*Full Length Research Paper*

# Does the quality of *Luehea divaricata* seedlings in the nursery correspond to their behavior in the field?

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The species, *Luehea divaricata* offers great ecological and timber potential in addition to a wide geographic distribution, although there are few studies comparing seedling production in the nursery with its development in the field. Therefore, this research aimed to evaluate the performance of *L. divaricata* seedlings produced in different substrates in the nursery, as well as verify if the results obtained influence survival and growth after planting in the field. The seedlings were produced with four different substrate formulations (T1: 100% peat-based commercial substrate (Peat); T2: 80% peat and 20% carbonized rice husk (CRH); T3: 60% peat and 40% CRH; T4: 40% peat and 60% CRH). In the nurseries, at 202 days after sowing, the height, stem base diameter, aerial dry mass, root dry mass, total dry mass and Dickson quality index were evaluated. After the seedlings were planted in the field, their survival, height growth and stem base diameter were monitored. *L. divaricata* seedlings produced with up to 40% CRH mixed with peat-based commercial substrate can present adequate growth in the field, although improved performance may occur with even 20% CRH. It should be noted that the growth response of *L. divaricata* seedlings in the nursery is more efficient when associated with the performance of the seedlings in the field.

**Key words:** Native species, carbonized rice husk, initial growth after planting, substrate.

## INTRODUCTION

The growing demand for forest seedlings for various purposes makes the production of healthy and well-developed seedlings increasingly necessary. The quality of the seedlings is of fundamental importance and is linked to the success of reforestation (Lima et al., 2014; Navroski et al., 2015). Therefore, it is important to establish a quality standard for seedlings of different species or groups, for adequate growth and survival in

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the field.

One of the important factors that influences the development of seedlings in nurseries is the composition of the substrate and proportion of components (Filho et al., 2015), which is directly related to seedling vigor at the time of sowing and consequently in post-planting. This influence may be associated with porosity, which is directly linked to the water-holding capacity (aeration space and easily available water) and availability of nutrients to the plant. In addition to the physical and chemical characteristics of the substrate, economic factors (low cost and availability) and ease of management should be considered in the choice of this input (Gasparin et al., 2014).

Many studies have addressed the use of inputs and suitable techniques for the production of seedlings in the nursery (Mesquita et al., 2011; Kratz et al., 2015; Berghetti et al., 2016). However, the behavior of the plants when transferred and planted in the field is not commonly investigated (Abreu et al., 2015). Thus, the results obtained only in the nursery may lead to erroneous conclusions (Vallone et al., 2009).

*Luehea divaricata* Mart. et Zucc belongs to the family Malvaceae and features wide geographical distribution, including Brazil, Uruguay, Argentina, Paraguay (USDA, 2015) and Bolivia (Tropic, 2015). This species is classified as a pioneer, with fast growth and economic potential, especially for the furniture industry, and it is eco-friendly, since it is recommended for mixed reforestation of degraded areas and permanent preservation (Carvalho, 2003).

Thus, this study aimed to evaluate the development of *L. divaricata* seedlings produced in different substrates in the nursery, as well as to verify whether the responses obtained in the nursery correspond to the survival rate and initial growth of the seedlings in the field.

## MATERIALS AND METHODS

### Seedling production (Experiment 1)

The fruits were collected from eight trees in a forest fragment (29°42'02" South and 53°47'12" West), in the municipality of Santa Maria, Rio Grande do Sul, Brazil. After processing the fruits and extracting the seeds, the seeds were stored for four months in Kraft paper bags in a cold chamber at a temperature of ±8°C and relative humidity of 80%.

The seedlings were produced in the forest nursery of the Federal University of Santa Maria (29°43' S and 53°43' W). Sowing was performed in polypropylene conical tubes with 110 cm³ of capacity. The substrates used for production of seedlings were composed of different proportions of peat-based commercial substratum (peat) Carolina Soil® and carbonized rice husk (CRH), with treatments being characterized as T1-100% peat, T2-80% peat and 20% CRH, T3-60% peat and 40% CRH and T4-40% peat and 60% CRH. Controlled release fertilizer (NPK 15:09:12) was used in the base

fertilizer at a dosage of 6.0 g $L^{-1}$.

