Influence of alternative substrates on biomass and quality of cedar seedlings

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Abstract. The production of native species seedlings is essential for the establishment of planted forests or for the recovery of degraded areas. In the nursery stage, the quality of the substrate is crucial for plant growth and development. The objective of this work was to evaluate the influence of alternative substrates, produced from agroforestry residues and decomposed forage grasses, on the biomass input and quality of cedar (Cedrela odorata) seedlings. The experiment was carried out in a greenhouse, located in Rio Branco, Acre, in a completely randomized design, with three treatments, consisting of substrates: brachiaria organic compost (1:1); organic compost combined with crushed brazil nut husk (2:1) and commercial substrate, with ten repetitions. At 90 days after sowing, total, shoot and root dry matter and Dickson's quality index were evaluated. The organic compost from Brachiaria grass favors the accumulation of biomass, improves the quality of cedar seedlings and can replace the commercial substrate in a viable way.

Keywords: Cedrela odorata, forest seedlings, agroforestry residue, forest nurseries

Introduction
The propagation of forest seedlings, in quantity and quality, is fundamental for the restoration of degraded areas, formation of riparian forests or for the establishment of planted forests. In addition to enabling the sustainable production of wood in the legal Amazon, it also ensures the regeneration and conservation of native species threatened with extinction (WIENER, 2010; SANTOS; FERREIRA, 2020). Cedar, Cedrela odorata L., family Meliaceae, is a large and valuable tree species that produces valuable wood and can be used in landscaping and for enrichment plantations, since the survival rate in gaps is greater than 80 % (VIEIRA et al., 2018). Its wood can be used in civil construction, charcoal production, making musical instruments, carpentry,
joinery, sheet and plywood manufacturing, in addition to providing non-wood products such as medicinal oils (CARVALHO, 2010).

Due to its high value, the species is the target of extractivism and illegal extraction, causing disproportionate felling in plant formations (DUARTE et al., 2021). Therefore, the need for seedlings for implantation in areas of regeneration or establishment of commercial plantations becomes evident.

Several factors influence the growth and development of seedlings during the nursery phase; among them we can mention: the temperature, the luminosity, the volume of the cultivation containers, and mainly, the quality of the substrate (Hartmann et al., 2011). The substrate is responsible for supporting root development and providing water and nutrients for the growth and development of the seedling (ARAÚJO et al., 2017). The use of commercial substrates is common, however, due to their price and distribution logistics, this can be replaced by alternative substrates, produced from different agroforestry residues (MANCA, 2020).

Several materials can be considered as substrates, however, it is essential to know the physical and chemical characteristics, establishing tests to validate their use. The organic compost, obtained from the fermentation and decomposition of forage grasses, such as brachiaria, has shown promising results, whether for the production of vegetable seedlings or fruit and forest species (ARAÚJO et al., 2021; PINTO et al., 2021). In addition, it is easy to obtain, as it grows along side roads in rural areas, so it is a possible economic and ecologically viable solution.

Another promising organic material is the crushed Brazil nut husk, an abundant waste in the North region, rich in nutrients, with good physical properties and that can be used alone or combined with other materials (ANDRADE et al., 2015; SOARES et al., 2014; SANTOS et al., 2018). In this context, this work aimed to evaluate biomass allocation and quality of cedar seedlings as a function of alternative substrates in Amazonian edaphoclimatic conditions.

Materials and Methods

The experiment was carried out in the forestry nursery of the Technology Foundation of the State of Acre (FUNTAC), in Rio Branco, from August to November 2020. The local climate, according to Alvares et al. (2013), is of the Am type, tropical monsoon, with average annual temperature around 26 ºC and rainfall of 2,200 to 2,500 mm. The temperature and relative humidity data during the experiment were presented in Figure 1.

The statistical design was completely randomized, with three treatments, the substrates being: BGOC - brachiaria grass organic compost (1:1), OCCC - organic compost combined with crushed Brazil nut husk (2:1) and the substrate commercial (SC) with ten replications per treatment, totaling 30 experimental units.

