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Characterization of juvenile growth of néré (*Parkia biglobosa* (Jacq.) R.Br. ex G. Don) in Northern Côte d'Ivoire

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ABSTRACT

Parkia biglobosa (Jacq.) R.Br. ex G. Don, a threatened multi-purpose woody species, is present in several phytogeographical areas of Côte d'Ivoire. This study aims to contribute to the domestication of the species with a view to its integration into agroforestry programs in Côte d'Ivoire. Germination tests were carried out on seeds of *Parkia biglobosa* according to three treatment methods T1 (seeds with pulp), T2 (dried seeds) and T3 (seeds soaked 48 hours in water) in shaded and sunny conditions. The T3 treatment (Seeds soaked 48 hours in water), applied in shaded conditions, allowed a rapid dormancy recovery (6.50 ± 0.58 days) with reduced germination speed (3.03 ± 0.30 days), while the best germination rate (80 ± 10.33%) was obtained in a sunny environment. The initial growth (number of leaves and diameter at the crown) of the seedlings was more favorable in shaded conditions. These results suggest that the seeds submitted to T3 treatment (seeds soaked 48 hours in water), constitute promising options for the domestication of *Parkia biglobosa* in Côte d'Ivoire.

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INTRODUCTION

In sub-Saharan Africa, many woody species provide non-timber forest products (NTFPs) that represent a substantial contribution to to food and nutritional security and to improving the livelihoods of local communities (Lykke and Padonou, 2019). They constitute a vast reservoir of plant biodiversity and play a fundamental role in meeting the diverse needs of local communities (IPGRI, 1999). The exploitation of NTFPs generates income that contributes to improving the socio-economic conditions of rural households and to the growth of national economies (Assogbadjo *et al.,* 2012; Vodouhê *et al.,* 2009).

Among these species, *Parkia biglobosa* (Jacq.) R.Br. ex G. Don (Fabaceae), commonly known as *néré*, occupies a prominent place. Native to sub-Saharan Africa, this species is commonly found in agroforestry parklands, where it is exploited for its multiple uses, particularly in food processing (Kombienou *et al.*, 2022).

In Côte d'Ivoire, the African locust bean tree is widely distributed from the pre-forest zone (Guinean savanna) to the Sudanian zone (Sudanese savanna) in the northern part of the country (Kouonon *et al.*, 2020). In these agroecological zones, the species remains largely wild, and its exploitation still relies on harvesting from natural populations. The pressure exerted by the use of its wood for the production of handicrafts and charcoal, agricultural expansion associated with population growth, climate change, and the low rate of natural regeneration have transformed its habitat into low-density agroforestry parklands, with approximately 1 to 6 trees per hectare (Cnangle, 2011). In this context, the domestication of *Parkia biglobosa* appears to be a strategic necessity for sustainably improving the livelihoods of rural populations in African. This domestication approach is initially based on exploiting the natural variability of the species through the participatory selection of individuals exhibiting the most desirable phenotypes (Solviev *et al.*, 2004), then on the development of vegetative propagation techniques aimed at stabilizing the genetic characteristics of the selected plant material (Danthu *et al.*, 1996).

It is within this context that the present study is initiated, with the overall objective of providing scientific information to support the domestication and valorization efforts for *Parkia biglobosain* agroforestry programs in Côte d'Ivoire. More specifically, the study aims to assess the parameters of (1) germination and (2) growth of *Parkia biglobosa seeds* subjected to three treatments in two different environmental conditions.

MATERIALS AND METHODS

Localisation de la zone d'étude

The collection of plant material was carried out in the Department of Korhogo in the north of Côte d'Ivoire (Fig. 1). The experimental tests were carried out in the nursery of the botanical garden of the Peleforo GON COULIBALY University in Korhogo. This garden is located between the longitudes 5°38'11" and 5°37'43 W and the latitudes 9°25'42 and 9°26'06 N. The climate is of the Sudanese tropical type with a dry season lasting seven months (November to May) and a rainy season lasting five months (June to October) with a maximum rainfall in August (Eldin, 1971). The average annual rainfall is 1277 mm and the temperature varies between 25°C and 30°C (Silué *et al.*, 2025). The vegetation cover corresponds to the Sub-Sudanian sector, characterized by vegetation formations of dense dry forests, open forests, wooded savannas and shrub savannahs (Kouonon *et al.*, 2020).

Plant material characteristics

The Nere (*Parkia biglobosa*) is native to the Sahelian and Sudanese regions. The species was first described by Brown in 1826, who named it after the famous Scottish explorer Mungo Park.

