

Nutrition and accumulation of nutrients in *Pochota fendleri* seedlings

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ABSTRACT: The economic importance of mahogany highlights the importance of morphometric analyzes of seedlings and the nutritional status for the training of seedlings quality. It was intended in this work to investigate the effects of the addition or not of nutrient solution in different substrates on the quality of *Pochota fendleri* seedlings grown for 60 days as well as the accumulation of macro and micronutrients. The experimental design was the completely randomized in a 4 x 2 factorial scheme with five replications. Each plot was made up of five seedlings. The studied factors were: four mixtures of substrates and addition or not of nutrient solution: (T1) = sand; (T2) = soil; (T3) = soil + sand; (T4) = sand + soil + ground Brazil nut fruit treatments are eight: shell; (T1) = sand + nutrient solution; (T2) = soil + nutrient solution; (T3) = soil + sand + nutrient solution; (T4) = sand + soil + Brazil nut fruit shell + nutrient solution. Growth traits (height, stem diameter and shoot and root dry mass) and quality parameters of seedlings (shoot dry mass/root dry mass ratio, total dry mass and Dickson quality index) were evaluated. *Pochota fendleri* seedlings with addition of nutrient solution present growth and quality independent of the substrate. The following nutritional requirement of the *Pochota fendleri* seedlings to the three substrates with nutrient solution addition follows the descending order for the macronutrients (N > Ca > K > Mg > P > S) and micronutrients (Fe > Mn > B > Zn > Cu).

Key words: Dickson quality index; nutrient solution; propagation

Nutrição e acúmulo de nutrientes em mudas de *Pochota fendleri*

RESUMO: A importância econômica da *Pochota fendleri* ressalta a relevância das análises morfométricas dos seedlings e o status nutricional visando à formação de mudas com qualidade. Objetivou-se neste trabalho analisar os efeitos da adição ou não de solução nutritiva em diferentes substratos na qualidade de mudas de *Pochota fendleri* cultivadas por 60 dias e o acúmulo de macro e micronutrientes. O delineamento experimental utilizado foi o inteiramente casualizado em esquema fatorial 4 x 2 com cinco repetições. Cada parcela foi composta por cinco plantas. Os fatores estudados foram: quatro misturas de substratos e adição ou não de solução nutritiva, constituindo oito tratamentos: ((T1) = areia; (T2) = solo; (T3) = solo + areia (1:1); (T4) = areia + solo + casca de ouriço da castanha do Brasil triturada (1:1:1)); ((T5) = areia + solução nutritiva; (T6) = solo + solução nutritiva; (T7) = solo + areia + solução nutritiva; (T8) = areia + solo + casca de ouriço da castanha do Brasil + solução nutritiva). Foram avaliadas características de crescimento (altura, diâmetro de caule e massa seca da parte aérea e radicular) e parâmetros de qualidade de mudas (relação massa seca da parte aérea/massa seca de raiz, massa seca total e índice de qualidade Dickson). Mudas de *Pochota fendleri* com adição de solução nutritiva apresentam melhor crescimento e qualidade independentes do substrato. A seguinte exigência nutricional das plântulas de *Pochota fendleri* aos três substratos com adição de solução nutritiva segue a ordem decrescente para os macronutrientes (N > Ca > K > Mg > P > S) e micronutrientes (Fe > Mn > B > Zn > Cu).

Palavras-chave: índice de qualidade Dickson; solução nutritiva; propagação

Introduction

In Brazil, the silvicultural studies have turned, almost exclusively, to the exotic fast-growing species, as for instance, those of the genus *Eucalyptus* and *Pinus*. However, other species, mainly the native ones, must be studied aiming at increased diversification concerning forest production (Reis et al., 2016). A species which has proved quite promising for that purpose is the pochote *Pochota fendleri* (Seem.) W. S. Alverson & M. C. Duarte belonging to the family Malvaceae, usually known as red ceiba, prickly ceiba, red ceiba or pachote (Halfeld-Vieira et al., 2007; Carvalho Sobrinho & Queiroz, 2011; Alvarado, 2012).

Found in the deciduous forests of Central America, widely distributed in low tropical zones, both in dry and wet climates. That species presents fast growth, reaching eight-meter-tall and 15 cm in diameter at three years of age (Rojas Rodríguez & Murillo Gamboa, 2004), providing, thus, good financial return in a short period of time when compared with other forest essences, inclusive mahogany (*Swietenia macrophylla* king, Meliaceae).

