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Seed seedlings development of different *Eucalyptus* and *Corymbia* species purposing forestry advancements for Cerrado biome

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Abstract
The production of quality seedlings has a direct impact on the productivity of a forestry establishment. Knowing the specifics of each specie and its adaptation to the edaphoclimatic conditions of a given region is essential for the success of a forest plantation. The production of seedlings of *Eucalyptus* spp. and *Corymbia* spp. presented in this work comes from the sexual propagation, by seeds. The study carried out the comparison between 13 species of *Eucalyptus spp.* and *Corymbia* spp., verifying the quality of the seed lots, via in vitro germination test and by sowing in tubes. The biometric measurements applied in this study were total seedling height, neck diameter and seedling vigor, three measurements of seedlings were carried out in plastic bags and the data were transferred to the R software to be analyzed, applying split-plot analysis of variance (ANOVA) and means of variables. The germination percentage was higher in tubes than the results obtained *in vitro*, with emphasis on the results of the species *Eucalyptus dunnii*, *Corymbia citriodora*, *Eucalyptus longirostrata* and *Corymbia maculata*, which reached 100% germination in tubes and these are also the species that stood out in biometric measurements, with emphasis on the results of the species *Eucalyptus dunnii*, *Corymbia citriodora* and *Eucalyptus longirostrata*. The study aimed to generate viable, healthy and vigorous seedlings from seminal propagules of *Eucalyptus* spp. and *Corymbia spp.*, to compose, at the end of the experiment, which has the potential to extend, beyond this study, the *Eucalyptus* Garden at Escola de Agronomia - EA/UFG), Goiânia, GO, Brazil, collaborating with the practical classes that will be able to use the space to present to the students the features inherent to the species.

Keywords
Germination – Seed vigor – Biometric measurements – Forest production

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1. Introduction

Planted forests in Brazil currently occupy 9.6 million hectares, areas with *Eucalyptus* cover 77.3% of the planted forests, according to data released by the IBGE Agency, in the "2020 Produção da Extração Vegetal e da Silvicultura" of IBA (2021), the planted trees sector had a growth of 17.6% in the gross value of production in Brazil in 2020. The total productive investment of companies associated with IBÁ was, on the order of US$ 60.0 billion, 24.0% above the previous year, highlighting investments in operations and expansion. *Eucalyptus* is the most commercially exploited tree in Brazil, and its economic indicators demonstrate its high productive and profitable potential, showing that investment in this market is viable.

In the Cerrado biome, there are some companies focused on their genetic breeding and consequently on increasing their production. The states of Minas Gerais (MG), São Paulo (SP), Mato Grosso do Sul (MS), Paraná (PR), Rio Grande do Sul (RS) and Santa Catarina (SC) continue to be the largest country holders of planted forests. Efforts still deserve to be made to strengthen the forestry scenario in the state of Goiás (GO), especially for planting and harvesting eucalyptus forests (Bahia et al., 2022). Possibly generating genetic materials specifically breeded and adapted to the Brazilian Midwest reality.

The seedling production process depends on several biotic and abiotic factors, starting with the quality of the seed lot that will be used. The care with raw material (seeds) must start from its origin, in the handling phases

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until obtaining the seeds. It is important to give due care to the storage of seeds, attention to exposure to temperature and humidity (Hoppe 2004). On the other hand, climatic conditions (Binkey et al., 2017) and genetic conditions (Castro et al., 2016) also directly interfere with the quality of seedlings, thus, in any seedling production system, the technology used must be adequate to the obtaining good quality seedlings (Simões, 1987).

According to Moura (2003), in Brazil the most used seedling production systems are: Seedlings from seeds and through the rooting of cuttings (clonal planting). In the system where the seedlings are produced by seeds, these can be obtained from commercial plantations, production areas or from orchards that carry seeds genetically improved through selections. In Brazil, the most planted species are *Eucalyptus grandis* and *Eucalyptus urophylla* and their hybrids (Assis et al., 2015). According to Oliveira et al. (2020), *Eucalyptus* plantations in Brazil are expanding to the North and Midwest regions of the country, their study on the evaluation of genetic and clonal parameters for *Eucalyptus* selection in the Cerrado biome region, indicated that clones of *E. urophylla* and *E. urophylla* × *E. grandis*, were the most productive (Oliveira et al., 2019; André et al., 2021).

Studies by Fernandes et al. (2016), already indicated the trend of expansion of the occupation of anthropized areas of the Cerrado biome, for the production of planted forests. Therefore, the application of studies that deal with the performance of different *Eucalyptus* species, through the production of seedlings and germination of forest seeds, in the region is relevant and can collaborate with the advancement of *Eucalyptus* spp. and *Corymbia* spp. to the Midwest region of the country, to occupy areas with productive forest plantations and supply the demand for forest products, whether timber or non-timber.

This work presents the study of germination test and seedling production of 13 species of *Eucalyptus* spp. and *Corymbia* spp., through the edaphoclimatic aptitude of the State of Goiás. Aiming at the development of *Eucalyptus* seedlings, both for didactic purposes, as to enable the verification of the adaptability of these species to drought and heat, in the region of Goiânia - GO. Therefore, testing the germination potential of 13 *Eucalyptus* spp. and *Corymbia* spp., both in a laboratory environment (gerbox) and in a nursery (plastic tubes); conduct the healthy growth of seedlings in an appropriate substrate; transplant the seedlings to a semi-definitive location (larger containers for future plantings in the *Eucalyptus* Garden of the Escola de Agronomia – EA/UFG); and evaluate the growth of seedlings in total height, neck diameter and seedling vigor.

