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MACRONUTRIENT UPTAKE, TRANSPORT AND USE EFFICIENCY IN SEEDLINGS OF *Pochota fendleri* PRODUCED IN DIFFERENT SUBSTRATES

EFICIÊNCIA DE ABSORÇÃO, TRANSPORTE E UTILIZAÇÃO DE MACRONUTRIENTES POR MUDAS DE Pochota fendleri PRODUZIDAS EM DIFERENTES SUBSTRATOS

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ABSTRACT: Seedlings produced in containers can be influenced by the materials used in the substrate, which affects the robustness of the plants and, indirectly, the time required for transplanting and for the plants to become established in the field. The aim of this study was to determine the chemical properties of different materials and on the absorption of macronutrients in *Pochota fendleri* seedlings (cedro-doce). The treatments were: sand (Sa), soil (So), sand+soil (Sa+So), and sand+soil+crushed Brazil nut capsules (Sa+So+CNC). The growth and macronutrient content were evaluated at 60 days after thinning. The amount of macronutrients in the substrate increased with the addition of crushed Brazil nut capsules. The use of different materials for the substrate, particularly Sa+So+CNC, had a positive influence on the morphological characteristics of seedlings, which ensuring high rates of establishment and survival after outplanting, making commercial reforestation with *Pochota fendleri* attractive.

KEYWORDS: Mineral nutrition. Seedling production. Substrate composition.

INTRODUCTION

The forest-based sector can be considered as an important component of the Brazilian economy, where it has a significant contribution through the generation of products, taxes, jobs, and income (CNI, 2017). The growing expansion of this sector has driven forestry investors to opt for the cultivation of native species (ABAF, 2016; IBÁ, 2017). Thus, quality seedlings are considered a prerequisite, since the quality of the seedlings influences the development of the plant in the field and the lower demand for crop treatments after planting (DIONISIO et al., 2019). Therefore, the success of reforestation projects depends mainly on the quality of seedlings produced in nurseries (MARQUES et al., 2018). In this case, they should have characteristics that help the maximum survival rate and rapid initial growth after planting (SMIDERLE; SOUZA; MENEGATTI, 2020a).

The cedro-doce [*Pochota fendleri* (Seem.) WS Alverson & MC Duarte] is among potential species for reforestation in the north of Brazil (SILVA et al., 2013; ESPITIA-CAMACHO; CARDONA-AYALA; ARAMÉNDIZ-TATIS, 2017; SMIDERLE et al., 2017; SMIDERLE et al., 2018), which has been prioritized due to its ability to adapt easily, irrespective of the soil or climate conditions (DURIGAN et al., 1997). In addition, *P. fendleri* has rapid growth, and its wood has a high value-added excellent quality, factors that enhance and guarantee its future commercialization at the local, domestic, and international level (ESPITIA-CAMACHO; CARDONA-AYALA; ARAMÉNDIZ-TATIS, 2017).

The successful planting and maintenance of reforestation areas require the use of seedlings with high quality and adequate nutritional status to ensure higher rates of survival and initial establishment (LIMA-FILHO et al., 2019), in addition to guaranteeing a return of the invested capital. However, the substrate is one of the factors that influence the seedling production process. Its purpose is to guarantee the development of the plant, including the good formation of roots and shoots. For this reason, it must have a high capacity for water retention, absence of pathogens, pests and it must also be of low cost (SOUZA et al., 2020a).

Alternatively, several authors propose the use of substrates made up of agricultural by-products, which can be used as a mixture to the commercial substrate or to other products, such as

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rice husks, charcoal, coffee straw, animal manure, as well as by-products of the agribusiness, which vary according to the region (SOUZA; SMIDERLE; CHAGAS, 2018). The combination of different materials can result in better results, improvising physical and chemical characteristics of the substrate and resulting in higher seedling growth, when compared to their individual use (SMIDERLE; SOUZA; MENEGATTI, 2020a). Substrates that guarantee the demand for macronutrients and provide better uptake efficiency, and consequently, transport and use, should be given priority, as they allow a reduction in chemical fertilization, thereby ensuring better use of the nutrients by the seedlings, reducing production costs and the impact on the environment caused by the possible leaching of fertilizers (SOUZA et al., 2019; MENEGATTI; SOUZA; BIANCHI, 2020).

Given the above, the aim of this study was to determine the chemical properties of different materials and on the absorption of macronutrients in *Pochota fendleri* seedlings (cedro-doce).

