Amazonian Journal of Plant Research *©2017 Universidade Federal do Pará*
This paper is available online free of all access charges – Faculdade de Engenharia Agronômica
https://www.ajpr.online - Amaz. Jour. of Plant Resear. 3(3):353-362. 2019

Amazonian Journal of Plant Research

Original Paper

OPEN ACCESS

Development of *Hymenaea courbaril* L. (Fabaceae) seedlings in hydroponic and soil system

Sandra A. Santos da Silva[1], Eliane N. Braz[2], Pedro V. de Araújo Júnior[1], Fabio Miranda Leão[2], Dhyene R. Silva Dos Santos[1] and Rafael Oliveira da Silva[3]

1 College of Agronomic Engineering, Federal University of Pará, Altamira - Pará, Brazil

2 Forestry Engineering School, Federal University of Pará, Altamira - Pará, Brazil

3 Federal University of Pará, Tucurui - Pará, Brazil

Received: 04 April, 2019. Accepted: 7 June, 2019
First published on the web December, 2019
Doi: 10.26545/ajpr.2019.b00044x

Abstract

The jatobá (*Hymenaea courbaril* L.) belongs to the family Fabaceae and subfamily Caesalpinioideae. It is a specie used for various purposes, it has a huge economic and ecological value, highly indicated for degraded areas recovery. In this context, this research aimed to evaluate the jatobá seedlings development, cultivated in hydroponic system and on the soil, in order to verify which is the most promising system for the seedlings production of the specie. The experiment was conducted in a greenhouse of the Forestry Engineering School of Pará's Federal University – UFPA, in the municipality of Altamira – PA. The experimental design used was in blocks completely randomized with two treatments (Hydroponic System and Soil) with four repetitions, being each repetition composed by five plants, making four blocks each treatment. The seedlings were cultivated in soil horizon B oxisol (treatment 1) and nutritional solution (treatment 2). The following parameters were evaluated: height, collar diameter, dry matter weight of the aerial part and root system and nitrogen contents, phosphorus and potassium of the aerial part and the root. The development in the seedlings diameter was similar in both studied systems, however, the best jatobá seedlings development observed was in soil cultivation, although the hydroponic system had provided better nitrogen and phosphorus absorption. The potassium absorption was similar between the treatments.

Key-words: Jatobá, Plant nutrition, Cultivation Systems

Introduction

Hymenaea courbaril L. popularly known as jatobá, is a plant belonging to the Fabaceae family, classified as late specie to climax in tropical forests. It is a tree that can reach up until 40 m of height, with a chest diameter of up to 2 m, with arranged leaves alternated and petiolated, fruit of the indiscent flattened pod type, of flavor and smell characteristic (Coradin et al., 2018).

Jatobá is a specie used for various purposes, however, its main product is the wood, for being hard, heavy and with excellent acceptance in the foreign market, being highly valued because of the durability and lack of cracks (Ferreira, 2017).

The plant has high geographical distribution and characteristics capable of developing in adverse environmental conditions, presenting tolerance strategies to the abiotic stress, where other plants can't establish themselves. According to Costa (2015) the jatobá occurs naturally in dry soils and of low fertility, but with good drainage, since it's a plant that presents certain tolerance to water deficiency. Due to its wide distribution and good adaptation to different environments, it is one of the main species indicated to the degraded forest areas recovery.

✉ Sandra A. Santos da Silva
E-mail: muh.agr@gmail.com

The jatobazeiro is still a specie of great ecological importance to family farmers and traditional people, besides of having an enormous economic value by the use of its fruits and by the hard wood a lot used in construction, furnitures and others (Costa, 2015). About the jatobá's nutritional requirements, several researches indicate that the same reacts significantly with higher nutrient content available to its development (Nascimento et al., 2014; Gonzaga et al., 2016). Matheus et al. (2011) affirms that the failure to supply of certain essential nutrients (N, Mo, S e Ca) can cause nutritional disorders to the plant, even so it's still a plant considered undemanding in moisture and soil fertility, being one of the reasons to be indicated to the degraded areas recovery.

In this way, the present work aimed to evaluate the jatobá's seedlings development, cultivated in hydroponic system and on the soil, in order to verify which is the most promising system for the seedlings production of the species.

Material and methods

The experiment was conducted in a greenhouse of the Forestry Engineering School of Pará's Federal University – UFPA, in the municipality of Altamira – PA, located at the geographical coordinates 03º12'00" S e 52º13'45" W (Moura and Ribeiro, 2009).

The climate data during the experiment, performed between Nov 28th 2012 to Feb 22nd 2013, presented average precipitation of 247mm per month, average relative air humidity of 81%, maximum temperature of 37,4ºC and minimum of 20,2ºC, average temperature of 26ºC (INMET, 2012; 2013).

The used experimental design was in blocks completely randomized with two treatments (Hydroponic System and Soil) with four repetitions, being each repetition composed by five plants, making four blocks each treatment.