The species is used as shade and shelter for livestock, the implantation of live fences, the manufacture of handicrafts and the recovery of degraded areas, as well as the use of wood for the production of agglomerated boards, plates, panels, doors, windows and furniture. In Brazil, the species is native to Roraima, being also found in Honduras, Nicaragua, Costa Rica, Colombia and Venezuela. Despite the recognized importance of sweet cedar, studies aiming at obtaining information related to seedling production are scarce for the species.

The production of high quality *Pochota fendleri* seedlings like that of other species native to the North region is till a little studied subject. The characterization of the quality of the seedlings is one of the greatest problems found in nurseries for seedling production due to the high cost. That is due, in part, to the development time of the plants and consequently, greater expenses on inputs (defensives and fertilizers), labor and equipment (Oliveira et al., 2017). In this context, the practice of mineral fertilizing, in addition to constituting a factor indispensable to the development of seedlings, speeds markedly growth, reducing the production costs (Souza et al., 2011a).

According to Souza et al. (2015) soilless culture has proved most effective in the furnishing the nutrients necessary to the growth of plants in an adequate and constant way in order to obtain good plant growth. The production of *Pochota fendleri* seedlings in soilless culture can be a promising method with adequate nutritional status, both healthy and vigorous. So, studies related to the nutrition of seedlings produced in this system become indispensable in the establishment of new forest plantings with best growth and quality (Smiderle & Souza, 2016).

So, it was intended to survey the effect of the addition of nutrient solution in different substrates in the production of high quality seedlings of pochote (*Pochota fendleri*) with

the potential for commercial exploration as well as the accumulation of macro and micronutrients grown for 60 days.

Material and Methods

The work was conducted at Embrapa Roraima, utilizing the outbuildings of the Seed Analysis Laboratory and the seedling nursery of the Fruitculture Sector located on the BR 174, Km 8, Industrial District, under reference geographic coordinates 02°45'28"N and 60°43'54"W and 90 m of altitude. Boa Vista is situated in the Tropical Climate Zone, without there being not either extremely dry or monthly average temperature below 18 °C. According to Köppen the climate is wet tropical of the Am type: rainy, tropical climate, warm and wet, with rainy season in the summer, the driest month present rainfall inferior to 60 mm. The average rainfall is of 1.750 mm annual, air temperature of 26.7 °C and air relative humidity 79% (Smiderle & Souza, 2016).

The seeds for formation of the seedlings were from four populations coming from experimental area of pochote (*Pochota fendleri*) established in September of 2008, in the Serra da Prata Experimental Field belonging to Embrapa Roraima and situated in the municipality of Mucajaí (RR).

After mixing the substrates, according to each treatment, two seeds were sown in each bag of 17 cm in height and 12 cm in diameter containing two liters of substrate. After the seedlings averaged five centimeters in height, the thinning was performed, making them more vigorous. The plants were conveniently spaced and kept in a nursery with 50% shade programmed every six hours during the day and lasted six hours. The experimental design utilized was the completely randomized in factorial scheme 4 x 2 with five replications. Each plot was made up of five seedlings (one plant in each container). The factors under study were four mixtures of substrates and the addition or not of nutrient solution constituting eight treatments (Table 1).

The nutrient solution applied on the seedlings in two weekly watering was of 30 mL of the solution proposed Table 2 at the end of the last daily irrigation to avoid nutrient leaching.

The values of height of the seedlings were obtained by measuring with a millimeter-calibrated ruler from the ground level to the apical meristem whereas the collet diameter, the measures were taken with a digital pachymeter at the soil level in fortnightly intervals.

At 60 days after sowing, each seedling was divided into leaves, stem and root, they being washed in running water and placed into paper bag, remaining in drying oven at 60-65 °C, with air circulation till constant mass was obtained. Carried out the weighing of the dry mass of the parts of the seedlings, these ones were ground in a Willey type mill, sampled for the quantification of the contents of macro (N, P, K, Ca, Mg e S) and micronutrients (B, Cu, Fe, Mn e Zn), according to the methodologies described in Malavolta et al. (1997).

Table 1. Substrates analysis results used in the growth of *Pochota fendleri*.