The physical analysis of the substrate was performed at the Substrates Laboratory of the Department of Horticulture and Forestry of the Federal University of Rio Grande do Sul (Table 1). Sowing was carried out with three seeds per container. Sixty days after sowing (DAS), thinning was carried out, leaving just the most central and vigorous seedling. The seedlings were kept in the greenhouse for 82 days and were then then transferred to beds in full sunlight with irrigation depth of 16 mm/day$^{-1}$, as recommended by Dutra (2012).

The nursery experiment was carried out in a randomized block design with four blocks and four formulations of substrates. The plot was composed of 24 seedlings, and the height (H) and stem diameter (SD) of the nine individuals was evaluated. Out of these, a sample of three plants was taken for destructive analyses (biomass production).

At 202 DAS, seedling height and stem diameter were evaluated with a graduated ruler and digital caliper, respectively. In addition, analysis of aerial dry mass (ADS), root dry mass (RDM) and total dry mass (TDM) was carried out. The aerial part was separated from the root with a pruning shear and the root system washed under running water in order to remove the substrate. The samples were placed in Kraft paper bags and dried in an oven with forced air circulation at 70°C for 72 h. Afterwards, the material was weighed in order to obtain the ADS and RDM, which resulted in the sum of the parts by TDM. The Dickson quality index (DQI) was calculated using TDM (g)/[H (cm)/SD (mm) + ADS (g)/RDM (g)] (Dickson et al., 1960).

### Planting in the field (Experiment 2)

Considering the respective treatments, seedlings from Experiment 1 were planted in an area belonging to UFSM (29° 43 ' South Latitude and 53° 44 ' West Longitude), Santa Maria, RS. The climate of the region is Cfa type according to Köppen, with annual average precipitation of 1720 mm and average annual temperature of 19.1, 32 and 9°C, the averages of the hot and cold months, respectively (Heldwein et al., 2009). The area features soil classified as Gray Argisol (Streck et al., 2008) and chemically analyzed at the Soil Analysis Laboratory of UFSM (Table 2). The area was prepared by mowing and sub soiling the planting line followed by opening holes in the dimensions of 5 x 15 cm with 100 g of dolomitic limestone to the hole.

Experiment 2 was conducted in randomized block design with a factorial scheme, with plots subdivided by time (substrate x time). Five blocks were used with nine seedlings per sampling unit, totaling 45 seedlings per treatment and 36 seedlings in each block. The spacing used in the planting was 2 x 2 m.

Seedling survival rate was assessed at 30 and 60 days after planting. On the occasion, fertilization with NPK (5:20:20) was carried out following nutritional recommendations for *Eucalyptus* (SBCS/CQFS, 2004). Two months after planting, concurrent to the second survival rate assessment, the first measurement of height (H) and stem diameter (SD) was conducted, which was maintained at intervals of 60 days during the first 12 months. To assess this, a graduated ruler and digital caliper were used, respectively.

Data were subjected to verification of the assumptions of normality and homogeneity of variance and, afterwards, statistical analysis was performed using the program SISVAR (Ferreira, 2014). Analysis of variance and comparison of means was carried out using the Tukey test and regression analysis at 5% probability of error.

**Table 1.** Physical characteristics of substrates used in the production of *L. divaricata* Mart. Et Zucc seedlings.

| Substrates | AS (%) | EAW (%) | BW (%) | RW (%) |
|---|---|---|---|---|
| T1 | 27.75 | 20.88 | 3.94 | 31.8 |
| T2 | 32.15 | 18.71 | 4.00 | 28.39 |
| T3 | 36.78 | 14.42 | 2.74 | 29.09 |
| T4 | 48.16 | 14.39 | 2.88 | 19.18 |

T1- 100% peat, T2- 80% peat and 20% CRH, T3- 60% peat and 40% CRH and T4- 40% peat and 60% CRH. AS = aeration space; EAW = easily available water; BW = buffering water; RW = remaining water.