2. Material and Methods

2.1 Plant Material

Seeds of 13 species of the genera *Eucalyptus* spp. and *Corymbia* spp. Myrtaceae family (Table 1), namely: *Corymbia citriodora* Hook.; *Eucalyptus cloeziana* F.Muell.; *Eucalyptus longirostrata*; *Eucalyptus pellita* F.Muell.; *Eucalyptus siderophloia* Benth.; *Eucalyptus dunnii* Maiden; *Eucalyptus maculata* Hook.; *Eucalyptus resinifera* Sm.; *Eucalyptus benthamii* Maiden & Cambage; *Eucalyptus grandis* W. Hill; *Eucalyptus globulus* Labill.; *Corymbia intermedia* (F.Muell. ex RTBaker) KDHill & LASJohnson; *Corymbia torelliana* (F.Muell.) KDHill & LASJohnson.

2.2 Methods – Laboratory

In the laboratory, distilled water was used to moisten the substrate, seeds of 13 species of *Eucalyptus* spp. and *Corymbia* spp., sodium hypochlorite solution diluted in water (with 2.5% of active principle), sterile blotting paper substrate, gerbox and petri dishes. Other equipment was used, such as: analytical balance; graduated glass beaker; sieve; tray; tweezers; in addition to gloves, 70% alcohol and filter paper.

In the nursery, the structure of the greenhouse was used. To disinfect the materials, a solution of sodium hypochlorite diluted in water was used. The container used were tubes of 55 cm^3 distributed in trays. For substrate preparation, the fertilizer Osmocote 14-14-14 was added. Sowing was carried out with the aid of tweezers and a petri dish. The experiment in tubes was identified with plates containing the respective species code and sowing date. The water was also used for rinsing materials and sprinkler irrigation.

2.3 Methods – Seedling Production

The experiment was carried out in a greenhouse at Viveiro Escola - ProFloresta of Escola de Agronomia - (EA/UFG), Goiânia, GO, Brazil (16°35'33.54"S, 49°17'27.09"W). According to the Köppen-Geiger climate classification, the climate is classified as *Aw*. The temperature here averages 23.4 °C. The seeds underwent a germination test, following the Instructions for Analysis of Forest Seeds (BRASIL, 2013) and the Rules for seed analysis (BRASIL, 2009). The germination test is important to evaluate the quality of the seed lot that will be used in the nursery for seedling production. Knowing the maximum germination potential of the 13 species of *Eucalyptus* spp. and *Corymbia* spp., under controlled laboratory conditions,

Manual sampling was performed, and, to homogenize the material, the container containing the seeds must be

Table 1. *Eucalyptus* spp. and *Corymbia* spp. used in this work. The lots were supplied by Klabin SA and "Instituto de Pesquisas e Estudos Florestais" (IPEF), respectively.

Genre	Code	Institution Source	Site Provenance*	Species	Track*	Year Collection
Eucalyptus	A	Klabin	ME 280	*E. grandis*	F38B2A3	2019
Eucalyptus	B	Klabin	Green gold	*E. benthamii*	10	2014
Eucalyptus	C	Klabin	MG	*E. sideraphyloia*	arv 3	2018
Eucalyptus	D	Klabin	ME 106	*E. dunnii*	A41	2019
Eucalyptus	E	Klabin	IPEF – Indoor Orchard	*E. pellita*	M316/10	2020
Corymbia	F	Klabin	MG	*C. toreliana*	82	2014
Eucalyptus	G	Klabin	BMR – I9A	*E. globulus*	7423 A1	2018
Eucalyptus	H	Klabin	Operational planting	*E. resinifera*	3	2012
Corymbia	I	Klabin	ME 002	*C. intermedia*	5	2019
Corymbia	J	IPEF	Ninheira (MG)	*C. citriodora*	00	2018
Eucalyptus	K	IPEF	Anhembi (SP)	*E. cloeziana*	A16B119	2008
Eucalyptus	L	Klabin	ME 625	*E. longirostrata*	TO 1	2019
Corymbia	M	Klabin	ME 221	*C. maculata*	3	2012

* Tree Matrices codes as provided by the institutions.

shaken before sampling (BRASIL, 2019). In the laboratory, all the material that was used in the experiment, including the seeds, underwent asepsis and/or sterilization process. The asepsis of the seeds was performed by immersion in a solution of sodium hypochlorite diluted in water (with 2.5% of active principle), for 5 minutes, followed by rinsing in water, until all residue of the solution was eliminated. The seeds were arranged on paper in a gerbox for germination.

According to the "Instruções para Análise de Sementes de Espécies Florestais", as these are *Eucalyptus* seeds, 100 seeds of each species were used for the germination test, distributed in 4 replications of 25 seeds, so that, in each gerbox there was a repetition containing 25 seeds evenly distributed. The distance must be sufficient so that there is no competition and favoring contamination between the seeds and seedlings that will be developed.

Two evaluations of the experiment were carried out in the laboratory, the first one after 5 days of test assembly, performing the count of how many seeds germinated, evaluating whether normal and abnormal seedlings were generated and also the amount of non-germinated seeds. As a result, only the generation of normal seedlings was considered. The second evaluation was performed 14 days after the experiment was set up. The comparison between the data obtained in the first and second evaluation provided information on the percentage of seed germination of the 13 *Eucalyptus* forest species.

In the nursery, the experiments were carried out inside the greenhouse and greenhouse. The container used was the rigid plastic tube, due to the ease of handling and availability in the market, in addition to having smaller dimensions that favor transport. Studies indicate that the tubes can contribute to the reduction of pests and diseases and with the help of trays and benches, they can be suspended, which can collaborate with a better working condition (Schorn, 2003).