The jatobá seedlings used in the experiment were manufactured in a greenhouse, which has a shade screen 50%, from seeds coming from Altamira county – PA. To the dormancy break, the seedlings were scarified with the use of water sandpaper nº 60 (Figure 1), after this procedure, it was executed the sowing in plastic trays containing washed and sterilized sand. The sterilization process was carried out in vertical autoclave, under 1,0 ATM of steam pressure, during 01h30.

One month after sowing, the more uniform seedlings were selected to the experiment setup, these were removed carefully from the tray avoiding to cause injuries to its root system, in this moment these were washed in running water.

Fig. 1. Process of Jatobá seedlings production (*H. courbaril*). (A) Seed scarification. (B) Seeds sowing.

For the hydroponic system, the seedlings were transplanted to plastic vases containing washed and sterilized quartz using 1,0 liter of nutritional solution, for each vase. In the plastic vases, it was inserted a faucet with a hose coupled in the bottom of its base with 3 mm of internal diameter, in order to allow that the solution drainage occurred by the gravity effect (Figure 2).

The nutritional solution used in the experiment was the proposal by Epstein (1975) modified by Silva (2006) according to table 1, which placed the referred solution into cultivation for Brazilian mahogany (*Swietenia macrophylla* King) in Pará's state, which provided the normal species development.

The nutritional solution was provided in the early morning hours (7h) and drained in the late afternoon (18h), manually, in order to offer the root aeration, staying the same flooded during 11 hours per day. The replacement of wasted water volume by evapotranspiration was made with distilled water whenever necessary.

Fig. 2. Hydroponic System Assembly. (A) Overview System. (B) Detail of the drainage process and solution storage.

Table 1: Chemical composition of Stock Nutritive solution, in molar (M), used in the experiment.

Stock Solution	Concentration (M)	Complete Solution (mL.L^{-1})
Potassium Nitrate	1M	9
MAP	1M	2
Magnesium Sulphate	1M	1
Calcium Nitrate	1M	4
Micronutrients	-	2

Fonte: Epstein (1975) modified by Silva (2006).

During the night time the nutritional solution was stored in pet's bottles painted with nontoxic black ink, suspended on the countertop below of each vase.

The vases were covered with aluminum paper, to minimize the light input, and so avoid the algae appearance and nutritional solution heating. The vases upper opening was closed with plastic lid, which contained a hole that allowed the seedling development and this was sealed with aluminum paper. In the space where it was installed the experiment countertop, it was used a transparent plastic cover, right below of the shade, in order to control the rain effects, so that the systems (hydroponic and soil) wouldn't receive the incidence of the same (Figure 3).

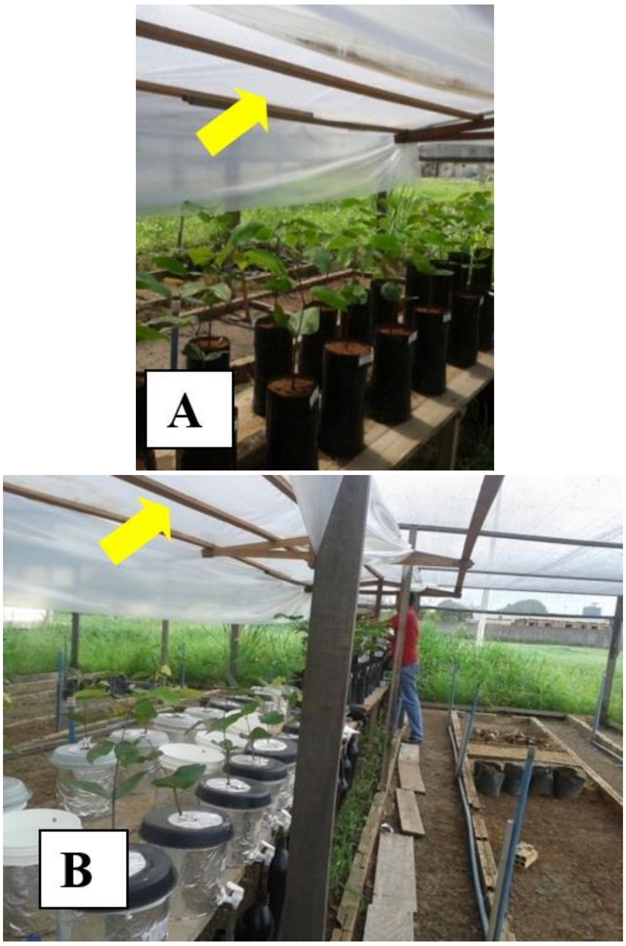

Fig. 3. (A) e (B) Plastic cover detail, protecting the seedlings from the rainwater incidence.

The nutritional solution was weekly changed, measuring the pH to 5,5 until 6,5, being this corrected, whenever necessary, with the calcium hydroxide solution ($Ca(OH)_2$) to raise the pH solution, when acid.

For the cultivation system in soil, it was used black polyethylene bags with capacity for three liters and this was filled with soil from the horizon B Oxisol and the sand in the prorpotion 3:1.