MATERIALS AND METHODS

The study was carried out at the Seed Analysis Laboratory and the forest nursery of Embrapa Roraima forestry sector. The species used was *Pochota fendleri* (Seem.) WS Alverson & MC Duarte ("cedro-doce"). The seeds were collected from plants located in Mucajaí, RR, Brazil, in the Serra da Prata experimental area of Embrapa Roraima.

The seeds were processed after gathering. Two seeds were planted in a polyethylene bag (17 cm in height and 12 cm diameter), containing approximately 2 dm^3 of the substrate. When the seedlings had an average height of five centimeters, they were thinned, leaving the most vigorous one. The seedlings were kept in a shade house under 50% of sunblock, suitably spaced, and irrigated by automatic sprinklers, programmed to activate for five minutes every four hours during the day.

The experimental design was completely randomized, with four replications, each with 10 plants. The treatments were sand (Sa), soil (So), sand+soil (1:1) (Sa+So), and sand+soil+crushed Brazil nut capsules (1:1:1) (Sa+So+CNC). To measure the required volume of each component included in the substrate, a measuring cylinder with a capacity of 1 L was used. Samples of each treatment were separated for chemical analysis.

The Embrapa method (2009) was used to determine the available macronutrient content, pH, exchangeable aluminum (Al), titratable acidity (H + Al), and cation exchange capacity at pH 7 (CEC) of the substrates used.

At 60 DAT (days after thinning) the seedlings met the standardized and recommended norms, according to Ordinance No. 26, Annex 4, in which the seedlings must have a diameter of 5.0 mm to 2.0 cm in height from the substrate; the height of 20 cm. The shoot height (H) (measured with a graduated rule, in cm) and root-collar diameter (CD) (measured 1 cm from the substrate, determined by digital caliper, in mm) were evaluated. The plants were removed from the polyethylene bags, the roots were separated from the substrate by washing in running water, and the shoots were separated from the root system.

The plants were divided into roots, stem, and leaves, and dried in a forced-air circulation oven at 70 ± 5 °C until constant mass for individual determination of dry weight (in grams) of the different parts of the plant: shoots (SDW), roots (RDW) and total dry weight (TDW). The materials were then ground and stored.

The ratio between the measured characteristics was determined by simple division. The Dickson Quality Index (DQI) was determined as a function of shoot height (H), collar diameter (CD), shoot dry weight (SDW), and root dry weight (RDW) using the formula by Dickson, Leaf, and Hosner (1960).

The N, P, K, Ca, and Mg content of root and shoot of each sample was determined using the methodology described in the Official Soil and Tissue Analysis Laboratory Network of the states Rio Grande do Sul and Santa Catarina - ROLAS (SBcS/cQFS, 2016). The dry weight and nutrient content of the plant, the indices of nutritional efficiency were calculated: (a) uptake efficiency = (total nutrient content of the plant)/(root dry weight), (SWIADER; CHYAN; FREIJI, 1994); (b) transport efficiency = [(nutrient content of the shoots)/(total nutrient content of the plant)] x 100 (LI; MCKEAND; ALLEN, 1991); and (c) use efficiency = (total dry weight produced)^2/(total nutrient content of the plant) (SIDDIQI; GLASS, 1981).

To verify the assumptions of the analysis of variance (ANOVA), the data were first checked for: a) normality with the Shapiro-Wilk test ($p > 0.05$), b) homoscedasticity with the Bartlett test ($p > 0.05$). When there was the normality of residues and homogeneity of variances, the data were submitted to analysis of variance (ANOVA), and, when significant, to the mean-value comparison test

(Tukey) at 5% probability. The statistical analysis was performed with the aid of the Sisvar software (FERREIRA, 2011).

RESULTS

An improvement in the chemical properties of the substrate due to the addition of crushed Brazil nut capsules was observed (Table 1), with a significant increase in the amount of organic matter (source of nitrogen), phosphorus, potassium, calcium, and magnesium, i.e., each of the macronutrients under evaluation.

Table 1. Available macronutrient content and chemical characteristics of the substrates formulated for the production of cedro-doce (*Pochota fendleri*) seedlings.

