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Initial Growth of Açaí Seedlings in Function of Basalt Powder Doses

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Abstract **- Seedlings production of native fruits is important for its sustainable commercial exploitation. The objective of this study was to evaluate the development of açaí seedlings as affected by application of powdered basalt to the substrate. The treatments consisted of five doses of basalt powder (0.42, 1.04, 2.08, 4.17 and 8.33 g kg^{-1}), two particle sizes, plus a control with five replications. The substrate was composed of 20% vermicompost and 80% soil, dystrophic Yellow Latosol (Xanthic Hapludox). The substrate was incubated for 90 days. At six months, height, stem diameter, number of branches, and dry biomass of shoots and roots, and the concentration of leaf nutrients were measured. The basalt powder presented potential to be used as fertilizer in the production of açaí seedlings. Increased of powder in soil promoted the increase of macro and micronutrients in the shoots of seedlings, which explains the better development of the seedlings. The dose between 6.0 and 6.3 g dm^{-3} of basalt powder, 0.05 mm particle size is recommended.**

Keywords **- Alternative Fertilizer, *Euterpe Oleracea*, Seedlings of Native Fruits, Stonemeal.**

I. Introduction

The açaí tree (*Euterpe oleracea* Mart.) is considered one of the most economically important species, whose fruits and palm-core are used commercially [17]. It is found in the wild, and is part of the floristic composition of dry land forests, lowlands, throughout Amazon [14]. It provides varied raw material, which is used by native populations to meet multiple needs. This species has been over exploited from predatory extraction of the palm-core, which has threatened the existence of the species. However, with the expanded use of açaí pulp in various regions of Brazil and world, it was removed from the list of endangered species, because the mature plants are the ones that provide the market's most valuable raw material. Its introduction to sustainable farming is being studied, and several studies have been conducted [15]-[13].

Significant increases in growth and quality of seedlings can be achieved through proper fertilization, resulting in better development, precocity, and greater survival [2]. The use of rock powder provides an ecological and sustainable alternative for soil nutrients required by the plants. It is a byproduct from the processing of raw minerals and has a relatively low solubility, which means that nutrients are supplied to plants for a longer period [9] - [20], working on family farms, showed that the use of stonemeal is a technology that has economic, environmental, and productive advantages for crops, sugar cane, fruits, and vegetables, compared to fertilization with highly soluble minerals, whose the benefits resulting from the use of rock powder include a slow release of macronutrients and micronutrients in cultivated soils.

Fertilization with rock powder is also a viable alternative in economic and ecological terms because it does not require any chemical processing; only grinding of the rocks used in the product is required. It also provides the gradual release of nutrients [12]. Furthermore, in Roraima State, there is abundant production of basalt powder, which can contribute to the sustainable use of this mineral residue. In this context, the aim of this study was to assess the growth response of "açai" seedlings to different rock powder doses, varying in particle sizes.

II. Material and Methods

The experiment was conducted in a greenhouse at the Agricultural Sciences Center of the Universidade Federal de Roraima, in Boa Vista, Roraima state, Brazil, geographical coordinates 2º 52' 15'' N and 60º 42' 39'' W, whose Köppen climatic classification is type Awi, with two well defined seasons, rainy (April-September) and dry (October-March) [1]. Açaí fruits were collected by hand from a population of plants found on the banks of the Cauamé River in the municipality of Boa Vista – RR. Ripe fruits of homogeneous size were selected. Seeds were extracted and separated with the aid of a sieve and washed in running water to remove pulp and peel residues. After selection, seeds were sterilized with a sodium hypochlorite solution consisting of one part of sodium hypochlorite and four parts of water. After being submerged in this solution for 15 minutes, the seeds were dried in the shade, on newsprint paper in a ventilated room for a period of 30 hours to reduce surface moisture. They were then stored in plastic bags and packed in hermetically sealed glass containers at a temperature around 10º C. Seeds were germinated in 125 cm^3 plastic pots containing 1:1 mix of sawdust and sand by volume.