The soil chemical analysis (Table 2) was done in the Soil laboratory of the Federal Rural Amazon University – UFRA, for fertility analysis, proposed by Embrapa (2011).

The analyzed parameters to evaluate the jatobá's seedlings development were plant height; collar diameter; root dry matter and aerial part; N, P, K from the aerial part and of the root. The measurements were performed biweekly for the variables height and collar diameter. The height was defined as the distance between the stalk next to the substrate (collar) until the plant apex (apical gem). To the collar diameter, it was obtained the measurement next to the substrate.

Table 2: Soil Chemical Analysis used in the experiment.

pH		Corg	M.O	N	P	K	Ca	Mg	Al	H + Al
H_2O	KCl	-------------g.Kg^{-1}------------			mg dm^{-3}	---------------------cmol$_c$ dm^{-3}----------------				
5,48	4,86	11,25	19,40	1,16	3,25	0,29	2,35	0,71	0,10	3,63

At the 84 days the experiment was removed from the filed, being the plants wrapped in paper bags properly identified and placed in the greenhouse with forced air circulation in the temperature of 70 ºC, until it reaches constant weight. After this process, it was obtained the values of root dry matter and of the aerial part.

The dry matter corresponding to each of the plants parts was weighed and milled in Willey type mill, then forwarded to the chemical analysis. The plant material analysis was done at the Brazilian Agricultural Research Corporation of the Eastern Amazon – EMBRAPA/CPATU at the Soil Laboratory. The samples extract was gotten by nitro-perchloric digestion in the concentration of 2:1. The nitrogen contents were determined by the Kjeldahl method proposed by Embrapa (2009). The phosphorus contents were determined through the colorimeter method and the Potassium through the atomic absorption spectrophotometer method, these proposed by Embrapa (2009).

The height data and diameter were submitted to repeated-time data ANOVA at 5% of probability. For the dry matter weight and contents of N, P and K, it was done the ANOVA, at 5% of probability. The statistical analysis was determined by the statistic program SYSTAT 12.

Results and discussion

H. courbaril Growth

In the table 3 it is found the average height (H), collar diameter (DC), Aerial part dry matter (MSPA), root dry matter (MSR), nitrogen contents on the aerial part (NPA), nitrogen contents on the root (NR), phosphorus contents on the aerial part (PPA), phosphorus contents on the root (PR), potassium contents on the aerial part (KPA) and potassium contents on the root (KR) of Jatobá's plants (H. courbaril) in function of the treatments.

Table 3: Average height (H), collar diameter (DC), Aerial part dry matter (MSPA), root dry matter (MSR), nitrogen contents on the aerial part (NPA), nitrogen contents on the root (NR), phosphorus contents on the aerial part (PPA), phosphorus contents on the root (PR), potassium contents on the aerial part (KPA) and potassium contents on the root (KR) of Jatobá's plants (*H. courbaril*) in function of the treatments.

Parameters	Treatments	
	Soil	Hydroponics
H	38,4a ± 1,7	31,0b ± 0,5
DC	5,0a ± 0,0	6,0a ± 0,0
MSPA	7,91a ± 0,75	4,40b ± 0,24
MSR	3,29a ± 1,48	0,83b ± 1,06
NPA	16,05b ± 1,63	22,38a ± 1,83
NR	12,37b ± 1,57	23,27a ± 0,97
PPA	1,07b ± 0,14	3,61a ± 1,83
PR	1,00b ± 0,06	3,81a ± 0,88
KPA	8,18a ± 0,34	6,76a ± 1,03
KR	5,28a ± 0,57	7,41a ± 0,31

Numbers followed by the same lowercase letters don't differ statistically with each other by ANOVA (P<0,05).

Height and stem diameter of H. courbaril plant seedlings

The biggest development in plants height was proportionate by the cultivation in soil (Table 3 and

Figure 4). Cabral et al. (2015) working with the same species of this study, analyzing the seeds' germination and the jatobá's seedlings development in different substrates, in Dystroferric Red Oxisol, obtained average height in the 67 days of 20,14 cm. The found datas in the literature were still numerically smaller than those found in this research, that presented average of 38,4 cm of height in 111 days. Vieira et al (2011) studying cherry seedlings (*Amburana acreana*) in nutritional solution through the missing element technique got, average height in the 90 days of 37,86 cm, similar values to those obtained in this study.

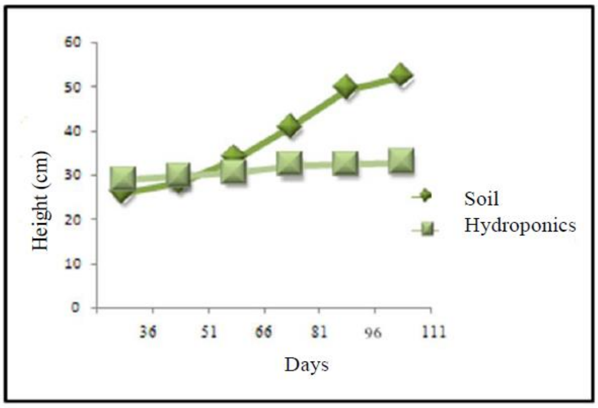

Fig. 4. Observed height growth in function of the experiment days.
Source: INMET, 2012, 2013. Elaboration: Braz, 2013.