For the production of organic compost, compost piles with 2/3 of Brachiaria decumbens and 1/3 of organic soil were assembled. The production was carried out at Sítio Ecológico Seridó, km 5 away from Rio Branco, Acre. The substrate based on Brazil nut shell was produced from waste donated by the Cooperative of Central Commercialization of Acre - COOPERACRE. The material was separated according to the particle size on a 2 mm mesh sieve. Commercial substrate was used as a control. It was composed of pine bark, vermiculite, charcoal mill and phenolic foam. Substrate preparations were analyzed for their physicochemical composition (Table 1).

![Figure 1. Temperature and relative humidity monthly average from Rio Branco, Acre, during the trial period.](image-url)
Cedar seeds were collected from 15 matrices located in the Industrial District of Rio Branco, Acre. Sowing was carried out at a depth of 3.0cm, in tubes with a capacity of 180 cm³ filled with substrates according to the treatments. Subsequently, the tubes were placed in trays placed on a suspended bench 1.0m above the ground, in the nursery covered with black monofilament mesh, capable of filtering 50% of the incident light.

Irrigation was performed daily, using micro-sprinklers, applying a water depth of 10 mm day⁻¹. There was no application of fertilizers to treatments during the experiment. At 90 days after sowing, the seedlings were removed from the tubes, washed in running water, and the root and aerial part were separated. The samples were placed in Kraft paper packages for drying in a forced ventilation oven at a temperature of 65°C, until reaching a constant mass. Afterwards, the aerial part (DMAP), root (DMR) and total (TDM) dry masses were measured using a semi-analytical balance (0.01g).

The height (cm) and diameter of the collar (mm) were collected to calculate the Dickson et al. (1960), using the following equation:

\[
DQI = \frac{TDM(g)}{\frac{A(cm)}{2} \cdot DMAP(g) + DMR(g)}
\]

For statistical analysis, the presence of discrepant data, normality of residues and homogeneity of variances were verified. Afterwards, the data were analyzed by variance, by the F test, and noting differences, they were compared by the Tukey test at 5% probability. Still, by means of orthogonal contrasts (Nogueira, 2004), the effect of the presence or absence of the organic compound in the substrates on the evaluated variable was verified.

**Results and discussion**

The dry mass of shoots (DMAP), roots (DMR) and total (TDM), as well as the Dickson quality index (DQI) were influenced (p ≤ 0.05) by the composition of the substrates (Table 2).

**Table 1. Physicochemical composition of BGOC, OCCC and SC substrates used in the rambutan tree experiment.**

| Substrates | pH | N    | P    | K    | Ca  | Mg  | C/N | PT | DU | DS | CRA | CTC |
|------------|----|------|------|------|-----|-----|-----|----|----|----|-----|-----|
| H2O        |    |      |      |      |     |     |     |    |    |    |     |     |
| BGOC       | 5.8| 6.3  | 0.7  | 3.4  | 3   | 1.6 | 16.9| 82 | 782.3| 419 | 140.5| 185.8|
| OCCC       | 5  | 8.2  | 0.7  | 5.5  | 2.4 | 1.4 | 21.5| 80 | 686.9| 417.3| 159.7| 301.7|
| SC         | 5.6| 4    | 2.5  | 6.9  | 10.4| 14.1| 83.2| 85 | 451.9| 273 | 292  | 200 |

*PH (potential of hydrogen); N (nitrogen); P (phosphorus); K (potassium); Ca (Calcium); Mg (magnesium); C/N (carbon and nitrogen ratio); PT (total porosity); DU (wet density); DS (dry density); CRA (water holding capacity); CTC (cation exchange capacity).

Among all substrates evaluated, BGOC (1:1) provided the best growth indicators for cedar seedlings (Table 3). This beneficial effect was also observed by Vieira and Weber (2015) in mahogany (Swietenia macrophylla King.) seedlings, and by Araújo et al. (2017) in paricá seedlings (Schizolobium amazonicum Huber ex Ducke), showing the potential of the organic compound as an alternative low-cost substrate.

