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# 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 Sitio 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).

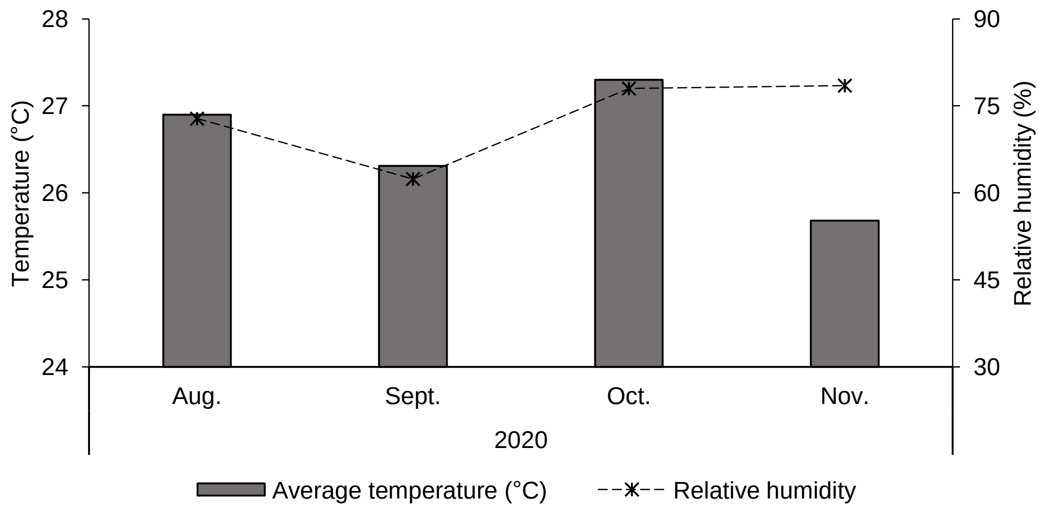


**Figure 1.** Temperature and relative humidity monthly average from Rio Branco, Acre, during the trial period.

**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 | g kg$^{-1}$ | | | | | | % | kg m$^{-3}$ | | %m/m | mmol dm$^{3}$ |
| 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 capability).

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 cm$^3$ 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:

$$\mathrm{DQI} = \frac{\mathrm{TDM(g)}}{\left(\frac{\mathrm{A(cm)}}{\mathrm{DC(mm)}} + \frac{\mathrm{DMAP(g)}}{\mathrm{DMR(g)}}\right)}$$

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 ($p \leq 0.05$) by the composition of the substrates (Table 2).

**Table 2.** Summary of analysis of variance (ANOVA) for aerial part (DMAP), root (DMR), total (TDM) dry mass and Dickson quality index (DQI) as a function of commercial substrates, organic compost of brachiaria (1:1) and organic compost of brachiaria combined with Brazil nut husk (2:1).

| Source variation | Degree of freedom | DMAP | DMR | TDM | DQI |
|---|---|---|---|---|---|
| | | medium square | | | |
| Substrate | 2 | 1.2925* | 1.0531* | 4.6582* | 0.3226* |
| Error | 27 | 0.0799 | 0.0271 | 0.1571 | 0.0208 |
| CV | - | 9.25 | 5.63 | 6.62 | 10.16 |

* significative at 5%.

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 ($p \leq 0.05$), 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 | DMR | TDM* | DQI |
|---|---|---|---|---|
| | | (g) | | |
| 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 |

* significative 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.

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