**Table 2.** Chemical analysis of the soil from the planting area, Santa Maria, RS, Brazil.

| pH | P* | K | Ca | Mg | Al | MO | Clay | V |
|---|---|---|---|---|---|---|---|---|
| H$_2$O | -----mg.dm$^{-3}$ ----- | | --------- cmol$_c$.dm$^{-3}$ --------- | | | -------------- % -------------- | | |
| 4.8 | 3.0 | 0.153 | 7.9 | 2.9 | 3.0 | 2.8 | 21 | 41.6 |

P: phosphorus *extracted by Mehlich's method I; K: potassium; CA: calcium; Mg: magnesium; Al: aluminum; OM: organic matter; V: base saturation.

**Table 3.** Characteristics of *L. divaricata* seedlings grown in different substrates in the nursery, 202 days after sowing, Santa Maria, RS, Brazil.

| Substrates | H | SD | ADS | RDM | TDM | DQI |
|---|---|---|---|---|---|---|
| T1 | 33.44[a] | 6.88[a] | 5.14[ab] | 4.82[a] | 9.96[ab] | 2.04[a] |
| T2 | 32.47[a] | 6.82[a] | 5.68[a] | 5.87[a] | 11.55[a] | 1.68[ab] |
| T3 | 29.69[b] | 6.59[a] | 3.67[bc] | 4.26[ab] | 7.93[bc] | 1.48[b] |
| T4 | 21.66[c] | 3.61[b] | 3.04[c] | 2.18[b] | 5.22[c] | 0.70[c] |

H = height (cm); SD = stem diameter (mm); ADS = aerial dry mass (g); RDM = root dry mass (g); TDM = total dry mass (g); DQI Dickson quality index; T1 = 100% peat; T2 = 80% peat and 20% CRH; T3 = 60% peat and 40% CRH and T4 = 40% peat and 60% CRH. *Means followed by the same letter, in the column, do not differ from each other, according to Tukey's test at 5% probability.

## RESULTS AND DISCUSSION

### Seedling production (Experiment 1)

The use of different proportions of commercial substrate and carbonized rice husk influenced *L. divaricata* seedling growth during the nursery stage (202 DAS) for all variables analyzed (Table 3). For the height variable, the best results were found in T1 (100% peat) and T2 (80% peat and 20% CRH), which did not differ statistically, while T4 (40% peat and 60% CRH) presented the lowest value for this variable as well as for stem diameter. Saidelles et al. (2009) found similar results, in which the highest proportions of carbonized rice husk also provided a less significant development of *Apuleia leiocarpa* seedlings. This was possibly due to the

high proportion of carbonized rice husk, which results in increased macro porosity (Silva et al., 2012), as noted in T3 and T4, which presented airing space (AS) above 35% and easily available water (EAW) below 15%. Treatments T1 and T2 on the other hand presented approximately 28 and 32% of AS, and 21 and 19% of EAW, respectively (Table 1).

The aerial dry mass (ADS) and total dry mass (TDM) presented the highest means when produced with up to 20% CRH, while root development was expressive with up to 40% CRH, which is due to the need for aeration of the root system (Delarmelina et al., 2014). For Trigueiro and Guerrini (2014), substrates with 40 and 60% CRH in mixtures with sewage sludge are best suited for the production of *S. terebenthifolius* seedlings.
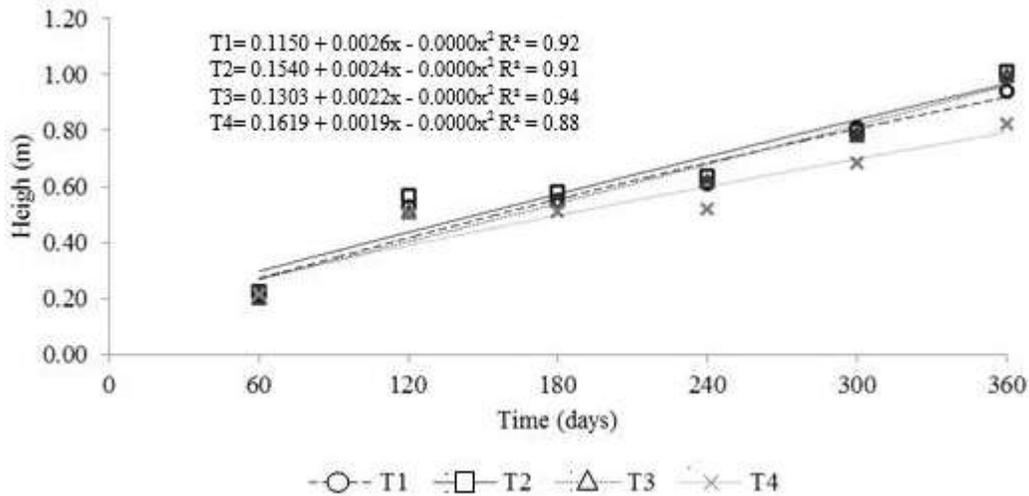
However, considering that TDM is a result of net