The experimental design used was a randomized block design in a (5x2+1) factorial arrangement with five replications, two particle sizes (G_1=0.05 and G_2=0.10 mm

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diameter), and five basalt powder doses (D_1= 0.42 D_2=1.04, D_3=2.08, D_4=4.17 e D_5=8.33 g dm^{-3}) of soil, plus a control with no added basalt powder.

Basalt powder was obtained from rocks of the geological formation Apoteri in the municipality of Boa Vista-RR. The rock was fragmented with a hammer and processed in a ball mill and then sieved on vibratory separator to obtain diameters of 0.10 and 0.05 mm. In order to define the quantities to be used, we took into account the values used for soils in the studies of [4] –[6], who were able to improve the chemical characteristics of soils and achieve high levels of nutrient availability. The powder was analyzed and chemically characterized by plasma spectrometry (Table 1).

Table 1: Levels of macro and micronutrients* in samples of basalt and granite powder. Mean values ± standard deviation (n=3)

Macronutrient (mg kg^{-1})	Sample	
	Basalt powder	Granite powder
Calcium	9,700	900
Magnesium	4,800	400
Potassium	48	1,600
Phosphorus	520	80
Sulphur	14	-***
Micronutrient (mg kg^{-1})		
Cobalt	45.48 ± 2.43	1.68 ± 0.38
Copper	218.82 ± 1.27	101.06 ± 8.82
Manganese	1,033.95 ± 16.08	233.90 ± 4.39
Molybdenum	< 0.05**	1.78 ± 0.16
Zinc	79.70 ±0.75	48.68 ± 1.93

*USEPA Method 3052. **Values proceeded by the < sign refer to the quantification limit of the analytical method. ***Not analyzed.

Each experimental unit consisted of a black polyethylene vase containing 14 dm^3 of substrate and one plant per pot after plant roughing, leaving one seedling per pot. The substrate consisted of a mixture of 20% vermicompost and 80% of soil. The soil was collected at the Campus do Cauamé, UFRR and was classified as Dystrophic Yellow Latosol (Xantic Haplustox), medium texture, collected from the 0 – 20 cm layer. Vermicompost and soil characterizations are shown in Tables 2 and 3. To the substrate was added 0.058 g dm^{-3} of P_2O_5 in the form of triple superphosphate and 1.04 g dm^{-3} granite powder. The basalt powder was applied according to each treatment. Granite powder was obtained using the same procedures used for basalt powder. The vases were incubated for 120 days (January to April), keeping the moisture close to field capacity.

Table 2: Chemical characteristics, organic carbon (OC) and C/N ratio of vermicompost used in the production of açaí seedlings

pH	K	P	N**	Ca	Mg	Fe	Zn	OC***	C/N
H_2O	--------g kg^{-1}-----------					--mg kg^{-1}---		%	
5.05	3.2	2.4	16.8	6.0	2.6	1,522	246	23.24	13.83

* Total contents determined in acid extract (nitric acid and perchloric acid).
** Kjeldahl method. *** Organic carbon determined by Walkley-Black Method.

Table 3: Chemical and granulometric characteristics of soil classified as Yellow Dystrophic Latosol (Xanthic Haplustox)

pH	K	P	Ca + Mg	Al^{3+}	BS	CEC*	m	OM**	Clay	Silt	Sand
H_2O	mg dm^{-3}		-------- cmol$_c$ dm^{-3} ----------				%	g kg^{-1}	---- g kg^{-1} -----		
4.8	15	0.1	0.8	0.9	0.84	3.7	48%	17	250	150	600

*CEC – capacity of exchange cations. **Soil organic matter.

After the incubation, two açaí seedlings were transplanted into each vase, the strongest seedling from each pot being selected after eight days. The pots were irrigated daily to maintain moisture condition close to field capacity.

Seedling growth was evaluated monthly, starting from the first month after planting. The following variables were measured: height, young stem diameter, and number of leaves of plants in the vase. For length measurements, we used a millimeter ruler, measuring from the level of the substrate to the tip of the last apical meristem. Root collar diameter was measured at the level of the substrate with a caliper rule.