The Nere is a tree 7 to 20 m tall but can exceptionally reach 30 m height (Hagos, 1962). The trunk is covered with ashy-grey to grey-brown bark that is often blackish, deeply striated, which gives a scaly appearance, in more or less quadrangular plates, and enabling it to withstand bush fires.

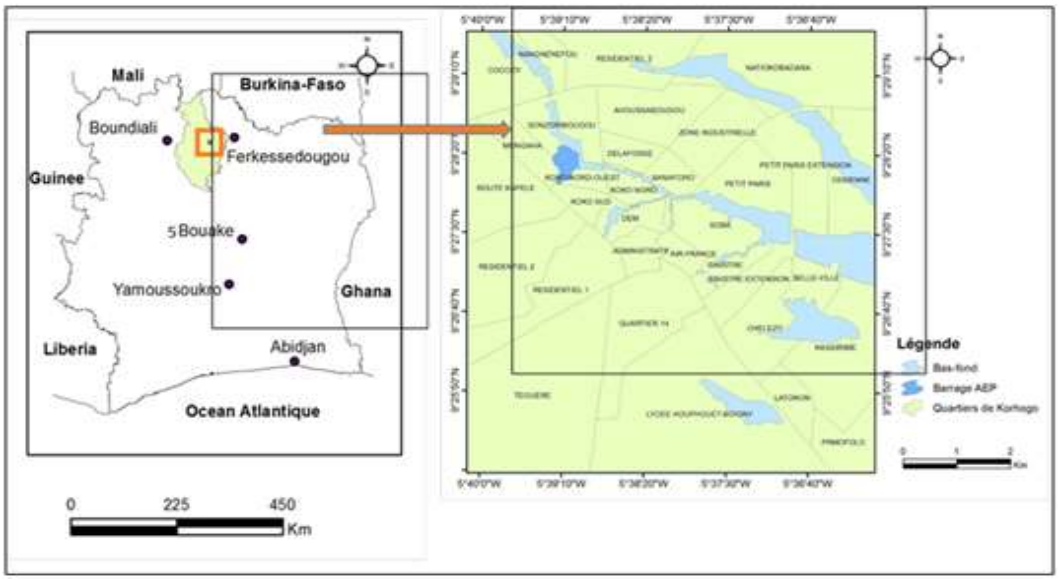


Fig. 1. Location map of the study area

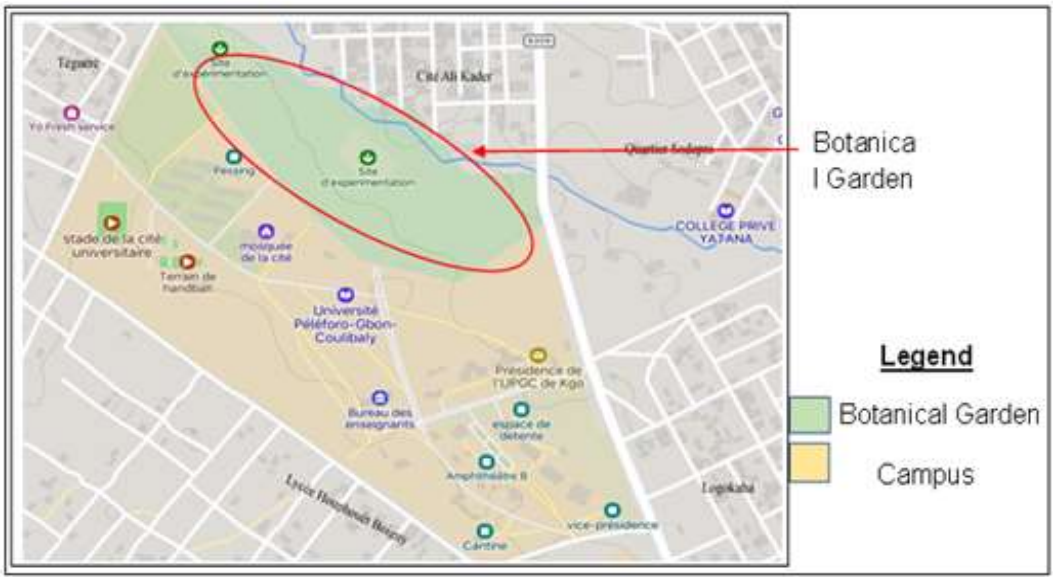


Fig. 2. Geographical location of the botanical garden of the University Peleforo Gon Coulibaly (Source: Mapcarta)