**Figure 1.** Growth in height (m) of *L. divaricata* seedlings, at 60, 120, 180, 240, 300 and 360 days after sowing in the field as a function of different types of substrate for seedling production. Where: T1 = 100% peat, T2 = 80% peat and 20% HRC, T3 = 60% peat and 40% HRC and T4 = 40% peat and 60% HRC.

photosynthesis, the proportion of 40% CRH can be considered a proper mixture, thus confirming *L. divaricata* that substrates composed of 20 to 40% of porous materials provide better growth conditions for plants produced from seeds, as proposed by Wendling et al. (2002).

The Dickson quality index (DQI) confirmed the results obtained for most of the variables evaluated, thus indicating that the DQI reduces with the increase in the percentage of CRH in the substrate composition. Similar behavior was observed by Oliveira et al. (2014) when testing different substrates for seedling production of *Eucalyptus* spp. and *Corymbia citriodora*, with the substrate composed of 75% CRH, which presented the least significant results for this variable in comparison with 25 and 50% mixture of CRH.

**Planting in the field (Experiment 2)**

At 30 and 60 days after planting in the field, a higher seedling survival rate was observed with values of 99.5 and 97% of survival, respectively. These percentages were similar in all treatments and are within the limits described by Carvalho (2003), who mentioned survival in experimental plantations ranging from 72 to 100%. The high survival rate may be related to the ruggedness and adaptability of the species, which even in acidic soils and with considerable nutritional deficiency (Table 1), obtained elevated values.

For the height variable (Figure 1), it was observed that at 60, 120 and 180 days after sowing, there was no difference between the substrates, although the highest values observed in all measurements were for seedlings produced in 80% peat and 20% CRH (T2) and 60% peat and 40% CRH (T3).

At 240, 300 and 360 days after sowing, treatments T1, T2 and T3 showed very similar values, differing only in T4, which presented the lowest mean growth (height). These results partially confirm the values found in the experiment held in the nursery (Experiment 1), where T1 and T2 exhibited the greatest growth in height, while T4 the lowest growth for this variable.