The development in seedlings diameter was similar to both studied systems, as it is observed in the Table 3 and Figure 5. Vieira et al (2011) and Nascimento et al. (2014) analyzing forest species in hydroponic systems obtained diameter values of 2,98 mm to cherry (*Amburana acreana*) and 6,39 mm to the jatobá. Cabral et al. (2015) studying the jatobá's culture development in Distroferric Red Oxisol got a diameter of 4,89 mm in the 90 days, being this result lower than this research when observed to the soil system, although this experiment remained in field for 21 days less than the current study.

Regarding the significance absence in relation to the seedlings diameter in both tested treatments, such fact can be explained because it is a low growing forest species, where the experiment time may have been insufficient for the species to demonstrate its potential development in diameter in relation to the treatments.

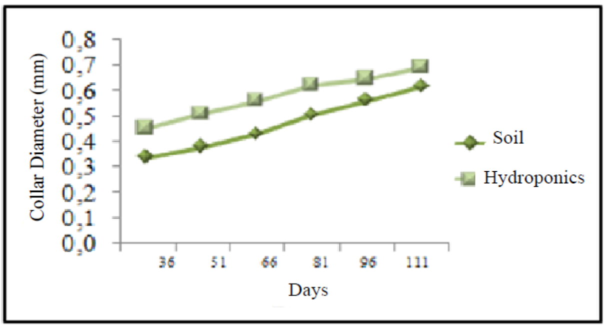

Fig. 5. Observed diameter growth in function of the experiment days.
Source: INMET, 2012, 2013. Elaboration: Braz, 2013.

One of the main hydroponic system advantages is to provide a better quality production besides of a higher productivity in short production cycles (Lazia, 2012). The low growth observed of the studied species in hydroponic system may have been affected by the high temperatures registered during the experiment conduction (minimum of 20,2ºC and maximum of 37,4ºC), as shown in Figure 6, because according to Genúncio (2014) for a good development of the cultivated plants in hydroponics, the temperature ideal values are between 15 to 27ºC, since the temperature rise above 30º can inhibit the root system growth.

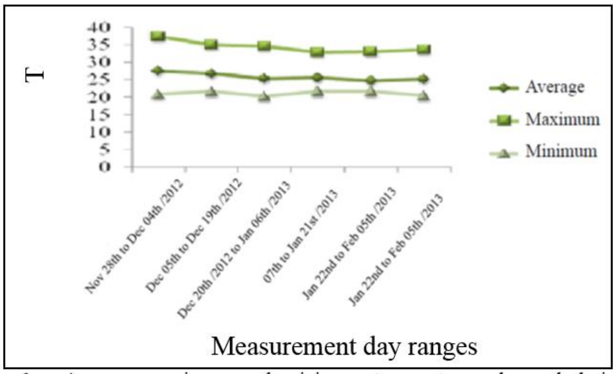

Fig. 6. Average, maximum and minimum temperatures observed during the experiment conduction.
Source: INMET, 2012, 2013. Elaboration: Braz, 2013.

He and Lee (1998) affirm that in places of tropical weather, in which occurs high temperatures and big light incidence, normally there is decreased growth of mild climate plants if the root zone temperature isn't controlled. Furthermore, Barbosa, Martinez and Kampf (1999) report that the increased evapotranspiration can reduce the available humidity to the roots, in order to concentrate the nutritional solution around these leading the plant to stress. He and Lee (1998) still report that, as the increased solar radiation as the root zone low temperature are important factors responsible by the high maximum photosynthetic rate higher productivity.

Another fact that may have negatively influenced the jatobá's production in hydroponic system, is the root aeration decrease since these do not have an automatic aeration system, remaining submerged in the nutritional solution for a long period (11daily hours). Such fact may have proportioned shortcoming into the root aeration system entailing production decrease and morphological variation in its root system, as illustrated in Figure 7. The root intense contact with the nutritional solution may cause obstacles to the root oxygenation and reduce in this way their production.

Fig. 7. *H. courbaril* seedlings roots. (A) Seedlings root submitted to the soil system. (B) Seedlings root submitted to the hydroponic system.

Santos et al. (2008) points out in their study with growth and development of seven native arboreal species, that species of slow growth, mainly the forestry, like the jatobá, present low response to the nutrient supply, characteristic, that may be completely related to the adaptation of low fertility soils.

Dry matter (from the aerial part and root) of H. courbaril plant seedlings

The dry matter production from the aerial part and of the jatobá's plants root system presented higher values in the soil system (Table 3), decreasing this production in hydroponic cultivation.

