

Qualities of *Colubrina Glandulosa* Perkins Seedlings Produced in TNT Containers and Water-Retaining Polymer

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Abstract

Given the relevance of studies focusing on the production of native forest seedlings and biodegradable containers and the use of new inputs to increase seedling survival in the field, the aim of this work was to evaluate the effect of TNT bags and hydroretentive polymer on the production of *Sobrasil* seedlings. The experiment occurred in the greenhouse, at the Federal Institute of Espírito Santo, Alegre campus. Six treatments were evaluated, differing between container and addition or not of hydrogel, evaluating morphological and physiological parameters. The data were processed by analysis of variance at 5% significance, and when they showed significant differences, they were compared using the Tukey test at 5% probability. The results demonstrate that the seedlings produced in TNT bags with and without holes had qualities equal to those in plastic bags. The use of hydrogel was only beneficial when combined with a TNT bag without holes.

Keywords: hydrogel, seedling production, non-woven fabric, *Sobrasil*, sustainability

1. Introduction

Colubrina glandulosa Perkins, known as *Sobrasil*, is considered a resistant plant with good cultivation. It is also indicated for the restoration and restructuring of degraded areas and agroforestry systems due to several attributes (Moraes Júnior et al., 2019) and high occupancy capacity space, due to the growth of its roots (Silva et al., 2020). The species also has ornamental qualities and can be used in the afforestation of wide streets and parks, as well as for the recovery of degraded areas and landscaping (Melo Júnior, Melo, Ferreira & Araújo Neto, 2019).

It is a species of ecological and socioeconomic importance, but it is threatened with extinction. It generally inhabits more open and secondary forests, with heavy and resistant wood used in civil construction and fencing (Moraes Júnior et al., 2019).

The formation of productive and healthy forests begins with the production of quality forest seedlings and the increase in demand for quality forest seedlings, aiming to restor degraded areas, makes it necessary to have good techniques that provide a lower cost aiming at germination and seedling development phases (Griebeler et al., 2021).

The production of seedlings in containers, mostly in polyethylene bags, is the most used method to provide greater care for the seedling in the primordial germination phase (Griebeler et al., 2021). According to Gomes and Paiva (2013), when choosing the best container, one must consider the number of seedlings and the species of interest,

in addition to the purpose of production, as the type of container acts directly on the development of the species' root system.

For Lima Filho et al. (2019), the use of polyethylene bags, commonly known as plastic bags, results in poor development and delayed root thickening, in addition to the curling of the root system. Furthermore, waste generated after use can be highlighted, due to the composition of the material, which accumulates in the environment, causing environmental damage (Postemsky, Marinangeli & Curvetto, 2016).

On the other hand, according to Zhang, Wang e Chen (2019), containers that have the property of degradation in the soil are beneficial to the environment when compared to traditional containers made of polyethylene. Therefore, biodegradable containers emerge as a viable alternative to help with the problems generated by the use of non-degradable bags. In addition, biodegradable bags made from so-called non-woven fabric (TNT) have their walls perforated and enable the development of the root system, possibilitating root integrity and contributing to faster seedling growth. All TNTs are biodegradable and the production of seedlings in bags made with these materials can contribute to the quality of the seedlings (Linhares, 2020).

Another concern in the seedling production stage is the rationing of water consumption. For good initial growth of these, it is necessary to take into account numerous factors, including the supply of water and the benefits of its use (Taiz & Zeiger, 2013). In this sense, the hydrogel acts as an important soil conditioner as it aims to retain and make water available to newly planted seedlings, enabling the reduction of the number of irrigation and nutrient losses, and reducing costs in crop development (Jain, Meena & Bhaduri, 2017).

The hydrogel has proven to be effective in absorbing water, whether from rain or irrigation, slowly releasing water into the environment, thus enhancing its retention and causing a decrease in irrigation frequency (Narjary et al., 2012; Rathore, Shekhawat, Babu & Singh, 2020).

In view of the above, it is necessary to carry out studies that evaluate the use and effects of TNT containers on the growth of species native to the Atlantic Forest and the effect of hydrogel on seedling production. Therefore, the objective of the present work is to analyze the use of the biodegradable TNT container together with the use of the hydrogel in the initial growth and quality of *Colubrina glandulosa* Perkins seedlings.