Sub ⁽¹⁾	pH	Exchangeable complex ⁽²⁾								V %	P mg dm ⁻³	MO dag kg ⁻¹	
		Ca ²⁺	Mg ²⁺	K ⁺	Al ³⁺	H+Al	SB	t	T				
cmol _c dm ⁻³													
T1	6.3	0.0	0.00	0.00	0.0	0.00	0.00	2.9	0.00	67.0	0.00	0.00	
T2	6.2	0.16	0.00	8.70	0.0	1.00	1.36	3.1	1.23	52.0	1.32	4.30	
T3	6.1	0.62	0.10	34.0	0.0	1.00	1.71	3.3	3.68	49.4	4.82	18.43	
T4	6.0	0.30	0.10	9.8	0.0	1.00	1.52	3.4	2.90	62.7	1.96	16.24	
Sub		Micronutrients ⁽³⁾											
		Zn	Fe	Mn	Cu	B	S						
mg dm ⁻³													
T1		1.04	0.00	0.00	0.00	0.10	3.1						
T2		1.52	8.04	4.96	8.06	0.19	5.5						
T3		2.89	34.73	19.87	34.76	0.18	6.2						
T4		2.96	4.10	4.69	4.10	0.28	15.8						

*T1= sand; T2= soil; T3= soil + sand (1:1); (T4) = sand + soil + ground Brazil nut seed shell (1:1:1). ⁽²⁾ pH in water (1:2.5); Ca²⁺, Mg²⁺ e Al³⁺: extractant KCl 1 mol L⁻¹; K⁺ e P: extractant mehlich-1; H+Al: extractant SMP; M.O.: organic matter – oxidation Na₂Cr₂O₇, 4N + H₂SO₄, 10N; SB: sum of exchangeable bases; t: cation exchangeable capacity (CEC) effective; T: CTC a pH 7,0; V: base saturation index; m: aluminum saturation index. ⁽³⁾ Zn, Fe, Mn e Cu: extractant mehlich-1; B: hot water extractant; S: monocalcium phosphate extractant in acetic acid.

Table 2. Nutrient solution composition of the treatments used in the trial.

Solution	N-NO ₃ ⁻	N-NH ₄ ⁺	P	K	Ca	Mg	S	CE	[Ions]	Ionic strength
	mg L ⁻¹							Ds m ⁻¹	mmol L ⁻¹	
	174.0	24	39	183	142	38	52	1.74	26.92	21.94

The determination of the amount of nutrients accumulated was obtained by the product between the contents of nutrients and the dry mass of the quoted part and that of the total accumulation of the nutrients was by the summation of the accumulations in each part of the plant. And the quality of the seedlings was established according to the Dickson Quality Index (DQI) (Dickson et al., 1960), using the formula:

$$DQI = \frac{TDM(g)}{\frac{H(cm)}{SD(mm)} + \frac{SDM(g)}{RDM(g)}}$$

where:

- TDM - total dry matter;
H - shoot height;

- SD - stem diameter;
SDM - shoot dry matter; and,
RDM - root dry matter.

The data obtained for the different variables were submitted to the analyses of variance and the means were compared by the Tukey test at 5%, utilizing the statistical software Sisvar (Ferreira, 2011).

Results

The average values observed in Table 3 for the variables studied demonstrate that the application of nutrient solution on the different substrates enabled significant increase of the growth of the *Pochota fendleri* seedlings in relation to the treatments without the application of nutrient solution. Low growth means were observed in the sand substrate

Table 3. Average values for seedling *Pochota fendleri* of height (H, cm), stem diameter (SD, mm), root dry matter (RDM, g), shoot dry matter (SDM, g), ratio root dry matter/shoot dry matter (RD/SD), total dry matter (TDM, g) and Dickson quality index (DQI) in the layers of shading screen: double and single, obtained at 60 days after sowing.