Substrate	pH	OM	K	P	Ca	Mg	Al	H+Al	CEC
	H_2O	dag kg^{-1}	cmol dm^3		cmol dm^3				
Sand (Sa)	5.00 b	0.12 c	0.01 c	3.72 c	0.22 c	0.10 c	0.00 d	2.10 a	2.43 b
Soil (So)	4.90 c	0.77 b	0.10 b	7.09 b	0.66 b	0.15 b	0.20 b	1.66 b	2.57 b
Sa+So	5.50 a	0.50 b	0.02 c	5.65 b	0.53 b	0.12 c	0.10 c	1.19 c	1.86 c
Sa+So+CNC	4.70 c	5.55 a	1.49 a	11.73 a	1.24 a	1.64 a	0.30 a	1.97 a	6.34 a
CV (%)	4.2	3.5	20.2	5.5	17.3	8.6	7.0	3.7	4.0

CNC: crushed Brazil nut capsules. CV: coefficient of variation. M.O.: organic matter. CEC.: cation exchange capacity. Mean values followed by the same letter in a column do not differ statistically by Tukey's test ($p>0.05$); * Significant ($p<0.05$).

Only the treatment consisting of Sa+So showed a pH within the range considered suitable for seedling development (5.5 to 6.5) (GONÇALVES; POGGIANI, 1996). The other substrates under test presented values for pH lower than those considered satisfactory.

Seedlings produced in the substrate composed of Sa+So+CNC presented superior results for height and collar diameter compared to the plants grown in the other substrates (Table 2). These results emphasize the different behavior of plants grown in various substrates but subjected to identical experimental conditions.

Table 2. Seedling height (H, cm) and root-collar diameter (CD, mm) in seedlings of cedro-doce (*Pochota fendleri*) grown in substrates composed of different materials.

Substrate	H (cm)	CD (mm)
Sand (Sa)	11.2 c	3.9 c
Soil (So)	21.6 b	5.7 b
Sa+So	17.1 bc	5.2 bc
Sa+So+CNC	30.2 a	8.5 a

CNC: crushed Brazil nut capsules. Mean values followed by the same letter in a column do not differ statistically by Tukey's test ($p>0.05$).

Seedlings produced in the substrate Sa+So+CNC showed higher mean growth (30.2, cm), value 62.91% higher than the mean height observed for the Sand (Sa), statistically differing from the substrate Soil (So) that also allowed greater growth of the aerial part in plants of 'cedro doce' (*Pochota fendleri*). As with height, root diameter was also greater in plants grown in the substrate containing crushed Brazil nut capsules.

In relation to biomass production, evaluated by quantifying the weight of the shoot, root, and total dry weight (Table 3), the results presented here made it possible to answer part of the research problem, noting in the post-transplant evaluation of sweet cedar seedlings (*Pochota fendler*i) that biomass production positively influenced the inclusion of crushed Brazil nut capsules in the substrate (Sa+So+CNC substrate).

Table 3. Shoot dry weight (SDW, g plant^{-1}), root dry weight (RDW, g plant^{-1}), total dry weight (TDW, g plant^{-1}), and Dickson Quality Index (DQI) in seedlings of cedro-doce (*Pochota fendleri*) grown in substrates formulated with different materials.

Substrate	SDW	RDW	TDW	DQI
Sand (Sa)	0.60 c	0.87 c	1.47 c	0.35 c
Soil (So)	2.28 b	2.46 b	4.74 ab	0.98 ab
Sa+So	1.58 b	2.30 b	3.88 bc	0.81 b
Sa+So+CNC	4.30 a	3.16 a	7.46 a	1.60 a

CNC: crushed Brazil nut capsules. Mean values followed by the same letter in a column do not differ statistically by Tukey's test ($p>0.05$).

The greatest Dickson quality index was also obtained in plants grown in the Sa+So+CNC substrate, the seedlings of this treatment again being considered superior, with a better balance between growth and nutritional quality for definitive planting.

In order to properly the nutritional quality in plants grown in each of the substrates under test were evaluated for nutritional efficiency for each macronutrient (Table 4). For use efficiency (UE), it was found that plants grown in the substrate composed exclusively of sand displayed the highest uptake rates for each macronutrient except S uptake. The superior UE shown by the plants grown in the 100% sand substrate may be related to the low CEC (Table 1), indicating that this substrate has limited retention capacity for some of these nutrients, such as Ca^{2+}, Mg^{2+}, and K^{+}, which favors their direct availability and uptake.

The highest uptake index found for N was expected due to the greater plant demand for this element and its importance, considering transport efficiency as the capacity of the plant to transport nutrients from the roots to the shoots, Ca was the nutrient with the highest indices, irrespective of the substrate (Table 4). The substrates used, the macronutrients N, K, and Mg it is worth mentioning that no differences in transport efficiency; however, when using single materials, soil stood out for the transport of P and Ca, whereas, for S, the substrate composed of sand was statistically superior (Table 4).