Compared to SC, BGOC promoted mean increments of 26.29; 24.71 and 25.75% in shoot, root and total dry matter, respectively; indicating viability of this material in the production of cedar seedlings. SC provided the lowest growth indicators, possibly explained by the higher C/N ratio of the material, 83.2:1 (Table 1). Organic materials with a carbon/nitrogen ratio greater than 50 indicate the microbial immobilization of nitrogen, and can generate nutritional deficiency, resulting in lesser development of the seedling (Kiehl, 2004). On the other hand, the ratios between 10:1 and 20:1 favor the mineralization and release of nutrients from organic additives (Sarma; Gogoi, 2015).

Nitrogen is an essential macro element and influences protein synthesis and amino acid composition, in addition to being a constituent of macromolecules and enzymes. Its concentration can represent from 2 to 5% of the dry mass of plants. The nutrient can be absorbed by nitric (NO₃⁻) and ammoniacal (NH₄⁺) forms, and in the plant, it is associated with carbon chains, promoting increases in cellular components and production of green and dry matter (Galindo et al., 2017). In leaves, 70% of nitrogen is found in chloroplasts (Marenco; Lopes, 2013), acting directly in various photosynthetic
processes, such as the formation of chlorophyll pigments (PIAS et al., 2013).

The seedlings produced with the organic compost had higher DQI followed by the substrate formulated based on Brazil nut husk (p ≤ 0.05), which enables the use of compounds with nut husk, since they can biostimulate the plant, providing nutrients such as calcium (16 g·kg⁻¹), magnesium (3.8 g·kg⁻¹) and phosphorus (2.2 g·kg⁻¹) (SOARES et al., 2014). In addition, the use of this organic material reduces the environmental impact and cost in the production of seedlings (MARANHO et al., 2013; ARAÚJO et al., 2020).

The DQI was considered as representative of the global growth of the plant to analyze the values of the differences between the orthogonal contrasts (Table 4).

Table 3. Total dry mass (TDM), aerial part (DMAP) and root (DMR), and Dickson quality index (DQI) of cedar seedlings at 90 days after sowing in SC, BGOC (1:1) and OCCC (2:1).

| Substrates | DMAP (g) | DMR (g) | TDM* (g) | DQI |
|------------|----------|---------|----------|-----|
| BGOC (1:1) | 3.41 a   | 3.28 a  | 6.69 a   | 1.60 a |
| OCCC (2:1) | 3.06 b   | 2.88 b  | 5.94 b   | 1.41 b |
| SC         | 2.70 c   | 2.63 c  | 5.32 c   | 1.24 c |

Averages followed by equal letters in the column are similar by Tukey’s test (p > 0.05).

Table 4. Comparison by orthogonal contrasts between commercial substrate (SC) and substrate with organic compost.

| Source variation | Degree of freedom | Medium square |
|------------------|-------------------|---------------|
| Contrast (SC x BGOC, OCCC) | 1 | 0.3226* |
| Error            | 27                | 0.0020 |

*significant at 5%.

In the analysis by orthogonal contrasts, differences were found between commercial substrates and those containing organic compound. The use of compost provided higher averages than the commercial substrate for the quality index. In addition, the organic compost showed seedlings with greater growth characteristics when compared to the use of commercial substrate. Similar response to the contrast of organic compound and commercial substrate were reported by Delarmelina et al. (2013) for the growth of seedlings of Sesbania virgata (Cav.) Pers.

Conclusion

The brachiaria organic compost favored the accumulation of biomass and improved the quality of cedar seedlings, which can be used as a replacement for commercial substrate.

The crushed Brazil nut husk, although it resulted in lower growth than the brachiaria organic compost, had a high potential to be used in the composition of substrates, since the results were superior to the commercial substrate.