In the preparation of the containers, it was used sodium hypochlorite diluted in water, to disinfect trays and tubes of 55 cm^3, submerged in a tank for 10 minutes, after that, the containers were rinsed with water until all residue was removed and placed to dry. The tubes were filled with substrate enriched with NPK 14-14-14 fertilizer. The isolated use of subsoil land should be avoided as it leads to a high percentage of faults and the use of clay peat as it leads to an inadequate state of aggregation between the substrate and the root system (De Aguiar, 1989). In each block of the experiment, identification plates containing the species code and date were used.

The seeds of *Eucalyptus* spp. and *Corymbia* spp. were sown on the substrate, with the aid of tweezers and a petri dish, with 4 to 5 seeds per tube, with 20 replicates per species, that is, each tube counted as one replicate, so 20 tubes with seeds were assembled sown for each species, aiming at the end of the experiment to obtain 20 seedlings for each specie. Water from the sprinkler irrigation system of the greenhouse was used to keep the experiment moist and conducive to seedling

development.

Considering good nursery practices, the experiment that was set up in the greenhouse went through the following steps: sowing in a tube, monitoring the weekly development; pricking out soon after seedling emergence. An important consideration is that in the transplanting phase, in cases where there was no seedling emergence in one of the tubes of the same species where more than one seedling had developed in the same tube, the excess seedling was transplanted into this tube. that was empty. The percentage of germination and seedling formation in tubes was evaluated.

After setting the roots, in the substrate, in a tube, forming the seedlings, the seedlings were transplanted to a semi-definitive place, large black polyethylene plastic bags, suitable for the production of seedlings. According to Gomes (2003), as the seedlings get older, they grow and, consequently, the required amounts of nutrients increase. These larger containers are suitable for the establishment of seedlings, for future planting in the *Eucalyptus* Garden of the Escola de Agronomia - EA/UFG.

The plastic bags were filled with an appropriate substrate for seedling production, containing subsoil soil, sand and organic compost. All material was sieved. Mixed mineral fertilizer, NPK fertilizer was added in the proportion of 0:30:20 (%N; %P205; %K2O), indicated for application via soil. The entire substrate was homogenized and then the bags were filled with the aid of a PVC pipe shovel. The bags were transported to the greenhouse in a wheelbarrow and arranged in 3 blocks with 5 bags for each species of *Eucalyptus* spp. and *Corymbia* spp.

The seedlings, which were initially developed in tubes, were transplanted into large plastic bags. Day zero was considered to be the day of transplantation (February 24, 2022). From then on, three periodic measurements were performed. The first data measurement was performed 08 (eight) days after transplanting the seedlings (March 04, 2022); the second measurement was performed 33 (thirty-three) days after transplantation (March 28, 2022); and the third and last measurement was carried out after 155 (July 29, 2022), and from the second measurement, the seedlings were placed outside the greenhouse for better hardening.

2.3.1 Experimental Design

The experiment was installed in a randomized block design, with 03 (three) blocks and 05 (five) replicates (observations per plot), for each species in each block. Fifteen bags were produced for each species, evenly distributed between block 1, block 2 and block 3. Five seedlings of each specie were placed in each block. Seedlings were randomly selected.

2.3.2 Biometric Measurements

The total height of the seedling, stem diameter and vigor were measured in the seedlings, stem diameter and vigor were measured in seedlings developing in plastic bags, and these measurements were carried out in three periodic measurements (8, 32 and 155 days after seedling transplanting). The height of the seedlings was measured with the aid of a ruler with a centimeter scale, from the collar to the apex of the stem, the neck diameter was determined with the aid of a digital caliper, the height of the soil (collection), with a scale in millimeters, always checking the calibration of the equipment, between measurements, for correct use, maintaining the accuracy and accuracy of the data.

A vigor scale was applied to all seedlings to assess quality, being classified from 1 to 4, where: 1 = optimal vigor; 2 = good vigor; 3 = regular vigor; 4 = worse vigor. Vigor die classified as 0 refers to dead seedlings. It was considered in the vigor classification, if the seedling had an erect structure, quantity and quality in the number of leaves, occurrence of visual symptoms of stress (leaf wilting), symptoms of attack by pathogens and insects (ant), considering, thus, its development as a whole.

2.3.3 Statistical Analysis

Analysis of variance (ANOVA) coupled with split-plot on time measurements was performed to evaluate the distribution in independent samples, being able to identify if there is a significant difference between the species for biometrics (total height, neck diameter at ground level and vigor). Significant differences were analyzed using the Scott-Knott test for multiple comparison of means. Germination percentage analyzes were carried out in the laboratory and nursery.

3. Results and Discussion

According to Vieira (2021), the seeds of the genera *Eucalyptus* and *Corymbia* are true orthodox and, thus, can be conserved in seed banks for many years, maintaining their viability, as long as they are stored under the correct conditions of temperature and humidity. The germination potential of the seeds of the 13 species of *Eucalyptus* spp. and *Corymbia* spp., in a laboratory environment (gerbox), ranged from 100% to 4% (lower in vitro germination rate). A germination and healthy growth test were carried out for 13 species of *Eucalyptus* spp. and *Corymbia* spp., generating seedlings in tubes, in the nursery, where new seeds were sown in an appropriate substrate and the percentage of germination of the species was evaluated. As shown in Figure 1, it is possible to compare the two germination tests, considering

Table 2. Summary of the split-plot analysis of variance (ANOVA) of the means of the evaluation parameters of seedling quality, stem diameter, seedling height and vigor for the 13 species of *Eucalyptus* spp. and *Corymbia* spp. evaluated.