Table 4. Macronutrient uptake (UE), transport (TE), and use efficiency (USE) in seedlings of cedro-doce (*Pochota fendleri*) grown in substrates composed of different materials.

			UE (mg g^{-1})			
Treatment	N	P	K	Ca	Mg	S
Sand (Sa)	9.15 a	2.47 a	7.29 a	7.08 a	2.35 a	0.76 a
Soil (So)	3.57 b	0.86 b	4.85 b	4.57 b	1.38 b	0.48 b
Sa+So	3.58 b	0.94 b	3.46 b	3.73 b	1.06 b	0.51 a
Sa+So+CNC	4.42 b	0.66 b	6.68 ab	2.53 b	1.20 b	0.55 a
			TE			
Treatment	N	P	K	Ca	Mg	S
Sand (Sa)	70.91 a	63.65 a	57.24 a	88.09 a	60.04 a	65.48 a
Soil (So)	72.97 a	63.63 a	69.55 a	86.80 a	64.46 a	40.92 b
Sa+So	73.13 a	53.19 b	65.43 a	81.63 b	59.54 a	35.12 b
Sa+So+CNC	65.62 a	47.62 b	56.24 a	74.61 c	65.10 a	45.06 b
			USE (g^{2} mg^{-1})			
Treatment	N	P	K	Ca	Mg	S
Sand (Sa)	0.29 c	1.09 b	0.38 c	0.33 b	1.17 c	3.50 c
Soil (So)	2.49 b	10.51 b	1.87 b	2.01 b	6.63 b	19.37 b
Sa+So	2.06 b	8.03 b	2.08 b	1.94 b	6.74 b	14.31 b
Sa+So+CNC	4.77 a	37.24 a	3.18 a	8.29 a	18.97 a	41.72 a

CNC: crushed Brazil nut capsules. Mean values followed by the same letter in a column do not differ statistically by Tukey's test ($p>0.05$).

DISCUSSION

The improvement in the chemical properties of the substrate due to the addition of crushed Brazil nut capsules may relate to the increase in macronutrient content obtained by incorporating the crushed Brazil nut capsules in the substrate. This fact possibly resulted in an improvement in the cation exchange capacity (CEC), which is responsible for retaining and prolonging nutrient availability in the substrate throughout the period of plant growth, ensuring the fertility of the substrate.

Crushed Brazil nut capsule is an organic residue, largely produced by the north nut industry and with few alternatives of disposal. It is worth mentioning that this residue can be reused in the composition of substrates, contributing to the fertility of the compost by providing an increase in cation exchange capacity, and supplying essential nutrients, such as nitrogen, a determinant element in plant nutrition and growth (ANJOS et al., 2017).

The substrates under test, except the treatment consisting of Sa+So, presented pH lower than those considered satisfactory (SMIDERLE; SOUZA; MENEGATTI, 2020a). The pH is an extremely important chemical characteristic (MENEGATTI; SOUZA; BIANCHI, 2019) since it is directly related to the availability of nutrients to the plants, where unsuitable values can affect plant development, especially in substrates with a pH of less than 5, characterized by excessive acidity and facilitating the uptake of large amounts of toxic elements (SOUZA et al., 2020b).

In general, the seedling height was greater in substrates with a smaller proportion of sand in their composition, whereas the highest mean height was obtained in seedlings produced in the Sa+So+CNC substrate, and the lowest in seedlings produced in the Sa and Sa+So substrates.

According to Smiderle et al. (2020b), even though sand is a readily found and inexpensive material to include in mixed substrates, it has a restricted capacity for moisture and nutrient retention compared with organic materials, and therefore may not be considered suitable for use in large proportions. Which can explain the inferior results for the height of seedlings produced in substrates containing this material in larger quantities.

Seedling height is an easily measured variable and is commonly used to estimate the quality and robustness, seedlings that show superior results for this characteristic capture solar energy more efficiently and consequently help in maintaining adequate photosynthetic rates, supporting biomass production and plant growth (SMIDERLE; SOUZA, 2016).