After six months from the beginning the experiment, we evaluated the dry biomass of the remaining shoot, root dry biomass, and total dry biomass per treatment. Plants were washed over a fine mesh sieve with gentle jets of water to remove the substrate adhering to the roots, and root segments retained by the sieve were collected. After this process, seedlings were separated into roots and shoots. After drying in a forced air oven at 65°C for 72 hours, samples were weighed separately on an analytical balance to determine shoot dry biomass, root dry biomass, and total dry biomass.

From the data obtained, we evaluated the root dry biomass/shoot dry biomass ratio (RDB/SDB), shoot height/root collar diameter ratio (SH/RCD), shoot height/shoot dry biomass ratio (SH/SDB), and Dickson Quality Index (DQI), which was determined as a function of shoot height (SH), root collar diameter (RCD), shoot dry biomass (SDB), root dry biomass (RDB), and total dry biomass (TDB) using the formula below [5]:

$$DQI = \frac{TDB}{(SH/RCD) + (SDB/RDB)}$$

Statistical analysis was performed with the aid of statistical software SISVAR [7] and SAEG 9.0 [18], applying the analysis of variance by F test. Qualitative data (growth of seedling) was compared by Tukey's test and quantitative data by quantitative data by curve response of data, adjusted to quadratic model. Graphics were generated by SIGMA PLOT 11.0 [19].

III. Results and Discussion

Among the characteristics evaluated significant interactions were obtained between doses of basalt powder and particle sizes only for SDB, RDB, and TDB. Particle sizes showed no significant differences in SH, RCD, and NR.

The values for shoot, root, and total dry biomass are present in the Table 4. Seedlings grown in the 0.05 mm particle size of basalt powder showed better development with a higher dry biomass. This result can be attributed to greater availability of nutrients by the exposure of greater specific surface area, favoring reactions and interactions with the substrate. Thus, basalt powder nutrients were more readily available on the sorption complex of the substrate and were absorbed by seedlings subjected to 0.05 mm of particle size.

Table 4: Growth variables of açaí seedlings (SDB – dry biomass of remaining shoot, RDB – root dry biomass and TDB – total dry biomass), subjected to six doses of basalt powder of 0.05 and 0.10 mm particle sizes

Particle size	SDB	RDB	TDB
	----------------------------(g)		----------------------------
0.05 mm	2.25 a	1.11 a	3.35 a
0.10 mm	2.03 b	0.89 b	2.92 b
Efficiency (%)[1/]	10.8	24.8	14.7

In each column, means followed by the same letter do not differ by Tukey test at 5% probability 1/Efficiency = {[(Best Treatment x 100)/(Worse treatment)]-100}.

The 0.05 mm particle size increased the efficiency of basalt powder in providing nutrients. This effect was especially evident for the RDB, which had growth of 24.8% greater compared to the control (Table 4). The lower values for RDB, when plants were subjected to the 0.10 mm particle size, can be explained by low availability of Ca, which has a direct effect on meristem growth because it stimulates growth and proper functioning of the root apex [3]. Another factor that possibly limited root growth of the seedlings was the presence of Al^{+3}. The 0.10 mm particle size is more resistant to chemical weathering (from water and organic acids) and hence for possible reactions that neutralize aluminum. This occurred to a small extent, i.e., there was no adequate neutralization of the Al^{3+} present in the soil used in the substrate, which had 48% aluminum saturation. Thus, soil containing high Al^{+3} saturation, as used in our substrate, may limit the successful development and root growth of plants, even with the addition of basalt powder.

According to [3], the toxic effects of high concentrations of Al^{+3} can be observed mainly by root thickening and a decrease in root ramifications, which affects the absorption of nutrients and water. These effects were observed in the açaí seedlings grown in the 0.10 mm particle size of rock powder, which were probably caused by Al^{+3} toxicity, because the values of root RDB data were strongly reduced in seedlings grown with this particle size, where the Al^{+3} concentration was significantly higher.