2. Method

The experiment occurred in a greenhouse at the Federal Institute of Education, Science and Technology of Espírito Santo, on the Alegre campus. The area is located in the district of Rive, in the municipality of Alegre (ES), at the geographic coordinates of 20°45'39.4" S and 41°27'25.4" W. The region's climate is type "Aw" with a dry season in winter, according to the Köppen classification. The average annual temperature is 23° C and annual precipitation is around 1200 mm.

The substrate came from the addition of equal proportions of sifted soil, tanned and sifted farmyard manure, and sand. For each 1000 L of substrate, the following fertilizers were inserted in their respective quantities: 90 g of urea, 270 g of simple superphosphate, 27 g of potassium chloride, and a 9-month controlled release fertilizer in the NPK 15:9 formulation: 12, which is used in the concentration recommended by the manufacturer and in grain form. Part of the treatment included the insertion hydrogel added in the form of dehydrated powder to the substrate and duly homogenized. A concentration of 2 g/L was adopted for the hydrogel (Mews et al., 2015).

Colubrina glandulosa Perkins seeds showed dormancy, and dormancy breaking was carried out through chemical scarification in concentrated sulfuric acid (98%) for 30 minutes, followed by washing in running water (Brancalion, Mondo & Novembre 2011). Sowing occurred immediately after dormancy was broken.

TNT was selected in black, with a weight of 40 g/m² and the dimensions were equal to plastic (15 cm x 25 cm). The determination of the number of holes (16) was due to the fact that the plastic bags sold had around 16 holes, allowing an approximation with the material available on the market.

The filled and sown bags were distributed on the floor, covered with canvas, in the greenhouse. Irrigation occurred through micro-sprinklers ranging from 1 to 3 times a day, lasting approximately 15 minutes. However, the frequency and time of irrigation were based on the weather conditions of the day, on the humidity of the substrate and on the development phase of the seedlings.

After the germination phase, the seedlings were thinned when they reached approximately 7 cm in height. At this stage, the most centralized seedling, with better development and robustness, was left as the remainder. Six treatments were used, which differ depending on the material of the bag, the presence of holes and the incorporation of the hydrogel into the substrate (Table 1).

Table 1. Treatments using traditional plastic bags and TNT (with and without holes) and use of hydrogel in the production of *Colubrina glandulosa* Perkins seedlings

Treatment	Description and abbreviation
T1	Traditional plastic bag (sp)
T2	Traditional plastic bag with hydrogel (sp + gel)
T3	TNT bag without holes (TNT)
T4	TNT bag without holes and with hydrogel (TNT + gel)
T5	TNT bag with 16 holes (TNT + hole)
T6	TNT bag with 16 holes and hydrogel (TNT + hole + gel)

Source: Author (2025).

The experimental design used was randomized blocks (DBC), with nineteen plants per treatment in three replications, totaling 57 plants per treatment. In order to evaluate the effects of the container and use of the hydrogel, the height (H) and collar diameter (DC) of the seedlings were measured with a graduated ruler and caliper, respectively. This activity was repeated every 30 days to monitor growth over time. The measurements began 30 days after sowing and ended at 180 days (the age at which the seedlings were ready to be taken to the field).

Two biomass analyses were carried out, one at 90 days and the other at 180 days, where 3 seedlings were selected per treatment to determine the aerial part dry matter (MSPA), the root system dry matter (MSR) and the total dry matter. The selected seedlings were cut, the aerial part separated from the root system and placed in paper bags, then taken to an oven at 70°C until they reached constant weight. From the data collected, the Dickson Quality Index (DQI) was calculated, according to Dickson, Leaf e Hosner (1960), using the following Equation (1):

$$DQI = MST / [(H/DC) + (MSPA/MSR)] \quad (1)$$

The means were submitted to analysis of variance (ANOVA). In case of significant differences, the means were then compared using the Tukey test, at 5% significance. All tests were carried out using the Sisvar program, version 5.6 (Ferreira, 2014).

3. Results and Discussion

3.1 Collection Height and Diameter

When it comes to height, at 30, 60, 90, 120 and 180 days, the values remained statistically similar. At 150 days, the height of T1 and T5 showed a higher average, showing that the height of these treatments was greater than the other treatments (Table 2).

