m and 1.0x0.5 m are more appropriate since higher proportion of the biomass is concentrated in the stem and lower percentage in the leaves (Figure 2).

4.2. Chemical, physical and energy characteristics of the biomass

The little variation in the chemical properties in the different spacings (Table 2) is explained by the fact that these characteristics are influenced by variations between sites, topography and climatic conditions (Stolarski et al., 2017). As the present trial locates in one site, with the same topography and soil conditions, few significant differences are to be expected between the spacings (Table 2). The contents of cellulose and lignin (Table 2) were lower than those reported by Gaitan-Alvarez et al., (2017) for biomass from trees growing in natural forests or older plantations, which is explained by the age of the trees, since it is expected that the chemical composition increased with the age (Gaitán-Alvarez et al., 2017). The genetic variation was not possible because it was planted same genetic material.

Lower density in green condition occurs with the greater spacing (Figure 3a and 3b), as could be observed in the present study. This can be explained by the fact that trees in wider spacings have less competition, therefore develop anatomical structures with greater cell wall or greater pore frequency or pore diameter (Aloni, 2001). This results in a lower moisture percentage (Figure 3a, 3c). In contrast, high density in green condition is related to the water present in the wood, which has larger spaces to contain water (Aloni, 2001), resulting in higher MC, as occurs in spacings 1.0x2 .0 m and 1.0x1.0 m (Figure 3c).

On the other hand, the GCV agrees with values reported in literature on fast growing plantations of around 5 years of age of Eucalyptus (Gominho et al., 2012) and *G. arborea* (Tenorio and Moya, 2013). In relation to the high GCV obtained in spacing at 1.0x1.0 m (Figure 3d, Table 2), it appears to be influenced by a low ash percentage (Figure 3e) and higher volatile content (Figure 2f).

The ash content is a parameter of high interest in biomass. High ash content reflects more residual material that cannot be burned during burning (Nielsen et al., 2009). Thus, the high value of ashes obtained in spacing 1.0x2.0 m is a negative factor compared to the other spacings studied (1.0x1.0 and 1.0x0.5 m), where less ash content was found (Figure 3e). This means that this spacing (1.0x2.0 m) would produce high ash content. Added to this negative factor, spacing 1.0x2.0 m presented higher MC (Figure 3c), lower GCV (Figure 3d) and low percentage of volatiles (Figure 3f). However, these values are consistent with those found by Gaitan-Alvarez et al. (2017) for other types of woody biomass such as *Cupressus lusitanica*, *Gmelina arborea*, *Tectona grandis* and *Vochysia ferruginea*.

Finally, according to the above mentioned biomass characteristics of *Dipterx panamensis* in a SRWC system for biomass production, it is a species that shows optimal physical, chemical and energy properties to be used for the production of biomass for energy purposes, since they are comparable to other tropical species used as biomass (Gaitán-Alvarez et al., 2017; Moya et al., 2019). However, the properties evaluated present some differences by spacing. There is higher production of stems as well as biomass production per hectare in spacings 1.0x1.0 and 1.0x0.5 m (Figure 2.3). Still, these production levels must be evaluated in other aspects, such as the economic aspect, since these values of biomass production per hectare are below the average found in other tropical species in SRWC systems (Eloy et al., 2016). Nevertheless, unlike the previous species, the biomass of *D. panamensis* has lower MC.

5.CONCLUSION

The characteristics presented previously of the biomass of *Dipterx panamensis* in a SRWC system for biomass production, determine that it is a species that has optimal physical, chemical and energy properties to be used for biomass production for energy purposes compared to other species used for the same purpose. The biomass extracted from trees growing in the short rotation crop system shows high value of specific gravity, low MC, accessible percentages of ash and volatile contents, as well as optimal values of GCV, comparable with other forest species used for biomass production. We observed higher biomass production in the stem and branches, in the spacings 1.0x1.0 and 1.0x0.5 m, at the age of 3 years. Although the biomass production per year is lower than that reported in other tropical timber species, the spacings at 1.0x1.0 m and 1.0x0.5 m show annual biomass production from 12.09 to 28.40 $t.ha^{-1}$, which is a good result if compared with species in other regions of the world. Concluding that *Dipteryx panamensis* plantations at spacing of 1.0 x 1.0 and 1.0 x 0.5 m works well for biomass production.

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