Only doses of 0.05 mm particle size of basalt powder affected the variables SH and RCD (Figure 1A and 1B), which were described using a quadratic model. Both the height and diameter of young stems were greatest at an application of 6.1 g dm^{-3} of basalt powder. For height, a maximum value of 21.26 cm and an increase of 23.73% relative to the control were obtained (Figure 1A). The maximum young stem diameter was 11.95 mm, an increase of 40.24% relative to the control (Figure 1B).

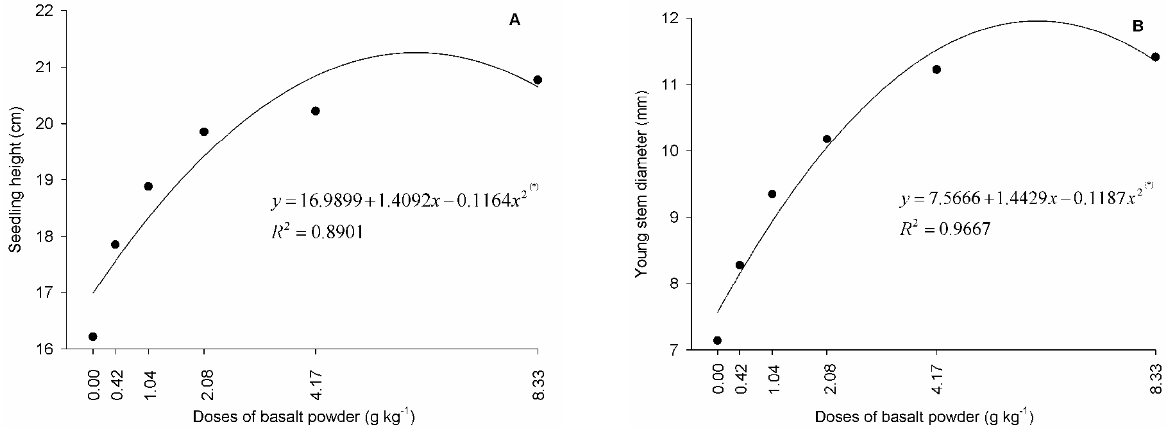

Fig.1. Height (A) and young stem diameter (B) of açaí seedlings as a function of increasing doses of basalt powder evaluated 180 days after transplantation.

Production of shoot dry biomass in the 0.05 mm particle size (G1) reached a maximum of 4.19 g in response to a dose of maximum technical efficiency (DMTE) of 6.22 g kg^{-1} of basalt powder, an increase of 83.96% relative to the control. In comparison, the production of SDB in the 0.10 mm particle size (G2) reached a maximum of 2.93 g after a dose of 6.20 g kg^{-1} (MTE) of basalt powder, an increase of 65.46% (Figure 2A).

The best chemical conditions of the substrate were provided by the basalt powder with finer particle size (0.05 mm), which led to better root development of açaí seedlings, as shown in Figure 2B. With this particle size were observed a maximum RDB of 1.94 g, at a DMTE 5.90 g kg^{-1} of basalt powder, an increase of 79.1% (Figure 2B - G1). In the 0.10 mm particle size (G2), the maximum RDB observed was 1.14 g at DMTE 6.19 g kg^{-1}, an increase of 54.20% (Figure 2B).