The fruits are glabrous, brownish pods, slightly flattened, hanging from the ends of long peduncles. The seeds are ovoid, brownish to brownish in colour, hard, smooth with pleurogram. They are contained in a sweet, yellowish, floury pulp at maturity and are edible. Up to 23 seeds may be counted, covering the entire cavity of the pod (Gutierrez *et al.*, 2000; Millogo, 2014). This tree, from the legume family, begins to produce when it is still a shrub, at 8 to 10 years of age. It reaches its final height of 10 to 20 m only between 30 and 50 years of age (Agbahungba and Depommier, 1989; Gutierrez *et al.*, 2000).

Experimental design and data collection

The plant material consisted of seeds (fruits and seeds) as well as seedlings of *Parkia biglobosa* obtained from germination trials conducted in the botanical garden of the Peleforo GON COULIBALY University (Fig. 2). Apparently healthy fruits of *Parkia biglobosa* were collected from natural populations in the Korhogo area. In each area, ten individuals of the species, at least 100 meters apart from each other, were identified and from each individual five clusters of fruits with their peduncles, were collected, giving a total of 150 fruit clusters.

The experiments were conducted in the Botanical garden of Peleforo Gon Coulibaly University. These experiments involved the sowing of 600 seeds obtained from the sampled fruits and corresponding to the fruit collection areas of *Parkia biglobosa*. The experimental design consisted of two environments, one shaded and the other exposed to sunlight, in which nursery bags filled with potting soil were arranged in a split-plot design and subdivided into three sub-blocks for the germination tests (Fig. 3).



Fig. 3. Experimental design for the germination trial of *Parkia biglobosa*

Each sub-block consisted of four batches of 25 sachets corresponding to the experimental unit and represents a treatment applied to the seeds before sowing:

Treatment 1 (T1) corresponding to the seeds sown with the pulp;
Treatment 2 (T2) corresponding to seeds sown without the pulp;
Treatment 3 (T3) corresponding to seeds without pulp soaked in warm water at 35°C for 48 hours.

Sowing was carried out by bag and regular watering was performed twice a day (morning and evening) throughout the experimental period.

To monitor the dynamics of juvenile growth of the species, 10 seedlings were selected two weeks after germination in both the shaded and sunny environments and subjected to measurements.

These measurements were carried out every 2 weeks, for 5 months. The parameters measured concerned the total height and the diameter and collar diameter, while the numbers of leaves and leaflets were counted on the selected seedlings.

Data processing and analysis

The analysis of data obtained from the germination trials of seeds collected from the different areas focused on determining and comparing the means of the germination parameters defined by Côme (1968) and Evenari (1957). These parameters include:

Latency Time (TL) (in days) which represents the time between sowing and the first germination;
Germination Rate (TG), which is the ratio of the number of seeds sprouted at the end of the trial to the number of seeds sown:

$$TG=\frac{\text{Number of germinated seeds}}{\text{Number of seeds sown}}\times 100$$

Germination Duration (GD) (in days) defined as the period between the germinated of the first seed and the last germinated seed during the experiment;

Germination Rate (GR) which is determined by the following formula:

$$VG=T1+\left(0,5-\frac{G1}{G2}-G1\right)\times(T2-T1)$$

G1: represents the cumulative percentage of germinated seeds whose value is closest to 50% by lower value, G2: represents the cumulative percentage of germinated seeds whose value is closest to 50%; T1 and T2 correspond to the time required to reach G1 and G2 respectively.

The analysis of the growth of the plants was done through the determination and comparing of mean values of the following growth parameters such as the mean plant height, mean collar diameter, mean number of leaves, mean leaf length, and mean leaf width.

Statistical analysis test

The measured variables were subjected to parametric Tests (Student's t-test for two samples and ANOVA test for three samples) and nonparametric tests (Mann-Whitney test for two samples and Kruskal-Wallis test for three samples) at the 5% significance level, after verification of their normality by the Shapiro test using XLSAT software. The statistical parameters considered are the minimum, the maximum, the mean and the standard deviation.

RESULTS

Effect of sunlight intensity on germination parameters

Observation of seed germination revealed that the intensity of sunlight did not have a significant effect on seed latency in nurseries (Table 1) However, germination was relatively faster (6.50 ± 0.58 days) under shaded conditions for treatment T3 and longer (17.50 ± 1.73 days) under full-sun conditions for treatment T1. The germination rate was comparatively higher (80.00 ± 10.33%) under full-sun conditions for treatment T3 and lower (42.00 ± 4.00%) under shaded conditions for treatment T1Regarding germination duration, it was relatively shorter (10.00 ± 2.16 days) under shaded conditions for treatment T1 and longer (17.25 ± 0.96 days) under shaded conditions for treatment T3.