Regarding height growth at the time (Figure 1), a significant increase was perceived between the first and second measurements in all types of substrates, contrary to what was observed regarding the two subsequent measurements. This was likely due to the unfavorable weather conditions of the following season, characterized by low temperatures and shorter photoperiod (April to August) in the study region. Growth becomes expressive once again in the fourth measurement, with the end of winter and early spring for all types of substrates, and which remained elevated until the final measurement (September to November). These results corroborate with Neves et al. (2006), who stated that several species have their growth interrupted in the colder seasons, restarting growth in the spring, with the increase in temperature and day length.
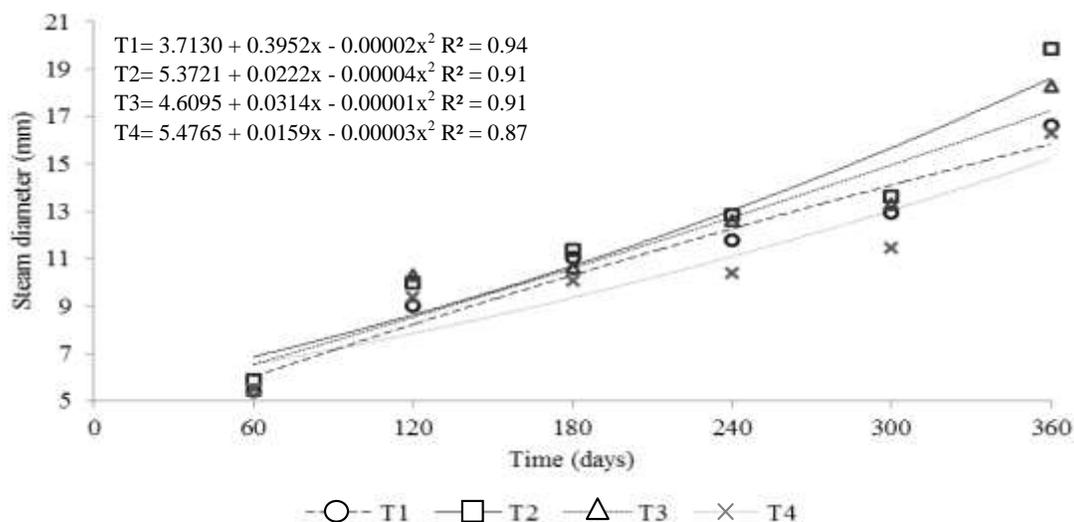
For the stem diameter (Figure 2), the seedlings showed

**Figure 2.** Growth in stem diameter (mm) of *L. divaricata* seedlings, at 60, 120, 180, 240, 300 and 360 days after sowing the field according to the type of substrate for seedling production. Where: T1 = 100% peat, T2 = 80% peat and 20% HRC, T3 = 60% peat and 40% HRC and T4 = 40% peat and 60% HRC.

no difference in the first three evaluations (60, 120, 180 days) for all substrates. At 240 and 300 days after sowing, T2 and T3 showed the highest average SD, while T4 presented the lowest average in the same evaluation period. In the last measurement, this growth behavior was maintained, with the highest mean in T2, thus standing out among the other treatments and the lowest mean verified in T4.

According to Gonçalves et al. (2000), a mixture with 70 to 80% of an organic component and 20 to 30% of a compound that increases macroporosity provides appropriate substrates for seedling production. In *L. divaricata*, high percentages of CRH in the composition of the substrate must be avoided, as evidenced in T4, which presents 60% CRH in its composition, providing the lowest values for both variables evaluated. Stem diameter growth (Figure 2) behaved similarly to height growth (Figure 1), which showed increased development in hotter periods (September to March) and decreased development in the colder seasons (April to August), although maintaining the same response in height in relation to the substrate. Another factor that may have influenced the results is the ruggedness of the species studied, which can adapt to different environments, whether the environment is dry or wet, shallow or rocky (Carvalho, 2003).

Treatments T2 and T3 exhibited similar growth for the variables analyzed in the field, despite T3 presenting lower values for most of the observed variables in the nursery. This tendency was confirmed by Gasparin et al. (2014), who reported that although a substrate composed

of 60% peat and 40% CRH did not provide the best result in the nursery, it did not differ from other substrates, when the *Cabralea canjerana* seedlings were transferred to the field. Such responses indicate the importance of the confirmation of the nursery results after immediate planting, especially in the first year, a period during which the seedlings need to overcome weed competition.

In this sense, the use of substrates consisting of 20% to 40% CRH is recommended as a way of reducing production costs, since this is a residue of rice production that causes no harm in the initial development of the species in field planting.

**Conclusion**

*L. divaricata* seedlings produced with up to 40% of carbonized rice husk and mixed with commercial peat-based substrate presented adequate initial growth in the field, although the best performance of the seedlings in the nursery occurred with up to 20% of carbonized rice husk. Growth responses of *L. divariacata* seedlings in the nursery were more efficient when associated with the performance of seedlings in the field.

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