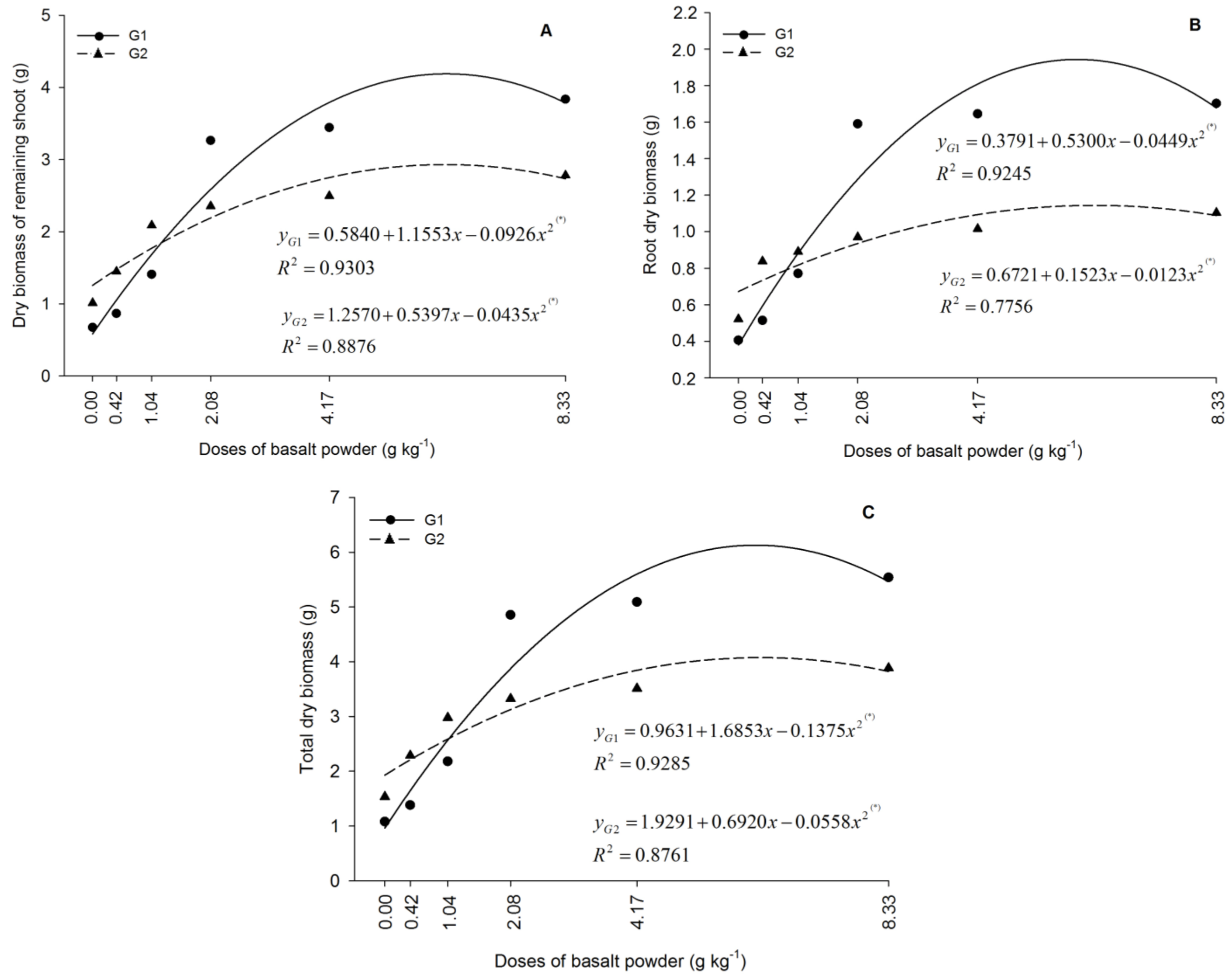

Fig.2. Shoot dry biomass (A), root dry biomass (B), total biomass (C) of seedlings of açaí as a function of increasing doses of basalt powder with grain sizes 0.05 (G1) and 0 10 mm (G2), evaluated 180 days after transplantation.

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For the results of TDB, seedlings grown in the 0.05 mm particle size (G1) exceeded in dry weight those grown in the 0.10 mm particle size (G2). The maximum TDB obtained in G1 was 6.13 g, in response to a dose of 6.13 g kg^{-1} (MTE) of basalt powder, an increase of 82.46% (Figure 2C). In comparison, in G2, TDB reached a maximum of 4.07 g at a DMET of 6.20 g kg^{-1} of basalt powder, an increase of 62.3% (Figure 2C).