Table 1. Effect of sunlight intensity on germination parameters

Midfield	Sunny			Statistical tests	Shaded			Statistical tests
Parameters	Treatment 1	Treatment 2	Treatment 3		Treatment 1	Treatment 2	Treatment 3	
Latency period (days)	17,50 ± 1,73	10,25 ± 0,50	8,50 ± 1,00	F = 10,203 p = 0,006	17,25 ±1,89	10,25 ± 0,96	6,50 ± 0,58	F = 9,986 p = 0,007
Germination rate (%)	50,00 ± 8,33	64,00 ± 5,66	80,00 ±10,33	F = 8,777 p = 0,012	42,00 ±4,00	70,00 ± 12,44	52,00 ± 3,27	F = 9,022 p = 0,011
Germination duration (days)	10,50 ± 0,58	16,50 ± 1,29	16,50 ± 0,58	F = 7,652 p = 0,022	10,00 ±2,16	13,50 ± 1,73	17,25 ± 0,96	F = 9,371 p = 0,009
Germination speed (mm/day)	4,75 ± 0,68	3,90 ± 0,45	4,85 ± 0,63	F = 4,178 p = 0,124	4,41 ± 1,34	5,31 ± 1,38	3,03 ± 0,30	F = 5,297 p = 0,071

Table 2. Effect of pre-germination treatments on germination parameters

Germination parameters	Treatment 1		Treatment 2		Treatment 3	
	Shaded conditions	Full-sun conditions	Shaded conditions	Full-sun conditions	Shaded conditions	Full-sun conditions
Latency period (days)	17,25 ± 1,89	17,50 ± 1,73	10,25 ± 0,96	10,25 ± 0,50	6,50 ± 0,58	8,50 ± 1,00
	F = 0,059 ; p = 0,816		F = 0,025 ; p = 0,874		F = 1,000 ; p = 0,356	
Germination rate (%)	42,00 ± 4,00	50,00 ± 8,33	70,00 ± 12,44	64,00 ± 5,66	52,00 ± 3,27	80,00 ± 10,33
	F = 2,188 ; p = 0,139		F = 1,046 ; p = 0,306		F = 5,398 ; p = 0,020	
Germination duration (Days)	10,00 ± 2,16	10,50 ± 0,58	13,50 ± 1,73	16,50 ± 1,29	17,25 ± 0,96	16,50 ± 0,58
	F= 0,000 ; p= 1,000		F = 3,607 ; p = 0,058		F = 1,493 ; p = 0,222	
Germination speed (mm/Days)	4,41 ± 1,34	4,75 ± 0,68	5,31 ± 1,38	3,90 ± 0,45	3,03 ± 0,30	4,85 ± 0,63
	F = 0,333 ; p = 0,564		F = 1,333 ; p = 0,248		F = 5,333 ; p = 0,021	

Table 3. Effect of pre-treatments and sunlight intensity on seedlings

Growth parameters	Treatment 1		Treatment 2		Treatment 3	
	Full-sun	Shaded	Full-sun	Shaded	Full-sun	Shaded
Height	14,10 ± 3,26	14,64 ± 3,87	15,39 ± 3,69	15,92 ± 4,18	15,19 ± 2,72	14,28 ± 3,91
	F = 5,455 ; p = 0,020		F = 1,148 ; p = 0,284		F = 3,348 ; p = 0,067	
Diameters	2,61 ± 0,30	2,73 ± 0,23	2,67 ± 0,27	2,73 ± 0,19	2,48 ± 0,39	2,71 ± 0,24
	F = 5,723 ; p = 0,018		F = 1,577 ; p = 0,209		F = 18,881 ; p < 0,0001	
Number of leaves	4,56 ± 1,30	3,71 ± 1,09	4,32 ± 1,26	3,90 ± 1,07	3,94 ± 1,01	4,98 ± 1,34
	F = 5,668 ; p = 0,018		F = 7,549 ; p = 0,006		F = 32,206 ; p < 0,0001	
Number of leaflets	16,25 ± 5,13	14,52 ± 4,06	15,19 ± 4,30	14,54 ± 4,16	13,26 ± 3,40	17,99 ± 3,68
	F = 8,701 ; p = 0,003		F = 1,360 ; p = 0,243		F = 69,212 ; p < 0,0001	

As for germination rate, it was lower (3.03 ± 0.30 mm/day) under shaded conditions for treatment T3 and higher (5.31 ± 1.38 mm/day) under shaded conditions for treatment T2.