Gonzaga et al. (2016), in experiment for the jatobá's seedlings production in dystrophic red oxisol in Minas Gerais, found lower values than the observed in this study, in the soil cultivation, for the dry matter weight from the aerial part (4,6 g) and from the root (1,3 g) in jatobá seedlings, although the experiment has remained in field for 210 days. A fact that may have occurred due to climatic variations between the studied areas, the north region may have proportioned better edaphoclimatic conditions to the species.

Similar results to the observed in this experiment were obtained by Wallau et al. (2008a) in study with mahogany seedlings cultivated in nutritional solution, which obtained for the dry matter from the aerial part and seedlings root, weight of 4,3 and 0,86 g, respectively. Nascimento et al. (2014) studying the jatobá in nutritional solution got average of 19,5 and 10,5 g of dry matter production from the aerial part and of the root system, respectively in the 100 days. These values are superior to the observed in this research, and, possibly, may be related to the required macronutrients omission by the species like N, P and K that can compromisse the allocation and dry matter production in plants.

The dry matter production in the hydroponic system may have suffered influence by the excess water, provoking oxygenation process reduction in the plant roots, since for Caldeira et al. (2008) the aerial part formation and of the root system are directly related to a good drainage, aeration capacity, good water retention and substrate sufficient availability.

Macronutrients contents of the aerial part and H. courbaril plants root

Regarding to the nitrogen accumulation, in the different parts of the plants, the treatment that provided higher absorption of this nutrient by the jatobá's seedlings was the hydroponic system (Table 3). The N content in the aerial part and on the jatobá's plants root submitted to the hydroponic system presented contents of 22,38 and 23,27 $g.Kg^{-1}$, respectively.

Lower results were found by Vieira et al. (2014) in african mahogany seedling (*Khaya anthotheca*), where it was obtained on the aerial part a result of 19,69 $g.kg^{-1}$ and Vieira et al. (2011) in cherry seedlings (*Amburana acreana*), in which obtained 15,59 $g.kg^{-1}$ and 8,49 $g.kg^{-1}$ of N content on the aerial parts and radicular, being the cherry tree belonging to the same family as the species in study.

The N average content in the root system was higher than that found by Vieira et al. (2011), when observed the hydroponic system, that obtained average content of 23,27 g.Kg^{-1} in the complete solution. This can be explained, probably, by the fact of the nutritional solution present more concentration of mineral salts, since during the experiment setup, on the first week, it was visualized nutritional deficiency symptoms, making it necessary the addition of more nutrients.

The absorbed N contents by the jatobá's seedlings on the soil system corresponds to 16,05 g.Kg^{-1} on the aerial part and 12,37 g.Kg^{-1} on the root. Silva and Farnezi (2009) found approximate value to the observed in this study, when analyzed the cultivation in soil, presenting contents of 16,00 g.Kg^{-1} on the aerial part of soursop seedlings (*Annona muricata* L.) cultivated in Distroferric Red Oxisol. A similar result to this study was acquired by Guedes et al. (2011) evaluating the early development and the mineral composition of copaiba seedlings (*Copaifera langsdorffii* Desf.) cultivated in Yellow Oxisol under the missing nutrient technique. These authors found 10,09 g.Kg^{-1} of N on the seedlings root.

According to the obtained data in this study, it was observed that the highest N contents were found in the hydroponic system. One of the explanations may have been due to the nutrient be readily supplied to the vegetable in this system, what differs it from the soil system, in this system the mineralization of nitrogen compounds by soil microorganism is observed. However, by the difficulty offered for the most resistant forms and that constitute the reservoir's larger fraction, only a fraction becomes available to the plant. The microorganism activity presented on the soil that decomposes vegetable remains and animal turning into organic matter requires nitrogen assimilation, that may lead to a microorganism competition with the plants by the studied nutrient (Gallo, 2018).

Phosphorus (P)

The highest phosphorus contents absorbed by the jatobá seedlings was proportionated by the hydroponic system (Table 3). The value of phosphorus content present on the soil, according to the chemical analysis (Table 2), was 0,33 g.Kg^{-1} ,being within the phosphorus range on the soils, that comprehends from 0,2 to 5,0 g.Kg^{-1}, however for Braga (2009), even though some soils present a big phosphorus quantity, only a small phosphorus fraction is found in available forms to the plants development, being the release of this nutrient controlled by several factors like nutrient availability, organic matter mineralization and microbial activity.

The soil-plant interaction may have caused lower absorption of this nutrient by the jatobá plants cultivated in soil,because, the phosphorus low mobility and its high affinity for iron oxides and aluminum make the soil a "plant competitor" reducing its availability to the plants (Sandim et al., 2008).

In relation to the phosphorus average content from the jatobá seedlings aerial part, Souza et al. (2010) in mahogany seedling cultivation (*Swietenia macrophylla* King.) in Distroferric Yellow Oxisol with low nutrient contents found on the plants aerial part, phosphorus average content of 0,60 g. g.Kg^{-1}, obtaining lower value than the observed in this study on the soil system. Similar behavior to the observed at the present research was obtained by Guedes et al. (2011), in *Copaifera langsdorffii* and by Valencia et al. (2010) in rosewood (*Aniba rosaeodora* Ducke), in which they obtained, respectively, phosphorus contents on the aerial part of 1,05 g.Kg^{-1} and 1,02 g.Kg^{-1}cultivated in soil.