SV	DF	Neck Diameter (mm)		Seedling Height (cm)		Seedling Vigor (score)	
		MS	P-value *	MS	P-Value	MS	P-Value *
Experimental Blocks	2	0.0374	0.906161	80.2	0.142	0.0117	0.93439
Species (SPE)	12	2.3157	0.000104 *	405.6	9.07e-07	0.7469	0.00123 **
Error A (Among plots)	23	0.3779	–	37.7	–	0.1718	–
Measurements (MEA)	2	290.94	<2e-16 *	36267	<2.00E-16	0.06708	0.3597
SPE × MEA interaction	24	1.41	5.19e-10 *	158	1.72e-09	0.13954	0.0105 *
Error B (Within plots)	50	0.18	–	21	–	0.06427	–

* (SV) Sources of variation; (DF) Degree of freedom; (MS) Mean square; P-value indicates the probability of observing a difference as large or greater than that observed under the null hypothesis; "SPE" is the species effect; "MEA" is the measurements over time effect.

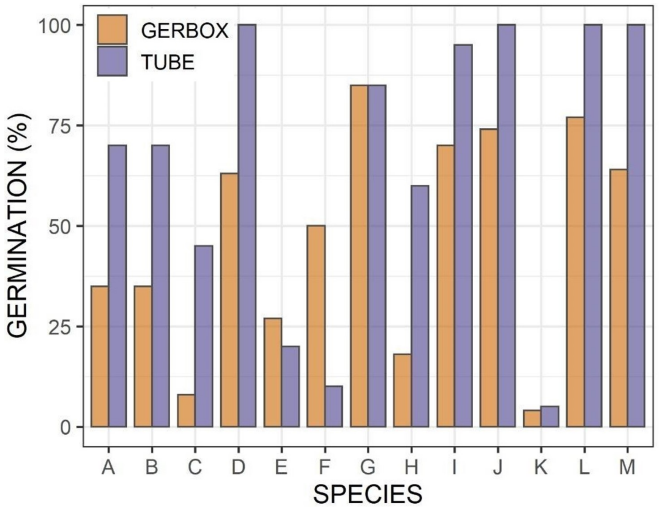


Figure 1. Germination test in percentage (%). Comparison of germination in gerbox in the laboratory and in tube in the nursery, of the 13 species of *Eucalyptus* spp. and *Corymbia* spp. evaluated.

the formation of normal seedlings.

The germination in tubes, in the nursery, presented the following percentages, respectively: *Eucalyptus dunnii*, *Corymbia citriodora*, *Eucalyptus longirostrata* and *Corymbia maculata* reached 100% germination; *Eucalyptus globulus* and *Corymbia intermedia* reached germination of more than 75%; *Eucalyptus grandis*, *Eucalyptus benthamii* and *Eucalyptus resinifera* reached germination above 50%; *Eucalyptus sideraphylaia* reached germination above 25%; *Eucalyptus pellita*, *Corymbia torelliana* and *Eucalyptus cloeziana* had germination below 25%.

In the production of *Eucalyptus saligna, E. alba*, *E. grandis* and *E. citriodora* seedlings, Simões (1968) found technical advantages of direct sowing in the container over transplanting. Analyzing the results, we see that the percentage of germination in vitro in the laboratory was lower than the percentage of germination in the tube, a factor that justifies this result is the fact that, even performing the entire asepsis, disinfection and disinfestation protocol, there was a high incidence of contamination, which had a negative impact on the development of normal seedlings. The fact that the seeds germinated in the laboratory have contamination made it impossible to carry out the transplant of seedlings germinated in gerbox, to the tubes.

The significant difference in germination between the 13 species of *Eucalyptus* spp. and *Corymbia* spp., showing how diverse and heterogeneous is the genetic material of the experiment, forest seedlings produced by sexual propagation, from seeds. In the nursery, the indicator used to evaluate germination was the number of seedlings produced, and sowing was tested in 20 tubes. Qualitative indicators were considered when evaluating germinated seedlings, which were considered normal, low vigor or dead, for evaluation purposes only normal seedlings were considered.

Most national plantations are hybrid clones with *Eucalyptus urophylla*, due to their high adaptive capacity and high production stability in almost all regions of Brazil (Flores et al., 2016; Assis et al., 2015). *Corymbia spp.* has recent studies that highlight its rapid initial growth. In this study *Corymbia maculata* had a germination rate of 100% in tubes, followed by *Corymbia intermedia* with a rate above 75%. However, this positive highlight in the results, considering the other analyzes carried out, extends only to the *Corymbia maculata* species.

Eucalyptus dunnii, according to the literature, is indicated for planting in cold climate regions, also for *Eucalyptus benthamii*, opposing the expectation of low germi-