Substrates	H	SD	SDM	RDM	RD/SD	TDM	DQI
Without application of nutrient solution							
T1 Sand (S)	11.2 c*	3.9 c	0.60 b	0.87 b	1.43 a	1.47 c	0.35 b
T2 Soil (So)	21.6 ab	5.7 b	2.28 a	2.46 a	1.04 b	4.74 ab	0.98 ab
T3 S+So	17.1 bc	5.2 bc	1.58 b	2.30 ab	1.45 a	3.88 bc	0.81 b
T4 S+So+O	30.2 a	7.5 a	4.30 a	3.16 a	0.72 c	7.46 a	1.60 a
With application of nutrient solution							
T1 Sand (S)	69.9 b	10.9 c	15.16 b	6.08 b	0.36 a	23.24 ab	3.59 a
T2 Soil (So)	72.7 b	12.0 b	17.26 a	7.47 a	0.46 a	24.73 a	3.68 a
T3 S+So	72.6 b	11.9 b	14.56 b	7.85 a	0.45 a	25.91 a	3.63 a
T4 S+So+O	75.5 a	13.7 a	18.06 a	7.70 a	0.55 a	21.60 bc	4.13 a
CV%	17.3	10.4	21.08	29.20	27.90	18.57	26.90

*In the column, distinct letters differ from one another by the Tukey test at the level of 5% of probability. *T1= sand; T2= soil; T3= soil + sand (1:1); (T4)= sand + soil + ground Brazil nut seed shell (1:1:1).

without fertilization of nutrient solution (treatment T1) for all the variables studied (Table 3).

The greatest diameter of the stem was induced by the application of nutrient solution into the substrate soil, which was also accompanied by highest height of the seedlings at 60 days after sowing (DAS). Although, it had not distinguished from treatments T1 (sand + nutrient solution), T2 (soil + nutrient solution), T3 (sand + soil + nutrient solution), it was found that the *Pochota fendleri* seedlings in the substrate of the treatment T4 (sand + soil+ round Brazil nut seed shell + nutrient solution) presented vigor superior to the other treatments. The greatest dry mass of the shoot was obtained by applying nutrient solution onto the substrate sand + soil, whereas for dry mass of the root, the greatest value was reached with T4. In the relationship dry mass of the shoot/ dry mass of roots, the lowest values obtained were with the application of nutrient solution (Table 3).

The positive results of the use of alternative components in the *Pochota fendleri* seedling production can be observed when analyzing Dickson quality index. For this index, the treatments T1 (sand + nutrient solution), T2 (soil + nutrient solution), T3 (sand + soil + nutrient solution) and T4 (sand + soil+ round Brazil nut seed shell + nutrient solution) presented no significant differences among the treatments. But compared with the seedlings of the treatments without application of nutrient solution (T1, T2, T3 and T4), provided DQI below the one observed in the treatments with application of nutrient solution, pointing out the importance of the application of the nutrient solution for the balanced growth of the *Pochota fendleri* at seedling phase. Because, the combination of these mixtures of substrates fertilized with nutrient solution provided greater accumulation of both macro and micronutrients in the shoot of *Pochota fendleri* seedlings (Table 4).

The accumulations of macro and micronutrients in leaves (Table 4) resulted into significant differences among the means of the treatments which were given no applications of nutrient solution compared with the treatments which were given applications. The average accumulation of N,

P and K in the shoot of *Pochota fendleri* seedlings ranged between 4.39; 0.80 and 4.45 (mg plant⁻¹) without application of nutrient solution at 10.96; 1.64 and 9.29 (mg plant⁻¹) with application of nutrient solution, respectively (Table 4).

That way, it was found that the results of the growth parameters, obtained in the seedlings were greater in the absence of the application of nutrient solution (T1, T2, T3 and T4) (Table 3), for not having the adequate nutrient supply (Table 4). So, the availability of some nutrients of the seedlings was endangered. However, positive effect of nutrient uptake in the treatments T1 (sand + nutrient solution), T2 (soil + nutrient solution), T3 (sand + soil + nutrient solution) and T4 (sand + soil+ round Brazil nut seed shell + nutrient solution) upon the growth and quality of *Pochota fendleri* seedlings when analyzing the Dickson quality index was found which points out high nutrient translocation from roots to shoot (Tables 3, 4 and 5).

It was found for the nutrients N, Ca, Mg, S, B and Mn in the root system that there were no significant differences among the means of the treatments either with or without application of nutrient pointing out low levels of translocation of the nutrients in the seedlings which were not given nutrient solution due to the solution, due to the high nutrient requirement in the shoot of the *Pochota fendleri* seedlings (Table 5).

In Table 6 the decreasing sequence of nutrient requirement by the *Pochota fendleri* seedling is established in the different substrates with and without the application of nutrient solution.