Regarding to the phosphorus absorbed content by the roots of jatobá's culture, Guedes et al. (2011), obtained, for the species Copaifera langsdorffii, lower value than that obtained in this research, content of 0,41 g.Kg^{-1} in Yellow Oxisol of low fertility, being similar only to the treatment in which the authors performed fertilization and liming on the soil, in which they obtained phosphorus content of 0,99 g.Kg^{-1} on the seedlings root of this species.

The absorbed P content by the plants was 2,07 g.Kg^{-1} on the soil system, this value is superior to the P content present in soil, that was 0,33 g.Kg^{-1}, this may have occurred due to the jatobá seeds have a reserve of various nutrients such as calcium, potassium, magnesium, among them the main, the phosphorus (Branco, 2016).

A research developed by Carlos et al. (2014) corroborate with the obtained results in this study, where these authors studying the pequi species (*Caryocar brasiliense* Camb.) got a low nutritional requirement during the seedlings formation process, that, according to them, can be related to the reserves contained on the seeds.

In the hydroponic system the phosphorus content was 3,61 and 3,81 g.Kg^{-1}, respectively, on the aerial part dry matter and from the root, being higher to the soil system. Such fact can be explained, probably, by the nutritional solution, once in this system doesn't occur the competition between plant and the soil, because, knowing that this one has the ability to immobilize some nutrients according to its valency and moisture, besides of the microorganisms presence. In the hydroponic system the nutrients are provided to the plants directly to the roots through balanced nutritional solution, seeking in this way to meet the plants needs (Oliveira, 2015).

Diverging from the results found in this study, Vieira et al. (2011) studying the forest species nutrition, obtained for the cherry tree high phosphorus content on the root of 4,35 g.Kg^{-1}, a plant also pertaining to the Fabaceae family. Willau et al. (2008b) in experiment with nutrient omission in brazilian mahogany, cultivated in nutritional solution obtained phosphorus contents similar to those found in this research, obtaining values of 2,96 g.Kg^{-1} on the aerial part and of 3,87 g.Kg^{-1} on the plants root.

Potassium (K)

The potassium content absorbed by the jatobá plants were similar to both systems tested both in the aerial part and on the seedlings root, as it shows the Table 3.

In the soil system the K content found on the aerial part was 5,28 g.kg^{-1} and on the seedlings root was 8,18 g.kg^{-1}. Studies performed by Carlos et al. (personal communication) on the aerial part of pequi seedlings in Minas Gerais, resemble to those obtained in this study, presenting values of 5,8 g.Kg^{-1}.

Smiderle et al (2017) evaluating the Sweet cedar (*Pochota fendleri*) in nutritional solution, obtained lower value on the seedlings aerial part (3,8 g.Kg^{-1}) than the observed in this research. In relation to the nutritional content on the jatobá seedlings root, it was obtained a content of 8,18 g.Kg^{-1}, being higher to those gotten by Guedes et al. (2011) on copaíba seedlings where the authors found a content of 2,8 g.Kg^{-1} on the seedlings root. For Prado (2018) soils with high magnesium content and calcium can reduce the potassium availability to the plants. In the study research, it was observed that the potassium content on the root was superior, probably, by the fact that the calcium contents and magnesium of the soil system is at average levels, however these average values don't unavailable potassium by the jatobá plants.

In the hydroponic system the potassium content found on the aerial part was 7,41 g.kg^{-1} and on the seedlings root was 6,76 g.kg^{-1}. Inocêncio et al (2014) studying forestry species nutrition in nutritional solution obtained K content of 15,05 and 16,79 g.Kg^{-1} on the aerial part and pigweed seedlings (*Sesbania virgata*), respectively. These results are numerically higher to the observed in the present research and, probably, are related to the plant faster development, because the experiment was conducted by a period of 50 days, while the research lasted 111 days.

Conclusion

The nutritional solution used in the experiment evidenced symptoms of nutritional deficiency in the plants during all the search execution time, suggesting that the used concentrations aren't still sufficient to the species normal development, observing the climate conditions of the city in study.

The studied period proportioned the best seedling development in the cultivation with the soil system. Whereas the hydroponic system was the one that better proportioned the N and P macronutrient absorption, nevertheless it didn't present Potassium absorption variation, since it was similar in the studied systems. Futhermore, the observation reduced time may have hidden the hydroponic system potentiality for the culture under discussion.

In this way, it is emphasized about the relevance of new researches that seek to elucidate: better dosages to be used to the jatobá culture; Higher observation period so that it can be confirmed or refuted the hypothesis that the hydroponic system can be a potential for the seedlings production of the culture under discussion; and studies focused on the nutritional solution temperature measurement, besides of the researches with different forms or its aeration time.

Conflict of interest: All authors declare no conflict of interest.