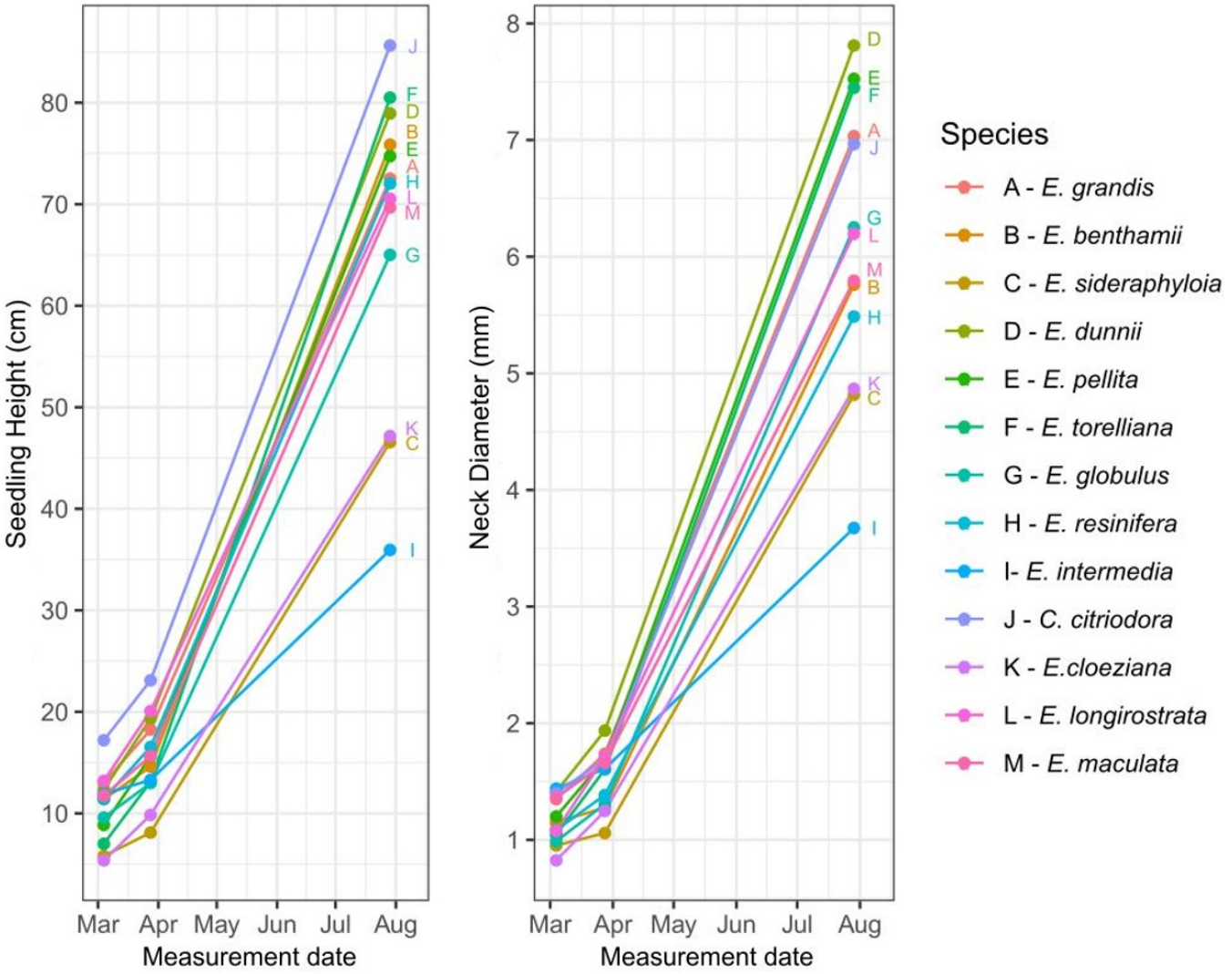


Figure 2. Interaction between the 13 species and the three measurement periods (8, 32 and 155 days after transplanting the seedlings). The colored lines are the *Eucalyptus* or *Corymbia* species as described in the legend.

nation, due to the region's climate, which is mostly hot and dry, the germination results were 100% and more than 50 % respectively. However, evaluating the biometric parameters between the two species, only *Eucalyptus dunnii* maintains its positive prominence. According to recent studies, water and saline stress are the main factors that affect plant development (de Sá-Martins, 2019). This fact does not apply to this study because all tests and experiments were carried out under a controlled environment, whether in vitro, in the laboratory or in the nursery, from germination to seedling growth, there was no water deficit.

From a climatic perspective, seed germination is vital for the persistence of many plant species and is linked to local environmental conditions. Small increases in temperature during this critical life history transition can threaten species, altering the timing and success of germination (Cochrane, 2017). In terms of temperature, the germination test in the laboratory was maintained in a "Biochemical Oxygen Demand" BOD oven, with temperature control ranging from 26.4 ℃ to 29.2 ℃. In the pond, the temperature ranged from 21 ℃ to 30 ℃. In this way, species less sensitive to temperature variation and adapted to the hot climate may have been favored. The growth variables showed significant differences between the species. Total height, neck diameter and vigor showed interaction. Biometric measurements of total height, neck diameter and seedling vigor generated the following analysis of variance (Table 2).

According to Maia (2009), estimates of variance com-

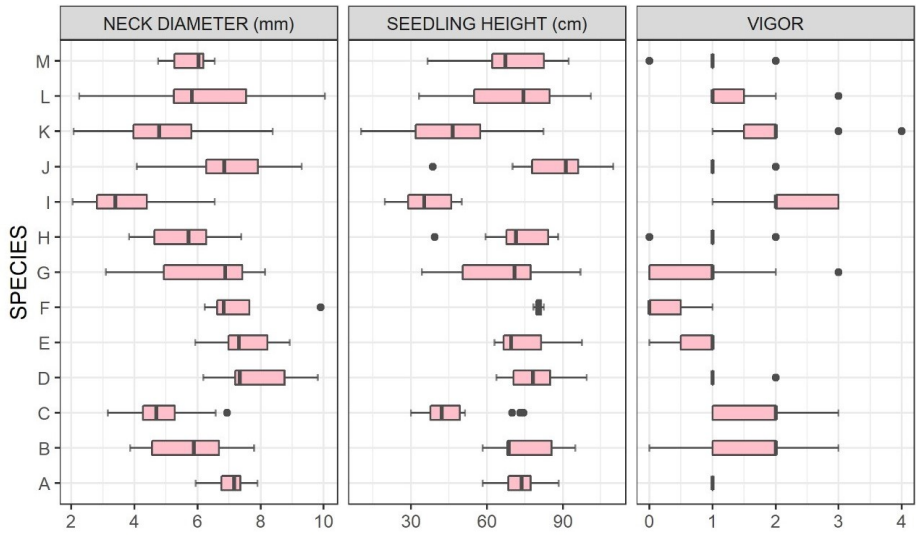


Figure 3. Diameter variables boxplot of the Neck Diameter, Seedling Height and Seedling Vigor for each of the 13 species of *Eucalyptus spp*. and *Corymbia* spp. evaluated.