As observed for height, collar diameter was also greater in plants grown in the substrate containing crushed Brazil nut capsules. This superiority may be associated with the greater presence of macronutrients and organic matter, which maximizes the possibility of obtaining high-quality seedlings, ensuring high rates of establishment and survival in the field (JACKSON; DUMROESE; BARNETT, 2012), and as a result, making commercial reforestation with *Pochota fendleri* more attractive.

The high K content of the Sa+So+CNC substrate, on average 65% higher than the other substrates under test (Table 1), may have had a direct influence on the greater mean value for collar diameter, since, according to Silva et al. (1997) and D'Avila et al. (2011), in more than 14 forest species, K is an element which is capable of promoting high water retention in plant tissue, inducing greater cell turgor, and resulting in greater thickening of the stem. This was also seen in plants of *Tectona grandis* grown in substrates formulated with biosolids, in which Trazzi et al. (2014) found that an increase in diameter is directly related to the level of K.

Souza, Smiderle, and Chagas (2018) studying the effect of potassium on the quality of *P. fendleri* seedlings, concluded that the species has a high demand for K and that potassium fertilization should be considered a strategy for producing seedlings of high quality in less time. As such, the results of the present study reinforce the possibility of the Sa+So+CNC substrate being the most efficient in producing seedlings of this species. This is due to its high K content and thus promoting superior values for the growth variables, root-collar diameter, and seedling height, so that the plants, when compared to seedlings grown in the other substrates, require a shorter stay in the nursery to reach the minimum standards required for transplanting.

The superiority in RDW production verified by plants grown in the Sa+So+CNC substrate may be the result of the higher macronutrient and OM content (Table 1) of this mixture, which may have supported the production and maintenance of longer root systems or a larger number of roots. These roots allow the exploitation of larger areas of substrate and, consequently, greater nutrient uptake efficiency (SOUZA et al., 2020b). Root uptake efficiency tends to guarantee the necessary supply of nutrients destined for the shoots; a fact demonstrated by the higher production of SDW in the plants grown in this substrate.

According to Menegatti, Souza, and Bianchi (2020), shoot dry weight indicates the robustness of a seedling, where the higher values obtained in plants grown in the Sa+So+CNC substrate represent more lignified and more robust seedlings, suggesting better establishment and survival in the field. The lower biomass, and the inferior CD and H characteristics of plants grown in the substrate composed exclusively of Sa (Tables 2 and 3), may be related to the reduced OM content (a variable that discriminates the N content available to the plants). Due to the high plant demand for N, access to a large content of this macronutrient results in higher production of dry weight, since the nutrient acts in various physiological processes during plant development, including photosynthesis, and cell multiplication and differentiation (POGORZELSKI et al., 2020).

The greatest Dickson quality index obtained in plants grown in the Sa+So+CNC substrate allows indicating the seedlings of this treatment as superior quality when compared to the ones produced in other substrates. According to Souza et al. (2019), this index is a good indicator of initial seedling survival after outplanting, as it considers important characteristics for evaluating the quality of the seedlings for transplanting, including robustness and the balance of weight distribution, presuming better outplanting results for seedlings of *P. fendleri* produced with the Sa+So+CNC substrate.

According to Smiderle, Souza, and Menegatti (2020a), a single material used as a substrate meets almost none of the desired chemical characteristics necessary for the growth and development of seedlings, including a good root-system and good shoot formation. This is confirmed by the superior results for each of the growth characteristics shown by the seedlings produced in the substrate composed of a mixture of three materials (Sa+So+CNC). However, it should be noted that this substrate had the lowest value for pH (approximately 4.7), underlining that it is not possible to generalize that substrates with a pH of less than 5 are unsuitable and affect plant growth. Souza et al. (2020a) verifying the effect of different substrates, in the presence and absence of controlled-release fertilizer, on the growth and morphological quality of seedlings of *Agonandra brasiliensis,* In the Substrate composed of soil from the cerrado + carbonized rice husks (CRH) + organic substrate (2:1:1) with pH 4.8 concluded that it is possible to obtain plants of *Agonandra brasiliensis* of good morphological quality.

The ideal pH value for growth is known to vary according to species (SOUZA et al., 2020a). According to Silva et al. (2013), *P. fendleri* is a forest species native to the state of Roraima, a region characterized by naturally acidic soils, suggesting that the Sa+So+CNC mixture, as a substrate for seedling production, is within the acceptable pH range for providing suitable chemical conditions and favoring the availability of nutrients for plant growth in this species.

According to Menegatti, Souza, and Bianchi (2019), the ability of a plant to exhibit high rates of growth and greater biomass accumulation occurs for several reasons that are related to the availability of nutrients in the substrate, which influences their uptake, transport, and use by the plants.