References

ALVARES, C. A.; STAPE, J. L.; SENTELHAS, P. C.; GONÇALVES, J. L. M.; SPAROVEK, G. Köppen’s climate classification map for Brazil. Meteorologische Zeitschrift, Stuttgart, v. 22, n. 6, p. 711-728, Dec./May 2013.

ANDRADE, F. R.; PETTER, F. A.; MARIMON JUNIOR, B. H.; GONÇALVES, L. G. V.; SCHOSSLER, T. R.; NÓBREGA, J. C. A. Formulação de substratos alternativos na formação inicial de mudas de ingaízeiro. Scientia Agraria Paranaensis, Marechal Cândido Rondon, v. 14, n. 4, p. 234-239, out./dez. 2015.

ARAÚJO, C. S. de; LUNZ, A. M. P.; SANTOS, B. B. dos; ANDRADE NETO, R. de C.; NOGUEIRA, S. R.; SANTOS, R. S. dos. Use of agro-industry residues as substrate for the production of Euterpe precatoria seedlings. Pesquisa Agropecuária Tropical, Goiânia, v. 50, n.1, p. 1-9, mar./fev. 2020.

ARAÚJO, E. F.; AGUIAR, A. S.; ARAUCO, A. M. de S.; GONÇALVES, E. de O.; ALMEIDA, K. N. S. de. Crescimento e qualidade de mudas de paricá produzidas em substratos à base de resíduos orgânicos. Nativa, Sinop, v. 5, n. 1, p. 16-23, jan./fev. 2017.

ARAÚJO, E. F.; SOUSA, L. B.; NÓBREGA, R. S. A.; NÓBREGA, J. C. A.; ARAUCO, A. M. de S.; PEREIRA, R. R.; LUTOSA FILHO, F. Organic residues improve the quality and field initial growth of Senna multifluga seedlings. Journal of Sustainable Forestry, Abingdon, v. 40. n. 3. p. 249-262. Apr. 2021.

CARVALHO, P. E. R. (2010) Brasília, DF: Embrapa Informação Tecnológica; Colombo, PR: Embrapa Espécies arbóreas brasileiras. Florestas, 4, 644.

DELARMELINA, W. M.; CALDEIRA, M. V. W.; FARIAS, J. C. T.; GONÇALVES, E. de O. Uso de lodo de esgoto e resíduos orgânicos no crescimento de mudas de Sesbania virgata (Cav.) Perf. Revista Agro@mbiente On-line, Boa Vista, RR, v. 7, n. 2, p. 184-192, maio/ago. 2013.
Carvalho et al. Influence of alternative substrates on biomass and quality of cedar seedlings

DICKSON, A.; LEAF, A. L.; HOSNER, J. F. Quality appraisal of white spruce and white pine seedling stock in nurseries. Forestry Chronicle, Mattawa, v. 36, n. 1, p. 10-13, Mar. 1960.

DUARTE, P. J.; BORGES, C. C.; FERREIRA, C. A.; CRUZ, T. M.; DE SOUZA, W. R. Q.; MORI, F. A. Anatomical identification of tropical woods traded in Lavras, Brazil. Journal of Tropical Forest Science, v. 33, n. 1, p. 95-103, Jan./Mar. 2021.

GALINDO, F. S.; BUZETTI, S.; TEIXEIRA FILHO, M. C. M.; DUPAS, E.; LUDKIEWICZ, M. G. Z. Application of different nitrogen doses to increase nitrogen efficiency in Mombasa guineegrass (Panicum maximum cv. mombasa) at dry and rainy seasons. Australian Journal Crop Science, v. 12, p. 1657-64, 2017.

HARTMANN, H.T.; KESTER, D.E. Plant propagation: principles and practices. 8. ed. New Jersey: Prentice Hall, 915 p. 2011.

KIEHL, E. J. Manual da Compostagem: Maturação e Qualidade do Composto. 4. ed. Piracicaba, 2004. 173 p.