These results show that seedlings subjected to the 0.10 mm particle size (G2) of basalt powder had their development and growth affected due to low supply of nutrients and adverse chemical conditions of the substrate. However, compared to the control, the increases obtained in the dry biomass of G1 reached values higher than 70%, while in particle size G2 the increases were less than 66%. These results demonstrated the positive effect of basalt powder as an alternative fertilizer for açaí seedlings. The powder allows a better nutritional balance for seedlings and is a good source of macro- and micronutrients. It is more efficient when used in smaller particle size.

The SDB/RDB index (Table 5) was not affected by doses of basalt, but particle size caused a range in SDB/RDB of 2.0 (0.05 mm) to 2.26 (0.10 mm). The SDB/RDB index value 2.0 as the best ratio between shoot dry biomass and root dry biomass. According to [16], this is an efficient and safe index to express the quality of seedlings. The results show that seedlings grown on substrates using basalt powder with a 0.10 mm particle size had higher shoot growth in relation to the development of roots, which is likely a reflection of nutritional stress resulting from reduced availability of nutrients in the substrate. It could be due to greater resistance of this particle size to chemical dissolution agents, besides tenors of aluminum, highest than 0.5 $cmol_c\,kg^{-1}$ of soil, which is toxic to plants.

Table 5: Morphological Index SDB/RDB (remaining shoot dry biomass/root dry biomass ratio) of açaí seedlings, subjected to six doses of basalt powder, with 0.05 and 0.10 mm particle sizes

Particle size	Index
	SDB/RDB
0.05 mm	2.00 b
0.10 mm	2.26 a

Means followed by the same letter in vertical do not differ by Tukey test at 5% probability.

The SDB/RDB and SH/RCD indexes were not influenced by particle size, but doses of basalt powder caused a quadratic response in these indexes (Figure 3A and B). The SDB/RDB index reached a maximum of 2.47 for DMTE 6.18 g dm^{-3}, an increase of 27.1% (Figure 3A). The SH/RCD index provides an indication of how thin the seedling is. The lower its value, the greater is the chance of survival and establishment at a planting site [10]. If, therefore, we consider this relationship as indicative of greater survival of seedlings in the field, seedlings of lower height would be favored [11]. Thus, the minimum obtained for this index was 1.75 at DMET 6.0 g dm^{-3}, a negative increment of 22.7% when compared to the control (Figure 3B).

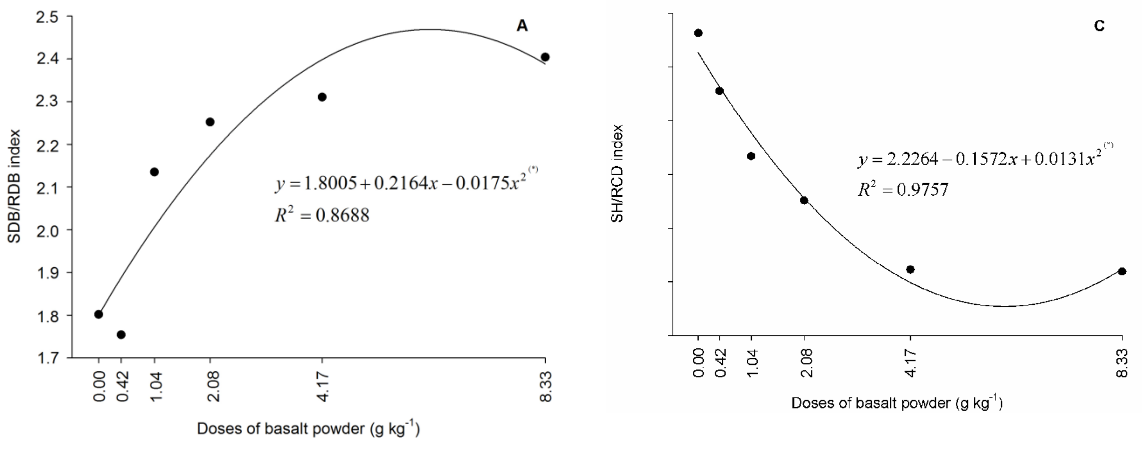

Fig.3. Morphological Indexes of remaining shoot dry biomass/root dry biomass ratio (SDB/RDB – A) and height/diameter of stem ratio (SH/RCD – B) as a function of doses of basalt powder, evaluated 180 days after transplantation.