It should be noted that N was the macronutrient with the highest uptake index. This result was expected due to the greater plant demand for this element, considering its importance in the production of those proteins, amino acids, and enzymes that are indispensable to the production of non-structural carbohydrates, including starch and soluble sugars (sucrose, glucose, fructose, and sorbitol), molecules that play an essential role in vegetative growth, providing structural components for the formation of new cells and, consequently, biomass production (HAIDER et al., 2018).

The results of the plants regarding macronutrient use efficiency supports the conclusion that seedlings grown in the substrate composed of Sa+So+CNC are able to redistribute and reuse more effectively the mineral elements of older and senescent organs in the metabolic processes that culminate in growth. According to Souza et al. (2020b), nutrient use efficiency can be determined as the relationship between nutrient concentrations in plant tissue and dry weight production, in other words, it indicates the ability of a species to exhibit satisfactory yields even under nutritional limitations.

It may be supposed that despite inducing inferior absorption efficiency, the Sa+So+CNC substrate provided the optimal amount of macronutrients, i.e., at levels which later enabled their transport and use by the plant so as not to compromise plant growth, a fact evidenced by the superiority of all the growth variables.

The plants grown in the substrate composed exclusively of Sa, despite displaying high uptake rates, it is related to low rates of macronutrient use and consequently provided levels below those suitable for maintaining plant metabolisms, such as cell-membrane formation and integrity, cellular-energy production and transfer, and carbohydrate metabolism (ULLAH et al., 2017). Each of these processes limited the maintenance of energy production for carbon metabolism, and indirectly restricted biomass production, exactly the behavior shown by the plants in the substrate in question (Sa).

The superior growth variables and use efficiency shown by the seedlings produced in the mixed substrate, composed of Sa+So+CNC, makes the use of these materials attractive in cultivating plants that will later be included in commercial plantations, since seedlings showing better nutritional status and rusticity, and whose contribution is greater, will require less investment in fertilizers for maintaining fertility during the initial phase of reforestation, as they ensure high rates of establishment, of initial start-up and survival in the field.

Besides highlighting superiority nutritional efficiency due to the high capacity for converting nutrients to biomass and making it possible to reduce fertilization with macronutrients, the proposed substrate offers a solution for the disposal of crushed Brazil nut capsules, an organic residue that is produced in large quantities in the states of the North Region of Brazil, and which is inexpensive, as is an example the sand substrate.

CONCLUSIONS

Organic matter and macronutrients in the substrate are increased by the addition of crushed Brazil nut capsules to their composition, resulting in seedlings with higher growth and biomass. The reutilization of crushed Brazil nut capsules in the production of *P. fendler*i can be a sustainable alternative for the disposal of this residue.

The use of different materials in the substrate influences the growth of *P. fendleri* seedlings, especially in the more-varied substrate (Sa+So+CNC), suggesting that mixing materials with different characteristics can result in substrates with better chemical and physical parameters for the production of forest seedlings.

The Sa+So+CNC substrate, despite reducing the efficiency of macronutrient uptake by the plants, allows for better nutrient use and resulted in the production of *P. fendleri* seedlings with better nutritional status and superior growth, biomass, and quality.

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RESUMO: As mudas produzidas em recipientes podem ser influenciadas pelos materiais utilizados no substrato, que afetam a robustez das plantas e, indiretamente, o tempo necessário para o transplante e o estabelecimento das plantas no campo. O objetivo deste estudo foi determinar as propriedades químicas de diferentes materiais e a absorção de macronutrientes em mudas de *Pochota fendleri* (cedro-doce). Os tratamentos foram: areia (Sa), solo (So), areia + solo (Sa + So) e areia + solo + casca de ouriço da castanha do Brasil triturada (Sa + So + CNC). O crescimento e o teor de macronutrientes foram avaliados 60 dias após o desbaste. A quantidade de macronutrientes no substrato aumentou com a adição de casca de ouriço da castanha do Brasil triturada. O uso de diferentes materiais para o substrato, principalmente o Sa + So + CNC, influenciou positivamente as características morfológicas das mudas, garantindo altas taxas de estabelecimento e sobrevivência após o plantio, tornando atraente o reflorestamento comercial com *Pochota fendleri*.

PALAVRAS-CHAVE: Composição de substrato. Nutrição mineral. Produção de mudas.

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