However, alteration in the dynamics of the nutrient uptake by the seedlings with the application or not of nutrient solution was noticed, which stands out the influence of the nutrient solution in the nutrient uptake dynamics by *Pochota fendleri* seedlings.

Discussion

The seedlings cultivated without the application of nutrient solution presented less growth, which resulted into

Table 4. Average values of accumulation of macro and micronutrients in aerea part determined in seedlings of *Pochota fendleri* at 60 days with and without application of nutrient solution under different substrates.

Substrates	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
	(mg plant ⁻¹)										
With application of nutrient solution											
T1 Sand(S)	10.65 bc	1.83 a	9.53 a	8.81 b	3.36 a	0.72 b	24.13 b	3.43 c	154.1 a	47.63 b	16.36 a
T2 Soil (So)	12.89 a	1.46 b	9.4 a	9.39 b	2.58 b	0.93 a	31.48 b	4.64 b	141.57 ab	60.15 a	12.46 b
T3 S+So	11.39 ab	1.60 ab	8.57 a	11.35 a	2.86 ab	0.68 b	47.55 a	3.54 c	131.96 b	47.57 b	12.22 b
T4 S+So+O	8.93 c	1.68 ab	9.67 a	9.02 b	1.72 c	0.65 b	44.15 a	6.01 a	74.95 c	26.84 c	11.71 b
Mean	10.96 A	1.64 A	9.29 A	9.66 A	2.63 A	0.75 A	36.93 A	4.4 A	125.64 A	45.55 A	13.19 A
Without application of nutrient solution											
T1 Sand(S)	3.67 b	0.60 b	2.55 c	3.62 b	0.86 a	0.25 b	12.77 b	2.45 a	10.13 b	12.73 b	5.83 a
T2 Soil(So)	4.01 ab	0.81 ab	4.96 b	5.86 a	1.32 a	0.29 ab	18.69 ab	2.91 a	57.37 a	22.36 a	8.06 a
T3 S+So	3.85 b	0.85 ab	3.28 bc	4.38 ab	0.91 a	0.31 ab	18.26 ab	3.29 a	43.09 a	15.28 ab	6.16 a
T4 S+So+O	6.04 a	0.95 a	7.04 a	4.33 ab	1.5 a	0.49 a	24.61 a	2.68 a	49.34 a	19.79 ab	7.95 a
Mean	4.39 B	0.8 B	4.45 B	4.55 B	1.15 B	0.33 B	18.58 B	2.84 B	39.98 B	17.54 B	7 B
C.V.%	14.5	13.7	12.6	12.4	18.7	19.5	20.1	13.9	13.3	13.4	14.7

In the column, distinct letters differ from one another by the Tukey test at the level of 5% of probability. *T1= sand; T2= soil; T3= soil + sand (1:1); (T4)= sand + soil + ground Brazil nut seed shell (1:1:1).

Table 5. Average values of accumulation of macro and micronutrients root system determined in seedlings of *Pochota fendleri* at 60 days with and without application of nutrient solution under different substrates.

Substrates	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
	(mg plant ⁻¹)										
With application of nutrient solution											
T1 Sand(S)	2.44 b*	0.82 ab	2.76 b	0.88 c	0.85 a	0.23 b	11.23 c	3.44 a	65.13 c	43.35 c	7.36 b
T2 Soil(So)	2.15 b	0.70 b	3.35 b	1.34 bc	1.09 ab	0.62 a	12.99 ab	4.44 a	328.59 a	93.45 b	22.24 a
T3 S+So	1.88 b	0.73 ab	2.54 b	1.46 ab	0.92 ab	0.72 a	7.28 c	4.66 a	197.20 b	84.28 b	17.20 a
T4 S+So+O	4.57 a	1.03 a	8.98 a	1.95 a	1.26 a	0.92 a	17.51 a	6.18 a	229.74 a	141.12 a	16.34 a
Mean	2.76 A	0.82 A	4.41 A	1.41 A	1.03 B	0.62 A	12.25 A	4.68 B	205.17 B	90.55 A	15.78 B
Without application of nutrient solution											
T1 Sand(S)	2.74 ab	0.57 a	3.42 a	1.44 a	1.17 b	0.62 b	11.14 b	10.80 b	291.19 b	75.23 b	15.87 b
T2 Soil (So)	2.41 b	0.52 a	3.04 a	1.28 a	1.36 ab	0.64 b	13.15 ab	13.92 b	344.49 ab	81.99 a	18.07 b
T3 S+So	2.45 b	0.49 a	2.58 ab	1.38 a	0.99 b	0.69 b	11.24 ab	13.18 b	319.71 b	76.97 b	19.07 b
T4 S+So+O	3.67 a	0.73 a	0.38 b	1.69 a	1.47 a	1.03 a	16.42 a	20.32 a	459.01 a	160.65 c	33.46 a
Mean	2.82 A	0.58 B	2.36 B	1.45 A	1.25 A	0.74 A	12.99 A	14.55 A	353.60 A	98.71 A	21.62 A
C.V.%	19.5	24.0	36.1	18.8	18.6	24.6	21.0	26.3	23.2	24.7	20.7