References

Coradin, L.; Camillo, J.; Pareyn, F. G. Espécies nativas da flora brasileira de valor econômico atual ou potencial: plantas para o futuro: região Nordeste [recurso eletrônico]. Ministério do Meio Ambiente, Secretaria de Biodiversidade. – Brasília, DF: MMA, 2018. 1311 p.: il. (algumas color.); gráficos; (Série Biodiversidade; 51) ISBN 978-85-7738-383-2 (online). Disponível em:<http://www.mma.gov.br/publicacoes/biodiversidade/category/142-seriebiodiversidade.html> Acessado em 19 de Março de 2019.

Barbosa, J. G.; Martinez, H. E.P.; Kampf, A. N. 1999. Acúmulo de macronutrientes em plantas de crisântero sob cultivo hidropônico em argila expandida para flor-de-corte. Pesquisa Agropecuária Brasileira. Brasília 34(4): 593-601

Braga, G. N. 2009. O Fósforo no Solo e a Solubilidade dos Fosfatos. Disponível em:https://agronomiacomgismonti.blogspot.com/2009/11/o-fosforo-no-solo-e-eficiencia.html. Acessado em 15 de Julho de 2018.

Branco, A. Jatobá: árvore nativa, medicinal. Uso da casca e das sementes. 2016 (enviado em: 30/12/2016). Disponível em: <https://www.greenme.com.br /remedios-caseiros/4519-jatoba-arvore-nativa-medicinal-uso-da-casca-e-das-sementes>. Acessado em 15 de Julho de 2018.

Cabral, E. M.; Castilho, R.M.; Pagliarini, M. K. 2015. Germinação de sementes e desenvolvimento de mudas de Jatobá (*Hymeneae courbaril* L. var. Stilbocarpa). Revista Eletrônica Thesis 23: 16-28

Caldeira, M.V.; Blumb, H.; Balbinotc, R.; Lombardid, K.C. 2008. Uso do resíduo de algodão no substrato para produção de mudas florestais. Revista Acadêmica, Ciência. Agrária Ambiental Curitiba 6(2): 191-202

Carlos, l.; Venturin, N.; Macedo, R. L. G.; Higashikawa, E. M.; Garcia, M. B.; Farias, E. S. 2014. Crescimento e nutrição mineral de mudas de pequi sob efeito da omissão de nutrientes. Ciência Florestal, 24 (1): 13-21. DOI: http://dx.doi.org/10.5902/1980509813318

Costa, C.B. 2015. Boas Práticas de Manejo para o Extrativismo Sustentável do Jatobá– Brasília: Instituto Sociedade, População e Natureza. 76 p

EMBRAPA – Empresa Brasileira de Pesquisa Agropecuária. Manual de métodos de análise de solos. 2011. Rio de Janeiro: Embrapa Solos, (2): 230

EMBRAPA – Empresa Brasileira de Pesquisa Agropecuária. 2009. Manual de análises químicas de solos, plantas e fertilizantes. Brasília: Embrapa informação Tecnológica (2): 627

Gallo, L.A. 2018. O nitrogênio e o ciclo do nitrogênio. Disponível em:http://docentes.esalq.usp.br/luagallo/metnitrogenio.html. Acessado em 20 de Julho de 2018

Genuncio, G.C.; Zonta, E. ; Nascimento, E.C. 2014. Monitoramento do pH, da temperatura e da oxigenação da solução nutritiva (enviada em: 15/12/14). Disponível em: http://www.revistacampoenegocios.com.br/monitoramento-do-ph-da-temperatura-e-da-oxigenacao-da-solucao-nutritiva. Acessado em 15 de julho de 18

Gonzaga, L. M.; Silva, S.S.; Campos, S.A.; Cunha, A. C. 2016. Recipientes e substratos para a produção de mudas de Jatobá (*Hymenaea courbaril* l.) Revista Brasileira de Agropecuária Sustentável (RBAS) 6(1): 64-73

Guedes, M. G. M.; Silva Júnior, M. L. Da; Silva, G. R. Da; Silva, A. L. P. Da; Lima Júnior, J. A. 2011. Efeito da adubação nitrogenada na produção de mudas de andiroba (*Carapa guianensis* Aubl.). Enciclopédia Biosfera. Goiânia, 7 (12)

He, J.; Lee, S. K. 1998. Growth and photosynthetic characteristies of lettuce (*Lactuna sativa* L.) under fluctuation hot ambient temperatures with the manipulation of cool root-zone temperature. Journal of Plant Physiology. Stuttgart 152: 387-391

INSTITUTO NACIONAL DE METEREOLOGIA (INMET). 2012. Boletim Agroclimatológico

INSTITUTO NACIONAL DE METEREOLOGIA (INMET). 2013. Boletim Agroclimatológico

Inocencio, M. F.; Carvalho, J.G.; Furtini, A.E. 2014. Potássio, sódio e crescimento inicial de espécies florestais sob substituição de potássio por sódio. Revista Árvore 38(1): 113-123