ponents are of great importance, as they help in the correct direction of the breeding program, as well as support the correct recommendation of genetic materials. The variance observed in Table 2 refers to the biometric measurements, primarily the neck diameter, which presented a not significant result (p-value of 0.906) among the species. As for the interaction SPE × MEA, the result is significant (p-value of 5.19e-10 *), which means that they not maintained the pattern along time measurements, that is, the species that presented good results in the first measurement, may not remained good results at diameter growth in the second and third measurement. From Figure 2 it is possible to observe the patterns of development of the species over time. Note that, although after the initial 30 days of seedling development, although there was an expressive development in height and diameter for all species, they did not substantially change their position (ranking). The variance for the seedling height factor showed a significant result among the species. For the interaction SPE × MEA, the result is also significant, but more pronounced between the first days of seedling development. For the vigor factor, the SPE × MEA interaction was not significant (p-value ≈ 0.140) but more declared between the first days of seedling development. For the vigor factor, the SPE × MEA interaction was not too significant (p-value = 0.0105 *) but more declared between the first days of seedling development. For the vigor factor, the SPE × MEA interaction is not significant.

The Table 3 presents the result of the Scott-Knott test, for each of the 13 species of *Eucalyptus* spp. and *Corymbia* spp. and their respective codes, correlating with biometric factors, demonstrating the species that have similar means or that differ statistically. The factor that showed the greatest heterogeneity was seedling height, classified between (a), (b), (c) and (d), with (a) being the best results. Diameter differed between (a) and (b), being (a) the best results. Vigor was the factor that differed the least, in this case, the results classified as (b) were better than (a). When interpreting the boxplot plot (Figure 3) of the variables neck diameter, total height and vigor, for each of the 13 species of *Eucalyptus spp*. and *Corymbia spp*. evaluated, no outliers were observed.

For the neck diameter parameter, studies consider that *Eucalyptus* seedlings with adequate quality standards must have a minimum value of 2.0 mm (Wendling & Dutra, 2010, cited by Caldeira et al., 2013), comparing Lopes et al. (2007), who advocate an average of 2.5 mm for planting *Eucalyptus grandis* in the field. In this study, there is evidence of difference between the averages of the treatments. Considering the results for diameter, there is greater variability in the species G (*Eucalyptus globulus*) and less in the species F (*Corymbia torelliana*). Considering the results for vigor, there is greater variability in species K (*Eucalyptus cloeziana*) and less in species A, D, F (*Eucalyptus grandis*, *Eucalyptus dunnii* and *Corymbia torelliana*, respectively).

The species that showed the highest height, in the measurements, was the species L (*Eucalyptus cloeziana*) and the smallest were C and K (*Eucalyptus sideraphylaia* and *Eucalyptus cloeziana*, respectively). The mortality of seedlings after transplantation was 01 (seedling). Species G (*Eucalyptus globulus*) presented an individual with a score of 0 for height, diameter and vigor, indicating that this seedling died. The species D (*Eucalyptus dunnii*) presented the highest result of neck diameter, the smallest was measured in the species C (*Eucalyptus sideraphylaia*). The best vigor results were obtained by species D and A (*Eucalyptus dunnii* and *Eucalyptus*

Table 3. Means of diameter variables of the neck diameter, total height and seedling vigor for each of the 13 species of *Eucalyptus* spp. and *Corymbia* spp. Evaluated by the Scott Knott Test, this test shows the results of the third measurement.

Code	Species	Neck Diameter	Seedling Height	Seedling Vigor
A	*E. grandis*	7.03b	72.53b	1.00b
B	*E. benthamii*	5.77c	75.48a	1.78a
C	*E. sideraphyloia*	4.82d	78.94c	1.60a
D	*E. dunni*	7.81a	78.94a	1.07b
E	*E. pellita*	7.53a	71.97b	1.00b
F	*C. toreliana*	7.98a	79.93a	1.07b
G	*E. globulus*	6.29c	64.11b	1.50b
H	*E. resinifera*	5.61c	70.74b	1.07b
I	*C. intermedia*	3.67e	35.94d	2.13a
J	*E. citriodora*	6.96b	85.63a	1.07b
K	*E. cloeziana*	4.87d	47.16c	2.00a
L	*E. longirostrata*	6.20c	70.54b	1.40b
M	*C. maculata*	5.77c	68.81b	1.07b
Overall Means		1.52	15.25	1.29

grandis, respectively)

The results observed in Figure 4 highlight the directly proportional correlation between the results of height and neck diameter, since the greater the result of a variable, the greater the result of its correspondent, thus forming an increasing diagonal. The superposition of the points formed by the first and second measurements, show that the relationship is maintained, but the height results stood out more, causing a greater slope in the straight line. Species G (*Eucalyptus globulus*) presented an individual with a score of 0 for height and diameter in the second measurement, indicating that this seedling died.