Table 2. Height (cm) of *Colubrina glandulosa* Perkins seedlings, in a greenhouse in the district of Rive, Alegre, ES

Treatment	30 days	60 days	90 days	120 days	150 days	180 days
T1 (sp)	3.686 a	8.753 a	29.530 a	53.776 a	76.666 a	81.666 a
T2 (sp + gel)	3.803 a	8.483 a	29.060 a	57.360 a	60.000 b	76.333 a
T3 (st)	3.983 a	8.423 a	26.866 a	42.320 a	60.333 b	79.333 a
T4 (st + gel)	3.710 a	7.766 a	24.860 a	43.000 a	55.333 b	76.666 a
T5 (st + orif)	3.966 a	7.763 a	25.293 a	44.433 a	62.333 ab	84.000 a
T6 (st + orif + gel)	4.033 a	8.066 a	25.996 a	37.900 a	56.000 b	75.333 a
Total average	3.863	8.209	26.933	43.465	61.777	78.888
CV (%)	17.23	8.36	8.39	18.22	10.12	8.34

CV: coefficient of variation. Means followed by the same letters do not differ significantly from each other, using the Tukey test at 5% significance.

Source: Author (2025).

According to Avelino, Schilling, Dalmolin, Santo e Mielke (2021), height is a parameter that cannot be assessed in isolation. Furthermore, seedlings of great height and with a small stem diameter are more likely to fall over when taken to field conditions (Gasparin, Avila & Araújo, 2014). The ideal height for forest seedlings changes according to the characteristics of each species. However, for tree species native to Brazil, heights between 20 and 35 cm show quality for planting (Oliveira et al., 2016). Therefore, all the containers under study provided a satisfactory height for the Sobrasil seedlings from 90 days onwards.

As for the collar diameter, the test indicated no statistical significance in the interval of 30, 60, 90 and 150 days after germination (Table 3). However, at 120 days, T2 was the one that showed a significant difference compared to T4, T5 and T6, but this difference disappeared at 150 days. At 180 days, T4 was the one that presented the greatest significance compared to T2, which presented the lowest value.

Table 3. Collar diameter in millimeters of *Colubrina glandulosa* Perkins seedlings, in a greenhouse in the district of Rive, Alegre, ES

Treatment	30 days	60 days	90 days	120 days	150 days	180 days
T1 (sp)	1.07 a	2.3466 a	4.0500 a	6.690 ab	6.833 a	8.36 ab
T2 (sp + gel)	1.07 a	2.3133 a	3.8366 a	6.883 a	7.043 a	7.966 b
T3 (st)	1.07 a	2.2000 a	3.9766 a	6.233 ab	6.470 a	8.700 ab
T4 (st + gel)	1.07 a	2.1866 a	3.8233 a	5.666 b	7.000 a	10.233 a
T5 (st + orif)	1.07 a	2.2133 a	3.6633 a	5.603 b	6.866 a	9.033 ab
T6 (st + orif + gel)	1.07 a	2.1500 a	3.3393 a	5.733 b	6.0166 a	8.733 ab
Total average	1.07	2.2350	4.9572	6.2011	10.016	12.888
CV (%)	0	4.25	98.83	8.51	143.04	131.10

CV: coefficient of variation. Means followed by the same letters do not differ significantly from each other, using the Tukey test at 5% significance.

Source: Author (2025).

The results confirm that the use of a TNT bag without holes linked to 2 g/l of hydrogel is viable in evaluating the quality of seedlings of the species under study, since the bag without holes may have favored a greater concentration of water and nutrients, resulting in a high value for the diameter of the collection. The pores of the TNT bag can allow the flow of part of the water to penetrate into the substrate, whether there are having holes or not. According to Abreu, Leles, Melo, Ferreira e Monteiro (2014), the holes at the bottom of the bag have the function of draining excess moisture and of allowing ventilation of the seedling's root ball.

According to David et al. (2015), the collection diameter of 3 mm for native forest species is accepted as adequate for the seedlings to be taken to the field. This value was found in all treatments from 90 days onwards. Collar diameter is an indispensable characteristic of seedlings, as it ensures greater support for the seedling, especially in the field (Grossnickle & Macdonald, 2018). This is because it is directly linked to the capacity for solutes to move from the root system to the aerial part of the seedlings. This characteristic relates this parameter to the subsistence of the seedling (Riikonen, 2016).