Effect of pre-germination treatments on seed germination in the nursery

The results obtained showed that pre-germination treatments of seeds have a significant effect on the majority of germination parameters except for the germination rate, regardless of the observation environment (Table 2). Under full-sun conditions, the latency period was shorter (8.50 ± 1.00 days) for seeds soaked in warm water for 48 hours (T3) and longer for T1 (seeds sown with pulp) (17.50 ± 1.73 days). For germination rate, the highest value was observed in treatment T3 (80.00 ±10.33%) and the lowest value was observed in treatment T1 (50.00 ± 8.33%).

In terms of germination time, treatment T1 (10.50 ± 0.58 days) was shorter, while treatment T2 (Seed without dried pulp) was longer (16.50 ± 1.29 days). As for the germination rate, it was lower (3.90 ± 0.45 mm/day) at the level of the T2 treatment and higher for the T3 treatment. Under shaded conditions, the latency period was shorter for treatment T3 (6.50 ± 0.58 days) and longer for treatment T1 (17.25 ± 1.89 days). The germination rate was higher (70.00 ± 12.44%) for treatment T2 and lower (42.00 ± 4.00%) for treatment T1. Regarding germination duration, it was shorter (10.00 ± 2.16 days) for treatment T1 and longer for treatment T3. As for germination rate, it was higher (5.31 ± 1.38 mm/day) for treatment T2 and lower (3.03 ± 0.30 mm/day) for treatment T3.

Effect of pre-treatments and sunlight intensity on seedling growth parameters in the nursery

Observation of seedling growth (Fig. 4) showed that sunlight intensity had no significant effect on the height growth (Fig. 5) of seedlings in the nursery (Table 3). However, height was relatively higher (15.92 ± 4.18 cm) under shaded conditions for treatment T2 and lower (14.10 ± 3.26 cm) under full-sun conditions for treatment T1. Collar diameter was slightly higher (2.73 ± 0.23 mm) under shaded conditions for treatment T1 and lower (2.48 ± 0.39 mm) under full-sun conditions for treatment T3. For the number of leaves and the number of leaflets, the highest mean values, respectively (4.98 ± 1.34) and (17.99 ± 3.68), were observed under shaded conditions for treatment T3, while the lowest mean value for the number of leaves (3.71 ± 1.09) was recorded under shaded conditions for treatment T1, and the lowest number of leaflets was observed under full-sun conditions (13.26 ± 3.40) for treatment T3. Regarding leaf length, the highest mean value (7.11 ± 1.69 cm) was observed under full-sun conditions for treatment T1.

DISCUSSION

The analysis of the morphological parameters of *Parkia biglobosa* seedlings under the different pre-germination treatments and light conditions reveals an effect of the environment on the physiology of the plant. The results showed a significant reduction in the latency period following the application of pre-treatments, this could be explained by the combined effect of the pre-germination treatment (soaking in warm water) and light intensity, which significantly influences the germination rate of *Parkia biglobosa seeds*. The results obtained are consistent with those of Kouyaté *et al.* (2011), who reported that hydrothermal treatments (soaking in hot or warm water) significantly reduce latency time in *P. biglobosa*. In terms of germination rate, the different treatments applied improved seed germination compared with the control (T1, untreated), under both environmental conditions. These observations indicate that the interaction between the treatments and the microclimate strongly influence seed germination, probably by modulating moisture availability, temperature, and seed coast permeability. This shows that the combination of treatment and microclimate strongly influences seed germination, probably by modulating the humidity, temperature and permeability of the seed coat.

These observations are consistent with those reported by Bourou and Braconnier (2010), who observed a significant increase in the germination rate of *Vigna unguiculata* following the seed pre-soaking. As for the germination duration, seeds with pulp T1 exhibited a shorter germination duration (10.50 ± 0.58 days) than seeds dried soaked seeds under full-sun conditions. In contrast, under shaded conditions, soaked seeds (T3) exhibited the longest germination duration (17.25 ± 0.96 days).