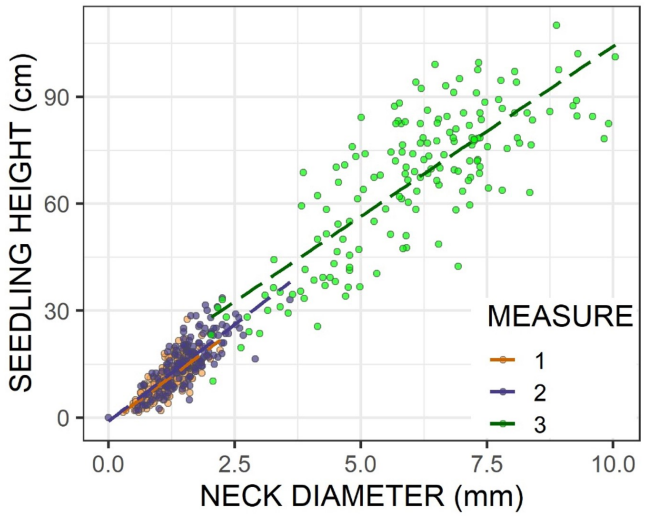


Figure 4. Relationship between the Neck Diameter (millimeter) and total Height of seedlings (centimeter) of *Eucalyptus spp*. and *Corymbia spp*. Overlay of data collected in the first and second measurement.

With a recent highly early flowering technique proposed by Castro et al. (2021), the improvement of *Eucalyptus* for tropical regions such as the Cerrado biome could be accelerated, providing the launch of new cultivars composed of hybrids of different species of *Eucalyptus* spp. and *Corymbia* spp.

4. Final Considerations

The production of seedlings from seeds, defined as the object of study in this work, was successfully achieved, with satisfactory results and fulfilled all the specific objectives of the proposed study. The germination potential test of *Eucalyptus* spp. and *Corymbia* spp., together with data from the evaluation of seedling growth in total height, neck diameter and vigor, indicated that the species *Eucalyptus Dunnii*, *Corymbia citriodora*, *Eucalyptus longirostrata* and *Corymbia maculata*, which reached 100% germination, are also among the species that stand out in biometric measurements, with emphasis on the results of the species *Eucalyptus dunnii*, *Corymbia citriodora* and *Eucalyptus longirostrata*.

As a suggestion for continuity of studies on this experiment, other procedures that must be carried out and that can generate data are: thinning of the seedlings, fertilization by covering, re-embankment and seedling hardening. Good nursery practices should be followed, in order to lead the healthy growth of seedlings, of good quality, aiming at the end of the experiment to obtain individuals of each species to go to the field, being able to avenge and

become great representative individuals of their species and thus, fulfill the objective of composing the *Eucalyptus* Garden of the School of Agronomy - EA/UFG.

Transplanting the seedlings into plastic bags, semi-definitive site, aimed, in the medium and long term, to contribute to the deepening of knowledge, especially among students, about the properties of the 13 species of *Eucalyptus* spp. and *Corymbia* spp., selected to compose, at the end of the experiment, which has the potential to extend, beyond this study, the *Eucalyptus* Garden of the Escola de Agronomia - EA/UFG), collaborating with practical classes that can use the space to introduce students to characteristics inherent to species such as: appreciating their shape, smelling, and texture of leaves, in addition to knowing their scientific names.

This study, therefore, collaborates with a better training of future professionals of the agrarian courses of the institution, having an impact of institutional scope, evaluating from the perspective of academic training and impact of state scope, evaluating from the perspective of training new professionals for the market of work, considering an increase in the level of knowledge about commercial forest species, in this case, *Eucalyptus* species.

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References

André, J. L., Oliveira, R. D. S., Sette Jr, C. R., Alfenas, A. C., Zauza, E. Â. V., de Siqueira, L., & Novaes, E. (2021). Wood volume of Eucalyptus clones established under different spacings in the Brazilian Cerrado. Forest Science, 67(4), 478-489.

Bahia M. A. M., Ribeiro, R. M., Coneglian A. & Sette-Jr, C. R. Efficiency and productivity of skidder dragging full-trees of *Eucalyptus* sp. *TreeDimensional*, 09, e022001, 1-5.

Borges, S. R., Xavier, A., Oliveira, L. S. D., Melo, L. A. D., & Rosado, A. M. (2011). Enraizamento de miniestacas de clones híbridos de Eucalyptus globulus. *Revista Árvore*, 35, 425-434.

BRASIL (2019). Instruções para análise de sementes de espécies florestais. *Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Defesa Agropecuária.*

Brondani, G. E. et al.(2008). Ácido indolbutírico em gel para o enraizamento de miniestacas de *Eucalyptus benthamii* Maiden & Cambage x *Eucalyptus dunnii* Maiden. *Scientia Agraria*, v. 9, n. 2, p. 153-158.

Castro, C. A. d. O., dos Santos, G. A., Takahashi, E. K., Nunes, A. C. P., Souza, G. A., & de Resende, M. D. V. (2021). Accelerating Eucalyptus breeding strategies through top grafting applied to young seedlings. *Industrial Crops and Products*, 171, 113906.

Castro, C. A. d. O., Resende, R. T., Bhering, L. L., & Cruz, C. D. (2016). Brief history of Eucalyptus breeding in Brazil under perspective of biometric advances. *Ciência Rural*, 46, 1585-1593.

Caldeira, M. V., Delarmelina, W. M., Peroni, L., Gonçalves, E. D. O., & Silva, A. G. D. (2013). Lodo de esgoto e vermiculita na produção de mudas de eucalipto. *Pesquisa Agropecuária Tropical*, *43*, 155-163.

Cochrane, A. (2017). Modelling seed germination response to temperature in Eucalyptus L’Her. (Myrtaceae) species in the context of global warming. Seed Science Research, 27(2), 99-109. Cochrane, A. (2017). Modelling seed germination response to temperature in Eucalyptus L’Her.(Myrtaceae) species in the context of global warming. *Seed Science Research*, *27*(2), 99-109.