Lazia, B. Algumas vantagens e desvantagens do sistema hidropônico. 2012. (Enviado em: 24/05/12) http://www.portalagropecuario.com.br/agricultura/hidroponia/algumas-vantagens-e-desvantagens-do-sistema-hidroponico/. Acessado em 16 de Julho de 2018

Matheus, M.T.; Amaral, J.A.; Pizzol, E. C.; Sousa, F.C.; Santi, G.C.; Guariz, H. R.; Lima, K.A.; Hoffmann, R. G. 2011. Sintomas de deficiência nutricional em plantas de jatobá. Revista Científica Eletrônica de Engenharia Florestal - Garça, SP 17 (1)

Nascimento, H. C.; Pacheco, C. M.; Lima, D. R.; Silva, E. C.; Nogueira, R. J. 2014. Aspectos ecofisiológicos de mudas de *Hymenaea courbaril* L. em resposta a supressão de N, P e K. Scientia Forestalis, Piracicaba, 42 (103): 315-328

Neto, E.B.; Barreto, L.P. 2012. As técnicas de hidroponia. Universidade Federal Rural de Pernambuco, Recife, PE. Anais da Academia Pernambucana de Ciência Agronômica 9:107-137

Oliveira, L. E. Soluções Nutritivas. 2015. Disponível em: < http://www.ledson.ufla.br/nutricao-e-metabolismo-mineral/solucoes-nutritivas/> Acessado em 19 de Março de 2019.

Prado, H. 2018. Solos e ambientes de produção para o agricultor. Disponível em: http://www.pedologiafacil.com.br/artig_7.php. Acessado em 17 de julho de 18

Sandim, A.; Vian, J. D.; Silva, A. R. B.; Camili, E. C.; Silva, P. R. A.; Mongelo, A. I. 2008. Avaliação de altura de plantas e número de gemas por metro da cultivar RB 83-5486 d cana-de-açúcar (*Saccharum officiarum*) em diferentes fontes fosfotadas na adubação de base em Campo Grande – MS. In: FERTBIO: Desafios para o uso do solo com eficiência e qualidade ambiental, Londrina-PR, 2008

Santos, J.Z.; Resende, A. V.; Neto, A, E.; Corte, E.F. 2008. Crescimento, acúmulo de fósforo e frações fosfatadas em mudas de sete espécies arbóreas nativas. Revista Árvore, Viçosa, MG, 32(5). http://dx.doi.org/10.1590/S0100-67622008000500003

Silva, E. de B.; Farnezi, M. M. de M. 2009. Limitações nutricionais para o crescimento de mudas de graviola em casa de vegetação em Latossolo Vermelho distrófico do norte de Minas Gerais. Bioscience Journal. Uberlândia 25(6) 52-58

Smiderle, O. J.; Souza, A.G.; Pedrozo, C.; Lima, C. G. 2017. Nutrient solution and substrates for ‘cedro doce’ (Pochota fendleri) seedling production. Revista Brasileira de Engenharia Agrícola e Ambiental Campina Grande, PB, 21(4):227-231. http://dx.doi.org/10.1590/1807-1929/agriambi.v21n4p227-231

Souza C.A.; Tucci, C. A.; Silva, J. F.; Ribeiro, W.O. 2010. Exigências nutricionais e crescimento de plantas de mogno (*Swietenia macrophylla* King.). Acta Amazônica 40(3): 515 – 522

Valencia, W. H.; Sampaio, P. De T. B.; Souza, L. A. G. 2010. Crescimento inicial de Palo de Rosa (*Aniba rosaeodora* Ducke) em distintos ambientes de fertilidade. Acta Amazônica 40 (4): 693-698

Vieira, C. R.; Weber, O. L.; Scaramuzza, J. F.; Costa, A. C.; Souza, T. R. 2011.Descrição de sintomas visuais em função das Deficiências de macronutrientes em mudas de Cerejeira (*Amburana acreana*). Floresta, 41(4): 789-796

Vieira, C. R.; Weber, O. L.; Scaramuzza, J. F. 2014. Omissão de macronutrientes no desenvolvimento de mudas de mogno africano. Ecologia e Nutrição Florestal, Santa Maria-RS 2(3): 72-83

Wallau, R. L.; Borges, A.R.; Almeida, D.R.; Camargos, S. L. 2008. Sintomas de deficiências nutricionais em mudas de mogno cultivadas em solução nutritiva. Cerne, Lavras 14 (4): 304-310

Wallau, R. L. R. de; Soares, A. de P.; Camargos, S. L. 2008. Concentração e acúmulo de macronutrientes em mudas de mogno cultivadas em solução nutritiva. Revista de Ciências Agro-Ambientais. Alta Floresta 6(1): 1- 12

Cite this article as:

Da Silva, S.A.S.; Braz, E.N.; Araújo Júnior, P.V.; Leão, F.B.; dos Santos, D.R.S.; da Silva R.O. 2019. Development of *Hymenaea courbaril* L. (Fabaceae) seedlings in hydroponic and soil system. **Amaz. Jour. of Plant Resear.** 3(3): 353-362.

Submit your manuscript at
https:// www.ajpr.online