*In the column means followed by distinct small letters among substrates and capital among fertilization differ from one another at 5% of probability by the Tukey test. *T1= sand; T2= soil; T3= soil + sand (1:1); (T4)= sand + soil + ground Brazil nut seed shell (1:1:1).

Table 6. Decreasing order of leaf macronutrient content (mg plant⁻¹) and micronutrients (mg plant⁻¹) obtained from seedlings of *Pochota fendleri* with and without application of nutrient solution. analyzed 60 days.

Treatments*	Macronutrients	Micronutrients
T1* (Without nutrient solution)	N>Ca>K>Mg>P>S	B>Mn>Fe>Zn>Cu
T2 (Without nutrient solution)	Ca>K>N>Mg>P>S	Fe>Mn>B>Zn>Cu
T3 (Without nutrient solution)	Ca>N>K>Mg>P>S	Fe>B>Mn>Zn>Cu
T4 (Without nutrient solution)	K>N>Ca>Mg>P>S	Fe>B>Mn>Zn>Cu
T1 (With nutrient solution)	N>K> Ca>Mg>P>S	Fe>Mn>B>Zn>Cu
T2 (With nutrient solution)	N>K>Ca>Mg>P>S	Fe>Mn>B>Zn>Cu
T3 (With nutrient solution)	N>K>Ca>Mg>P>S	Fe>Mn>B>Zn>Cu
T4 (With nutrient solution)	N>K>Ca>Mg>P>S	Fe>Mn>B>Zn>Cu

*T1 = sand; T2 = soil; T3 = soil + sand 1:1; T4 = sand + soil + ground Brazil nut seed shell 1:1:1; with and without application of nutrient solution.

less amount of dry mass both of the shoot and of the root. The opposite was observed when there was application of nutrient solution highlighting the importance of the addition of nutrient solution for the balanced growth of *Pochota fendleri* in the seedling period.

Regarding the growth of the seedlings, the best results were obtained by Silva et al. (2013) in the growth of *Pochota fendleri* seedlings grown under nursery conditions in 180 cm³ polyethylene tubular containers, under two correction levels of the substrate with dolomitic limestone and five doses of potassium cover, by foliar route were obtained at 57 days after the planting, with the control treatment with average growth of 10.9 cm and diameter 3.73 mm. However, the values of these variables were below the ideal limit proposed by Reis et al. (2016) for native forest species, 20 to 35 cm in height and 5 to 10 mm in diameter. Thus, the nutrient solution used in the present study can be considered as an efficient strategy to promote the production of seedlings of *Pochota fendleri* of high quality and in short time.

The data obtained in this work corroborate Souza et al. (2011a) and Souza et al. (2011b), Who working with rootstocks of '*Pyrus ssp*' and *Prunus persica*, utilizing the same nutrient solution of the present study, obtained excellent growth of seedlings at 77 days, with height and average diameter at 10 cm from soil of 45.16 cm; 5.0 mm and 78.67 cm; 6.0 mm, respectively. According to Smiderle

et al. (2017) possibly that anticipation in seedling formation is allied to the environment more favorable obtained inside the greenhouse due to the availability of water and nutrients, allowing that the seedlings present faster growth, shortening the production cycle, increasing yield, even if the gains range from a crop to another.

Results found in the literature utilizing the same nutrient solution of the present study in rootstocks of *Citrus limonia* L. Osbeck, by Souza et al. (2013a), obtained superior growth when compared with the traditional system in the seedling production, justifying the importance of the application of nutrient solution for seedling development.