The SH/SDB and DQI indexes were affected by particle size (Figure 4A and B). The response of the SH/SDB index reached a minimum of 1.60 (G1) and 6.18 (G2) in DMET 5.63 and 5.95 g dm^{-3} (Figure 4A), respectively. The SH/SDB index is the ratio that measures SDB increase per unit of SH, indicating the degree of seedling lignification. According to [10], the lower the value of SH/SDB index, the greater the chance of seedlings survival in the field. Thus, seedlings grown in basalt powder of finer particle size were more efficient in producing dry biomass during their development, increasing their chance of surviving in the field due to their lower values of the SH/SDB index.

The DQI is considered a good indicator of seedling quality, because the strength (SH/RCD ratio) and balance of biomass distribution (SDB/RDB ratio) are used in its

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calculation [8]. The higher DQI, the better the quality of seedlings produced. Thus, the best results were obtained in seedlings grown in the 0.05 mm particle size. They reached maximum DQI of 5.6 at DMET 6.18 g dm^{-3}, an increase of 61.4% relative to control. However, seedlings grown in the 0.10 mm particle size reached a maximum DQI of 4.98 at a dose 6.16 g dm^{-3}, an increase of 48.0% (Figure 4B).

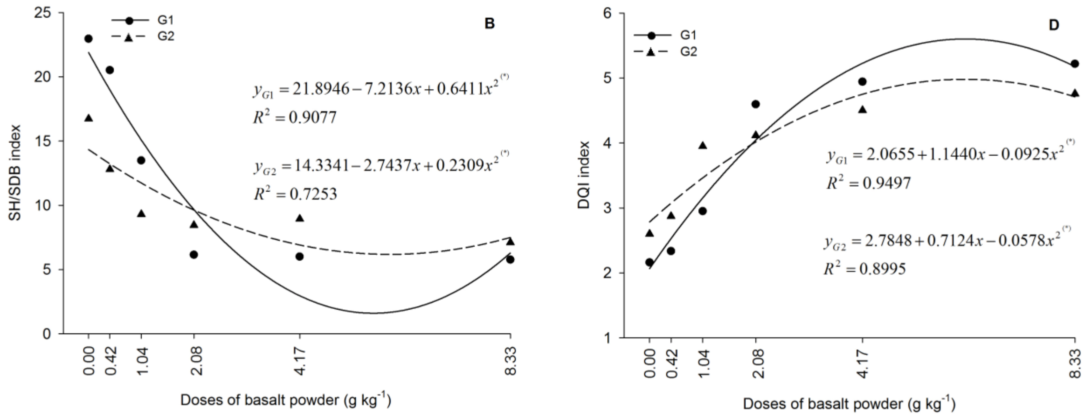

Fig.4. Morphological Indexes of (SH/SDB – A) ratio and Dickson index (DQI – B) of açaí seedlings, as a function of increasing doses of basalt powder, in particle sizes 0.05 (G1) and 0.10 mm (G2), evaluated 180 days after transplantation.

IV. Conclusion

These results show that seedlings produced in a particle size of 0.05 mm are of better quality, and, thus this particle size is recommended for field cultivation.

With the exception of height and young stem diameter, all other growth variables were affected by the particle size of basalt powder. However, the particle size of 0.05 mm was better than the size of 0.10 mm for all variables studied.

The doses of maximum efficiency for the growth variables of açaí seedlings ranged from 6.0 to 6.29 g dm^{-2} of basalt powder, and in the same interval were obtained the best indexes that define the quality of açaí seedlings with a particle size of 0.05 mm.

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References

[1] Araújo, W.F., Andrade Júnior, A.S., Medeiros, R.D., and Sampaio, R.A. Probable monthly rainfall in Boa Vista, Roraima State, Brazil.. *Revista Brasileira de Engenharia Agrícola Ambiental*, 5: 563-567. 2001.