This indicates that light conditions interact with pre-germination treatments to influence the germination duration. Similar observation were reported by Ouattara *et al.*, (2019) who showed in *Acacia auriculaeformis* that treatment with sulfuric acid treatment followed by soaking in water for 48 hours improved germination speed. The treatments tested had no significant effect on seed germination speed, either under the full-sun or shaded conditions, unlike other parameters such as germination rate and latency period, which showed significant differences. Our results are inconsistent with those reported by Silué *et al.* (2021), who observed that *Khaya senegalensis* seeds treated with water achieved a germination energy of at least 50%, indicating rapid and vigorous germination, suggesting that appropriate environmental conditions can accelerate germination.

The assessment of seedling growth parameters revealed a differential response depending on the treatments applied and the light environment. Under high-light condition (full-sun conditions), a significant difference was noted between the treatments ($F = 5.455$; $p = 0.020$), with higher mean recorded for seedlings originating from treatments T2 (15.39 ± 3.69 cm) and T3 (15.19 ± 2.72 cm) compared with treatment T1 (14.10 ± 3.26 cm).

This increase may indicate more efficient utilization of available light and enhanced photosynthetic activity, thereby promoting stem elongation. In contrast, under shaded condition, o significant variation among treatments was observed ($p= 0.284$), indicating a uniform growth response, probably due to reduced light availability. This light light limitation may attenuate the effect of pre-germination treatments on vertical growth. These observations confirm that light is a key factor influencing stem elongation during the juvenile growth stage, whereas low-light environments tend to homogenize the morphological responses of seedlings regardless of the treatment applied. A similar response was also observed in *Khaya senegalensis* by Tchoundjeu *et al.* (2007). collar diameter, under full-sun conditions, the variations observed among treatments were statistically significant ($F= 5.723$; $p= 0.018$), indicating that the pre-germination treatments applied to the seeds positively influenced radial growth of the seedlings. This response may be attributed to enhanced photosynthetic activity under high-light conditions, resulting in greater carbon assimilation and resource allocation to support tissues. This highlights that adequate light exposure promotes biomass accumulation in the stems, particularly when combined with effective dormancy alleviation. Similar results were reported by Tang *et al.*, 2022 who showed in *Medicago sativa* that low-light conditions accelerate stem elongation but inhibit photosynthesis, whereas sufficient light enhances photosynthetic capacity. Under shaded conditions, however, differences among treatments were not statistically significant ($F = 1.577$; $p = 0.209$), reflecting a more homogeneous seedling growth response regardless of the initial treatment.

This response may be explained by the reduced light intensity, which constitutes a limiting factor for growth. These findings are consistent with those of Poorter *et al.* (2012), who showed that some species tend to allocate more resources to radial growth (collar and root system thickening) when subjected to moderate light stress. Leaf development showed contrasting results between the two environments. Under shaded conditions, seedlings originating from dried seeds (T2) and soaked seeds (T3) produced a significantly higher final number of leaves ($p < 0.0001$) than those grown under full-sun conditions. This adaptive response suggests that shading promotes leaf development to maximize light

capture (Sina, 2006). Furthermore, under ful-sun conditions, the leaf length of seedlings originating from the different treatment (soaked seeds or T3, seeds with pulp or T1) did not differ significantly d(p = 0.24), indicating a non-significant variability between the applied treatments. These results suggest that light intensity influences leaf production more than leaf size, which is consistent with observations made in *Adansonia digitata* by Assogbadjo *et al.* (2005).

Under shaded conditions, seedlings originating from soaked seeds (T3) exhibited the highest values for the final number of leaflets (21.60 ± 2.41) and final leaf length (7.28 ± 1.59 cm), indicating that soaking may promote rapid leaf development under low-light conditions, possibly through improved seed hydration and enhanced water availability during the early stages of seedling establishment. Overall, the results show that light environment and seed pre-germination treatments have a significant combined influence on the juvenile growth of *Parkia biglobosa*. Shaded conditions appear to be more favorable for leaf development, whereas full-sun conditions promote more consistent height and collar diameter growth across the different treatments. These findings are important for guiding nursery management and reforestation practices, particularly in the context of participatory domestication of agroforestry species.

CONCLUSION

This study showed that germination tests of *Parkia biglobosa* seeds highlighted the positive effect of post-harvest treatments (drying and soaking) on seedling growth, especially in shady conditions, highlighting the role of the light environment in regeneration. Seed germination is improved by pretreatments, which reduce latency time and significantly increase germination rate, both in sunny and shaded environments. These results highlight the importance of environmental factors and seed treatment practices in domestication, genetic improvement and conservation strategies for *Parkia biglobosa*.

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