Navroski, Araujo, Reiniger, Muniz & Pereira (2015) showed, in their work, that the non-use of the hydrogel in the substrate generated a low value for the collection diameter of *Eucalyptos dunnii* seedlings. According to the same authors, increasing the dose of hydrogel influenced the increase in the diameter of the duct.

Mews, Sousa, Azevedo & Sousa (2015) determined the cultivation of *Handroanthus ochraceus* (Cham.) Mattos seedlings in a nursery, examining the impact of different amounts of hydrogel and nitrogen fertilizer on seedling production. In general, the hydrogel and fertilizer interaction positively influenced the growth and quality of the seedlings. For each morphological parameter, a different dose (0 to 4 g) of hydrogel was considered optimal. For the diameter of the collar, the optimal dose was 2 g for the species under study.

Bernardi, Sperotto Junior, Daniel e Vittorino (2012) evaluated the results of fertilizer doses on substrates containing the hydrogel, on the development of *Corymbia citriodora* seedlings. The authors observed that the presence of the hydrogel combined with fertilization allowed good results in the growth of the seedlings. The authors found greater

height development reaching 22.99% and diameter totaling 23.12% for seedlings produced with 6 g of gel per liter of substrate when compared to seedlings without the addition of the polymer.

3.2 Biomass and Leaf Area

Regarding total dry mass (MST), partial and final results (90 and 180 days after germination) show that there was no statistical difference as for the different treatments used. Regarding the dry mass of the aerial part at 90 days, T4 presented the highest value, which was significant compared to the other treatments. Taking into account that the dry biomass of the aerial part can be used as a parameter for the high degree of rusticity of the seedlings (Gomes & Paiva, 2013; Eloy et al., 2013), it is expected that the T4 seedlings will present greater performance in the field. Singh et al. (2021) states that the use of hydrogel increases plant growth as a whole. The presence of the hydrogel next to the biodegradable container without holes may have provided a better interaction of morphological parameters, which may justify the higher value in T4. Regarding root dry mass, T1 presented a higher significant value compared to T6 (Table 4).

Table 4. Leaf area and root, aerial part and total biomass of *Colubrina glandulosa* Perkins seedlings, in a greenhouse, at 90 and 180 days, in the district of Rive, Alegre, ES

Treatments	MSR (g)	MSPA (g)	MST (g)	MSPA/MSR	Leaf área (cm ²)
90 days after germination					
T1 (sp)	1.476 a	2.110 ab	4.846 a	1.623 b	583.76 ab
T2 (sp + gel)	1.146 ab	2.146 ab	4.376 a	1.963 b	574.55 ab
T3 (TNT)	0.630 ab	1.876 ab	3.376 a	3.580 ab	519.87 b
T4 (TNT + gel)	1.040 ab	2.846 a	5.266 a	3.006 ab	692.99 a
T5 (TNT+ orif)	0.876 ab	1.980 ab	3.680 a	2.593 ab	463.59 b
T6 (TNT + orif + gel)	0.360 b	1.596 b	2.876 a	4.653 a	465.15 b
Total average	0.09216	2.093	4,0705 a	2.903	549.98
CV (%)	43.10	22.34	23,88 a	21.16	12.66
180 days after germination					
T1 (sp)	7.340 a	8.580 a	24.566 a	1.180 a	1250.15 a
T2 (sp + gel)	6.013 a	7.913 a	21.993 a	1.320 a	1083.98 a
T3 (TNT)	6.306 a	8.483 a	23.760 a	1.356 a	1393.87 a
T4 (TNT+ gel)	8.966 a	8.960 a	28.600 a	1.006 a	1430.39 a
T5 (TNT + orif)	6.423 a	8.536 a	24.943 a	1.343 a	1382.92 a
T6 (TNT + orif + gel)	7.043 a	8.506 a	24.346 a	1.213 a	1755.76 a
Total average	7.015	8.496	24.716	1.23	1382.85
CV (%)	19.31	17.84	14	15.24	24.18

MSR= Total dry mass of roots. MSC= Stem dry mass. MSPA= Dry mass of the aerial part. MST= Total dry mass

Source: Author (2025).

In relation to the leaf area of the analysis at 90 days, T4 presented a higher significant value compared to T5, T6 and T3. According to Morgado, Bruckner, Rosado, Assunção e Santos (2013), leaf area is a fundamental morphological parameter, as it affects photosynthesis, respiration rate and plant growth. According to Wang, Sun, Zeng e Huang (2023), the larger the leaf area, the larger the photosynthetic areas. This influences greater production of photoassimilates and, consequently, more vigorous and good-quality seedlings. Since the decrease in aerial development of seedlings results in a smaller leaf area, these parameters are intrinsically linked.