[2] Barbosa, Z., Soares, I., and Crisóstomo, L.A. Growth and nutrient uptake by soursop seedlings. *Revista Brasileira de Fruticultura*, 25: 519-522, 2003.

[3] Cantarutti, R.B., Barros, N.F., Prieto, H.E., and Novais, R.F. Avaliação da fertilidade do solo. In: Novais, R.F., et al. (Eds), Fertilidade do Solo. Viçosa, Sociedade Brasileira de Ciência do Solo, p.769-850. 2007.

[4] Dias, F.O., Melo, V.F., Uchôa, S.C.P., and Barbosa, G.F. Levels of finely ground basalt rock in the chemical properties of a yellow latosol of the savannah of Roraima., *Acta Amazônica*, 42: 471 – 476. 2012.

[5] Dickson, A. Leaf, A.L., and Hosner, J.F. Quality appraisal of white spruce and white pine seedling stock in nurseries. *Forest Chronicle*, 36: 10-13. 1960.

[6] Escosteguy, P.A.V., and Klamt, E. Ground basalt as nutrient source. *Revista Brasileira Ciência do Solo*, 22: 11-20. 1980.

[7] Ferreira, D.F. Estatística básica. Universidade Federal de Lavras, Minas Gerais- Brazil, 2005. 676p.

[8] Fonseca, E. P., Valéri, S. V., Miglioranza, E., Fonseca, N. A. N., and Couto, L. Target seedlings of *Trema micrantha* (L.) Blume grown under different periods of shading. *Revista Árvore*, 26: 515-523, 2002.

[9] Gillman, G.P. The effect of crushed basalt scoria on the cation exchange properties of highly weathered soil. *Soil Science Society of American Journal*, 44: 465-468, 1980.

[10] Gomes, J.M., and Paiva, H.N. Viveiros florestais: propagação sexuada. Viçosa, Brazi, UFV, 2004.116p.

[11] Knapik, J. G., and Angelo, A. C. Growth of Prunus sellowii Koehne seedlings in response to NPK fertilizers and basalt dust. *Floresta*, 37: 257-264, 2007.

[12] Leonardos, O.H., Theodoro, S.C.H., and Assad, M.L. Remineralization for sustainable agriculture: a tropical perspective from a Brazilian viewpoint. *Nutrient Cycling Agroecosystems*, 56:3-9, 2000.

[13] Lima, R.L.S., Severino, L.S., Sofiatti, V., Gheyi, H.R., and Arriel, N.C. Chemical attributes of substrate of organic waste compost. *Revista Brasileira de Engenharia Agrícola Ambiental*, 15: 185–192, 2011.

[14] Nascimento, W.M.O., Ciceros, S.M., and Novembre, A.D.L.C. Conservation of açaí seeds (*Euterpe oleracea* Mart.). *Revista Brasileira de Sementes*, 32: 24-33, 2010.

[15] Oliveira, R.B., Nascimento, J.S.S.X., Souza, C.A.M., Silva, S.A., and Martins Filho, S. Production of Seedlings of forest species on different substrates and monitoring the development on field. *Ciência Agrotectenolocgia*, 32: 122-128, 2008.

[16] Santos, C.B., Longhi, S.J., Hoppe, J.M., and Moscovich, F.A. Effect of content container and kinds of substrate on the quality of *Cryptomeria japonica* (L.F.) D. Don. seedlings. *Ciência Florestal*, 10: 1-15, 2000.

[17] Queiroz, J.A.L., and Melém Junior, N.J. Effect of container size on seedling development of açaí (Euterpe oleracea Mart.). *Revista Brasileira de Fruticultura*, 23: 460-462, 2001.

[18] Ribeiro Júnior, J.I., and Melo, A.L.P. Guia prático para utilização do SAEG – Viçosa, MG, 288p. 2008.

[19] Sigmaplot. For windows, version 11.0. Systat Software. 2008.

[20] Theodoro, S.H., and Leonardos, O.H. 2006. The use of rocks to improve family agriculture in Brazil. *Anais da Academia Brasileira Ciência*, 78:721-730, 2006.