MANCA, A.; SILVA, M. R. da; GUERRINI, I. A.; FERNANDES, D. M.; BOAS, R. L. V.; SILVA, L. C. da; FONSECA, A. C. da; GUGGIU, M. C.; CRUZ, C. V.; SIVISACA, D. C. L.; MATEUS, C. de M. D.; MURGIA, I.; GRILLI, E.; GANGA, A.; CAPRA, G. F. Composted sewage sludge with sugarcane bagasse as commercial substrate for Eucalyptus urograndis seedling production. Journal of Cleaner Production, ATDMerdam, v. 269, p. 1-10. Oct. 2020.

MARANHO, S. Á.; PAIVA, A. V. de; PAULA, S. R. P. de. Crescimento inicial de espécies nativas com potencial madeireiro na Amazônia, Brasil. Revista Árvore, Viçosa, v. 37, n. 5, p. 913-921, set./out. 2013.

MARENCO, R. A.; LOPES, N. F. Fisiologia Vegetal. 3. Ed. Viçosa: Ed. da UFV, 2013. 486 p.

NOGUEIRA, M. C. S. Orthogonal contrasts: definitions and concepts. Scientia Agricola, v. 61, n. 1, p. 118-124, jan./fev. 2004.

PIAS, O. H. de C.; CANTARELL, E. B.; BERGHETTI, J.; LESCHEWITZ, R.; KLUGE, E. R.; SOMAVILLA, L. Doses de fertilizantes de liberação controlada no índice de clorofila e na produção de mudas de gráopia. Pesquisa Florestal Brasileira, Colombo, v. 33, n. 73, p. 19-26, jan./mar. 2013.

PINTO, G. P.; TOMIO, D. B.; FERREIRA, R. L. F.; ARAUJO NETO, S. E de; SOUZA, L. G. de S. e; SILVA, N. M. da. Crop of organic arugula in greenhouse using high seedlings from different volumes of substrates. Comunicata Scientiae, Bom Jesus, v. 12, n. 1, p. 1-7. maio 2021.

SANTOS, J. P.; BRAGA, L. F.; RUEDDELL, C. M.; SEBEN JUNIOR, G. de F.; FERBONINK, G. F.; CAIONE, G. Caracterização física de substratos contendo resíduos de cascas de amêndoas de castanha-do-brasil (Bertholletia excelsa H.B.K). Revista de Ciências Ambientais, Canoas, v. 12, n. 2, p. 7-17. maio/ago. 2018.

SANTOS, V. A. H. F. dos; FERREIRA, M. J. Initial establishment of commercial tree species under enrichment planting in a Central Amazon secondary forest: Effects of silvicultural treatments. Forest Ecology and Management, v. 460, n. 1, p. 1-10, Jan. 2020.

SARMA, B.; GOGOI, N. Germination and seedling growth of Okra (Abelmoschus esculentus L.) as influenced by organic amendments. Cogent Food & Agriculture, v. 1, n. 1. Apr. 2015.

SOARES, I. D.; PAIVA, A. V. de; MARANHO, Á. S. Propriedades físico-químicas de resíduos agroflorestais amazônicos para uso como substrato. Nativa, Sinop, v. 2, n. 3, p. 155-161. jul./set. 2014.

VIEIRA, C. R.; WEBER, O. L. dos S. Avaliação de substratos na produção de mudas de mogno (Swietenia macrophylla King). Revista Uniara, v. 18, n. 2, p. 153-166. dez. 2015.

VIEIRA, S. B.; CARVALHO, J. O. P de; GOMES, J. M.; SILVA, J. F. da S.; RUSCHEL, A. D. R. Cedrela odorata L. tem potencial para ser utilizada na silvicultura pós-colheita na Amazônia brasileira? Ciência Florestal, Santa Maria, v. 28, n.3, p. 1230-1238, jul.-set, 2018.

WIENER, E. M. Ecological Research and the Management of Young Sucessional Forests: A case Study on the Reintroduction of Native Tree Species on a Terra Firme Site in Northeastern Peru. Journal of Sustainable Forestry, v. 29, n. 6, p. 571-590, June/Agu., 2010.