Souza et al. (2013b) evaluating the initial growth and the quality of golden shower tree seedlings due to doses combined of N and P, obtained greater values of DQI (1.98) when utilizing 125.16 mg kg⁻¹ of P₂O₅. However, Freitas et al. (2013) found greater DQI (3.1) in pinheira seedlings (*Annona squamosa* L. Annonaceae) at the dose estimated of 10.5 mL dm⁻³ (143.16 mg P seedling⁻¹) of the commercial product Cosmofert®.

The Dickson quality index (DQI) is pointed out as a good indicator of the quality of seedlings from taking into consideration for its calculation the robustness and the balance of the distribution of the biomass, being balanced several important characteristics (Smiderle et al., 2016; Alves et al., 2016), the higher the DQI, the better the quality of the

seedling produced is. So, the positive increments reached with the addition of nutrient solution demonstrated that nutrition in *Pochota fendleri* seedlings interferes directly and positively in their quality.

According to Malavolta et al. (1997), the concentrations of N accumulation in the shoot considered adequate for the forest essences range from 10 a 25 mg plant⁻¹. The treatments T1, T2 and T3 stayed within that range. The accumulation of P the shoot considered adequate for the forest essences are in the range of 1.0 to 3.0 mg plant⁻¹ (Malavolta et al., 1997). Therefore, in the present study the seedlings of the treatments T1 (sand + nutrient solution), T2 (soil + nutrient solution), T3 (sand + soil + nutrient solution) and T4 (sand + soil+ round Brazil nut seed shell + nutrient solution) presented accumulation of shoot within the range proposed by Malavolta et al. (1997), demonstrating the importance for the species in the seedling phase.

According to Marles (2017), the adequate leaf accumulations of K in forest species range between 2 to 18.5 mg plant⁻¹, corroborating with the present study. According to Malavolta et al. (1997) leaf Ca accumulation between 3.0 and 15.0 mg plant⁻¹ are considered adequate to the forest essences. Therefore, in all the treatments, adequate accumulation of that nutrient at 60 days in the cultivated seedlings were found. According to Vliet & Giller (2017) and Malavolta et al. (1997) the adequate range of leaf Mg accumulations is between 1.0 and 5.0 mg plant⁻¹, therefore, in all the treatments of the present study the accumulation observed were in the range considered adequate, except for T1 and T3 without nutrient solution.

Evaluating the accumulations in the shoot of micronutrients, according to Dechen & Nachtigall (2006), for boron the adequate level of the nutrient for forest species ranges from 12 to 50 mg kg⁻¹, range found in the treatments (Table 4).

Silveira et al. (2005), studying the nutrition of different species of *Eucalyptus* sp., reported that adequate values of Zn in the leaf tissue ranged between 10 and 25 mg plant⁻¹ having all the seedlings within this range. For Dechen & Nachtigall (2006), the variability of the leaf iron content in plants can occur between 10 and 1.500 mg plant⁻¹, considering accumulation adequate to the good growth of plants those occurring between 50 and 100 mg plant⁻¹ therefore, both treatments presented high contents of iron.

Freiberger et al. (2013) evaluating the effect of accumulation of nutrients in seedlings of *Cedrela fissilis* (Meliaceae) in the initial growth, obtained accumulation of shoot of 23.75; 1.274; and 12.35 mg plant⁻¹ for B, Fe and Zn, respectively, these data being corroborated by those obtained in the current study, except for the nutrient Fe.

The results of the present work disagreed from those obtained by Trazzi et al. (2014) who obtained the following decreasing order of the macronutrients Ca>N>Mg>K>P>S and micronutrients Zn >Fe >Mn >B >Cu, in the growth of seedlings of *Tectona grandis* (Lamiaceae) in organic substrates, which can be explained by the four factors described by Peticila et al.

(2017) which influenced both the content and accumulation of nutrients absorbed by the species, namely: the total need of nutrients, the development and growth velocity, the use efficiency of nutrients in the metabolic processes and adsorption capacity of nutrients to the substrate.

Conclusions

The use of nutritive solutions promotes the reduction in the time to obtain the seedlings of *Pochota fendleri* and is highly important in the growth and quality of the seedlings.

The following nutritional requirement of the *Pochota fendleri* seedlings to the three substrates with nutrient solution addition follows the descending order for the macronutrients (N> Ca> K> Mg> P> S) and micronutrients (Fe> Mn> B> Zn> Cu)

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