Regarding the MSPA/MSR ratio at 90 days after germination, T6 presented a significant value of 4.65, a value higher than 2, which is recommended in the literature according to Gomes & Paiva (2013) (Table 4). These inferior data found in treatments 1 and 2 can be justified by the type of container, since the lack of a suitable container

generates poorly developed seedlings with heterogeneous growth, showing a difference between root and aerial part growth.

According to Caldeira, Winkler, Delarmelina, Faria & Juvanhol (2013), in the relationship between shoot dry mass and root dry mass in seedlings, the proportion must be 2:1, and the opposite relationship must be 1:2. This relationship must be analyzed since the aerial part of the seedlings should not be significantly larger than the root area, creating difficulties for the absorption and transfer of water to the aerial part.

At 180 days after germination, the dry biomass of the root, the aerial part and the total leaf area presented statistically similar values, with no loss of biomass accumulation with the use of TNT when compared to plastic bags, regardless of the use of hydrogel (Table 4).

In his work, Poubel (2018) found that the use of the TNT bag did not negatively influence the development of guava seedlings, which corroborates the data from this research since the leaf area of the six treatments analyzed did not show a significant difference, revealing that the TNT bags provide similar conditions for the development of seedlings as the plastic polyethylene bags. Through these results, we observed the importance of monitoring the growth of seedlings until the planting phase, as differences between treatments may disappear.

3.3 Dickson Quality Index

In relation to DQI, all treatments presented statistically similar means, but all treatments, except treatment 2, presented values within those recommended by the literature for native species. Therefore, these treatments were able to provide high-quality seedlings (Tables 5).

Table 5.

Treatment	DQI
T1 (sp)	2,33 a
T2 (sp + gel)	1,99 a
T3 (st)	2,47 a
T4 (st + gel)	2,87 a
T5 (st + orif)	2,34 a
T6 (st + orif + gel)	2,50 a

Means followed by the same letters do not differ significantly from each other, using the Tukey test at 5% significance.

Source: Author (2025).

The DQI changes according to the age of the seedlings (Silva et al., 2020), species, genetic material, and cultivation conditions (Gasparin, Avila e Araujo 2014), and it is proposed that the Dickson quality index for forest species in nurseries is higher than High Dickson Quality Index values represent good quality seedlings (Caldeira, Winkler, Delarmelina & Faria 2013).

Therefore, all treatments tested, except treatment 2, presented a quality standard, making it possible to produce surplus seedlings with the same quality standard used for plastic bags. This finding is similar to the work of Poubel (2018), who observed the effectiveness of using TNT bags in the production of guava seedlings.

4. Conclusion

Given the results, it is observed that the combinations of hydrogel with plastic bags and TNT bags with holes presented lower values in some parameters than the TNT bags without holes. Therefore, we conclude that the use of hydrogel presented better results, being linked to the combination with TNT with no holes.

As for the TNT bag, there is no need for holes and it proved to be viable for the production of seedlings, maintaining its characteristics similar or superior to seedlings produced in plastic bags. Therefore, its use is recommended without loss in the quality of the seedlings, as they did not suffer negative impacts regarding growth in height, stem diameter, biomass and Dickson Quality Index, presenting values within the standard.

Ecologically, TNT bags are biodegradable and permeable. Therefore, their use becomes favorable due to the lack of need for removal at the time of planting, which favors low clod breakage and, consequently, lower energy

expenditure by the plant at this stage, generating greater quality of the seedling. And when compared to plastic bags, the functionality of TNT containers stands out, ecologically too, reducing waste production and speeding up the planting operation.

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Authors contributions

M.Sc. Jacylli Sgranci Angelos was responsible for data curation, writing and editing the original draft. Dr Carlos Henrique Rodrigues de Oliveira was responsible for the experimental design and implementation, for supervision, data collection and fund acquisition, Marcos Vinicius Winckler Caldeira, Fabricia Benda de Oliveira, Lessa Braz Lopez, João Filipe Leite Vargas & Lorayne Saluci Ramos were responsible for software, validation, review and editing. All authors read and approved the final manuscript.

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