De Aguiar, I. B., Valeri, S. V., Banzatto, D. A., Corradini, L., & Alvarenga, S. F. (1989). Seleção de componentes de substrato para produção de mudas de eucalipto em tubetes.

De Assis Teotônio Francisco; Abad, Júpiter Israel Muro & Aguiar, Aurélio Mendes (2015). Melhoramento genético do eucalipto. In Schumacher MV and Vieira M (eds) *Silvicultura do eucalipto no Brasil*. UFSM, Santa Maria, p. 225-247.

De Sá-Martins, R., Cleiton-José, A., Rocha-Faria, J. M., & de Melo, L. A. (2019). Effect of water and salt stress on seeds germination and vigor of different eucalyptus species. *Journal Of Tropical Forest Science*, *31*(1), 12-18.

Fernandes, G. W., Coelho, M. S., Machado, R. B., Ferreira, M. E., Aguiar, L. D. S., Dirzo, R., ... & Lopes, C. R. (2016). Afforestation of savannas: an impending ecological disaster.

Ferreira, M., & Santos, P. D. (1997). Melhoramento genético florestal dos Eucalyptus no Brasil breve

Flores, T. B., Alvares, C. A., Souza, V. C., & Stape, J. L. (2016). *Eucalyptus no Brasil: zoneamento climático e guia para identificação* (p. 447). Piracicaba: IPEF.

Gomes, J. M., Couto, L., Leite, H. G., Xavier, A., & Garcia, S. L. R. (2003). Crescimento de mudas de Eucalyptus grandis em diferentes tamanhos de tubetes e fertilização NPK. *Revista Árvore*, *27*, 113-127.

Gomes, J. M., & Paiva, H. D. (2004). Viveiros florestais: propagação sexuada. *Viçosa: UFV*, *3*.

Goulart, P. B. (2006). Influência do acondicionamento, antioxidantes, auxinas e seus cofatores no enraizamento de miniestacas de clones de Eucalyptus grandis X E. urophylla.

Higashi, E. N., Silveira, R. L. V. A., & Gonçalves, A. N. (2000). Propagação vegetativa de Eucalyptus: princípios básicos e a sua evolução no Brasil. *Circular técnica IPEF*, *192*, 1-11.

Hoppe, J. M., & Brun, E. J. (2004). Produção de sementes e mudas florestais. *Caderno didático*, *1*(2).

IBÁ. Indústria Brasileira de Árvores. (2021). *Relatório Anual* 2021. 93 p.

IBGE. Instituto Brasileiro de Geografia e Estatística. (2020). Produção da Extração Vegetal e da Silvicultura. Rio de Janeiro, v. 35, p.1-16.

Lopes, E. D. (2005). *Qualidade de mudas de Eucaliptus urophylla, E. Camaldulensis e E. citriodora produzidas em blocos prensados e em dois modelos de tubetes e seu desempenho no campo* (Doctoral dissertation, Universidade Estadual do Sudoeste da Bahia.).

Lopes, J. L. W., Guerrini, I. A., & Saad, J. C. C. (2007). Qualidade de mudas de eucalipto produzidas sob diferentes lâminas de irrigação e dois tipos de substrato. *Revista Árvore*, *31*, 835-843.

Maia, M. C. C., de Resende, M. D. V., de Paiva, J. R., Cavalcanti, J. J. V., & de Moura Barros, L. (2009). Seleção simultânea para produção, adaptabilidade e estabilidade genotípicas em clones de cajueiro, via modelos mistos. *Pesquisa Agropecuária Tropical*, 43-50.

Melo, L. A. D., Xavier, A., Paiva, H. N. D., & Borges, S. R. (2011). Otimização do tempo necessário para o enraizamento de miniestacas de clones híbridos de Eucalyptus grandis. *Revista Árvore*, *35*, 759-767.

Moura, V. P. G., & Guimarães, D. P. (2003). Produção de mudas de Eucalyptus para o estabelecimento de plantios florestais. *Embrapa Recursos Genéticos e Biotecnologia-Comunicado Técnico (INFOTECA-E)*.

Oliveira, J. L. A., Ribeiro, D., Barbosa, R. d. O., Reis, C. A. F. & Novaes,E. (2019) Hypsometric equation adjustments for multi species clonal plantations of Eucalyptus in the Cerrado Goiano. *TreeDimensional*, *08*, 1-17.

Oliveira, R. D. S., Ribeiro, C. V. G., Neres, D. F., Porto, A. C. D. M., Ribeiro, D., Siqueira, L. D., ... & Novaes, E. (2020). Evaluation of genetic parameters and clonal selection of Eucalyptus in the Cerrado region. *Crop Breeding and Applied Biotechnology*, *20*.

Simões, J. W. (1968). *Métodos de produção de mudas de eucalipto*. Escola Superior de Agricultura" Luiz de Queiroz" da Universidade de Sao Paulo, Maio.

Simões, J. W. (1987). Problemática da produção de mudas em essências florestais. *Piracicaba: IPEF*.

Schorn, L. A., & Formento, S. (2003). Silvicultura II: produção de mudas florestais. *Apostila. Universidade Regional de Blumenau–Dep. de Engenharia Florestal*.

Vieira, E. S. N. (2021). Banco de sementes e a conservação de germoplasma de eucaliptos e corimbias pela Embrapa Florestas.

Pinto Junior, J. E., de Oliveira, E. B., Edilson Batista de Oliveira, C. N. P. F., & Junior, J. E. P. (2021). O eucalipto e a Embrapa: quatro décadas de pesquisa e desenvolvimento.

Wendling, I., & Dutra, L. F. (2010). Produção de mudas de eucalipto por sementes. *Produção de mudas de eucalipto*, *2*, 13-46.