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THE EFFECT OF SEED TREATMENTS ON GERMINATION OF *Pterocarpus angolensis* DC IN THE NURSERY ENVIRONMENT IN NAMIBIA

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ABSTRACT

This study was carried out at the University of Namibia, Ogongo campus to determine the effect of seed treatments on germination percentage of P. angolensis in a nursery environment in order to contribute to the imminent needs for restoration of degraded Miombo woodlands in Southern Africa. The experiment, which involved three seed treatments replicated four times, was designed in a completely randomised design. Three seed treatments used are: (1) soaking the seeds in warm water 40°C for 10 minutes, (2) nicking and (3) control. The experiment was established in a nursery during the rainy season period (November 2023 to March 2024). The germination percentage in the whole experiment was very low ranging from 15% to 32 %. Untreated seeds (control) had the highest germination percent (32%) followed by the seeds that were soaked in warm water 40°C for 10 minutes (24%). The seeds that were nicked achieved the lowest germination percent (15%). Statistically the parametric one -way ANOVA shows that there is no significant difference among the treatments (p=0.230). The low germination percent are partly attributed to various factors such as dormancy, seed rotting due to waterlogging in a shaded nursery during the rainy season. This study revealed the importance of environmental factors as key determining factors of P. angolensis germination rate.

Key words: *Pterocarpus angolensis*, near-threatened, seed dormancy, germination, nicking, soaking

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INTRODUCTION

Pterocarpus angolensis (Kiaat), a member of pea family *Fabaceae* and a subfamily *Papilionoideae* (Curtis and Mannheimer, 2005), is a valuable, deciduous nitrogen fixing tree species. It is distributed in both savannah and forest biomes throughout tropical and subtropical parts of Africa, specifically in the natural deciduous Miombo woodland. This tree occurs in Malawi, Angola, Namibia and Tanzania. (Chisha-Kasumu *et al.*, 2006). In Namibia, the tree is found in the dry woodland savannahs, of the eastern and western Kavango, Zambezi, Otjozondjupa, Omaheke, Ohangwena and Oshikoto regions (Graz, 2004). In addition, the database of the Namibia Botanical Research institute shows that *P. angolensis* was also spotted in Kunene region. The adaptation of *P. angolensis* is highly determined by the rainfall regime in combination with coarse-textured soils and fire tolerance (Kayofa, 2015).

P. angolensis is well-known for producing one of the best timbers in Southern Africa, which is in high demand for its high value (Stahle *et al.*, 1999). The timber is durable, light and strong. It is utilised for furniture', carvings, carpentry and firewood'(Moses, 2013). In addition ,this tree is also used as a medicinal tree, its sap and bark has been used in treating nose bleeding, ulcers, malaria, coughs, diarrhoea, body sores , headaches and ringworms (Orwa *et al*., 2009).

The native tree's roots are powdered to make a brownish red dye, which is utilized in Zimbabwe and Namibia's cottage industry to dye traditional leather garments worn by both men and women. Apart from the dye powder, the root ash of *P. angolensis* is drunk in water to treat asthma and tuberculosis (Moses, 2013). The flowers of *P. angolensis* also serves as a good source of pollen for honeybees (Orwa *et al*., 2009).

Despite its importance, the current regeneration of *P. angolensis* is unsatisfactory due to poor survival of seedlings in the woodland (Mojeremane and Lumbile, 2016). The species has limited natural regeneration and it is threatened by overharvesting, harsh conditions, delayed seed production and low survival rate of seedling during the development stages. In addition, *P. angolensis* is from the legume family and this family is reported to have several type of dormancy which reduces germination percentage of species under this family (Mbailwa *et al*., 2023 , Tselakgosi, 2021). A study conducted by Mojeremane and Lumbile, 2016 reported that, germination rate of *P. angolensis* under controlled environmental condition is poor. As a result, there is a decline of *P. angolensis* trees in the woodlands (Kanime, 2003). It was suggested by Azad *et al*., 2010 that, adopting suitable treatment techniques for *P. angolensis* seeds may result in improved germination rate.

Few studies (De Cauwer and Younan,2015) have been conducted in Namibia to understand the germination requirements for *P. angolensis*, both in nature and under controlled environment. However, the findings from these studies have been somewhat limited. In addition, Namibia has established targets for various initiatives under the Nationally Determined Contributions (NDCs). One such initiative involves plans to rehabilitate specific areas with trees as part of efforts to mitigate climate change. Results from this study can contribute to this strategy by providing advises regarding suitable seed treatment for this tree species in order to promote its germination for further rehabilitation of Namibian Miombo woodlands. This study was therefore conducted to determine the effect of seed treatment on germination percentage of *P. angolensis* in the nursery environment.

MATERIALS AND METHODS

Study Area

The seed experiment was performed under a nursery environment at the University of Namibia, Ogongo Campus forestry nursery (latitude 17º40.38″S longitude15º18.02″E). Ogongo campus is situated in northern Namibia, 700 km from the capital city Windhoek. The climatic conditions within and around the study area is variable and unreliable with an annual mean rainfall ranging from 450-500 mm and a mean temperature of >22°C (Awala *et al.*, 2021). The nursery in which the seedlings were raised is constructed with a shade net providing 80%.

Soil for potting media

Seeds were sown in a mixture of growing media containing soil collected from various sites in Ohangwena region, which is the ecological range areas of *P. angolensis* (Figure 1). The growing media consisted of 50% soil from Ogongo campus and 50% soil from Ohangwena region (Table 1). Although the aim was to collect the whole growing media from the ecological range areas, this was not feasible due to the challenge of transporting many kilograms of sand over a long distance. As a result, soils were mixed in order to create a nutrient –poor soil that would naturally support this tree species. In the field, the soil was collected at the depth of 15cm.

Table 1: Soil collection points in villages at Ohangwena Region

Village name	Coordinates (S)	Coordinates (E)
Ohameva	17° 35. 6841′	017° 05. 1224′
Ondeumane	17° 38. 9300′	017° 23.7825′
Onamafila	17° 35. 820′	017° 05. 6935′
Enyana	17° 37. 2728′	017° 21. 7145′
Omupembe	17° 35. 8467′	017° 08. 1760′
Onheleiwa	17° 35. 8479′	017° 08. 1761′
Ogongo	17° 14. 4212′	15° 17. 4820′

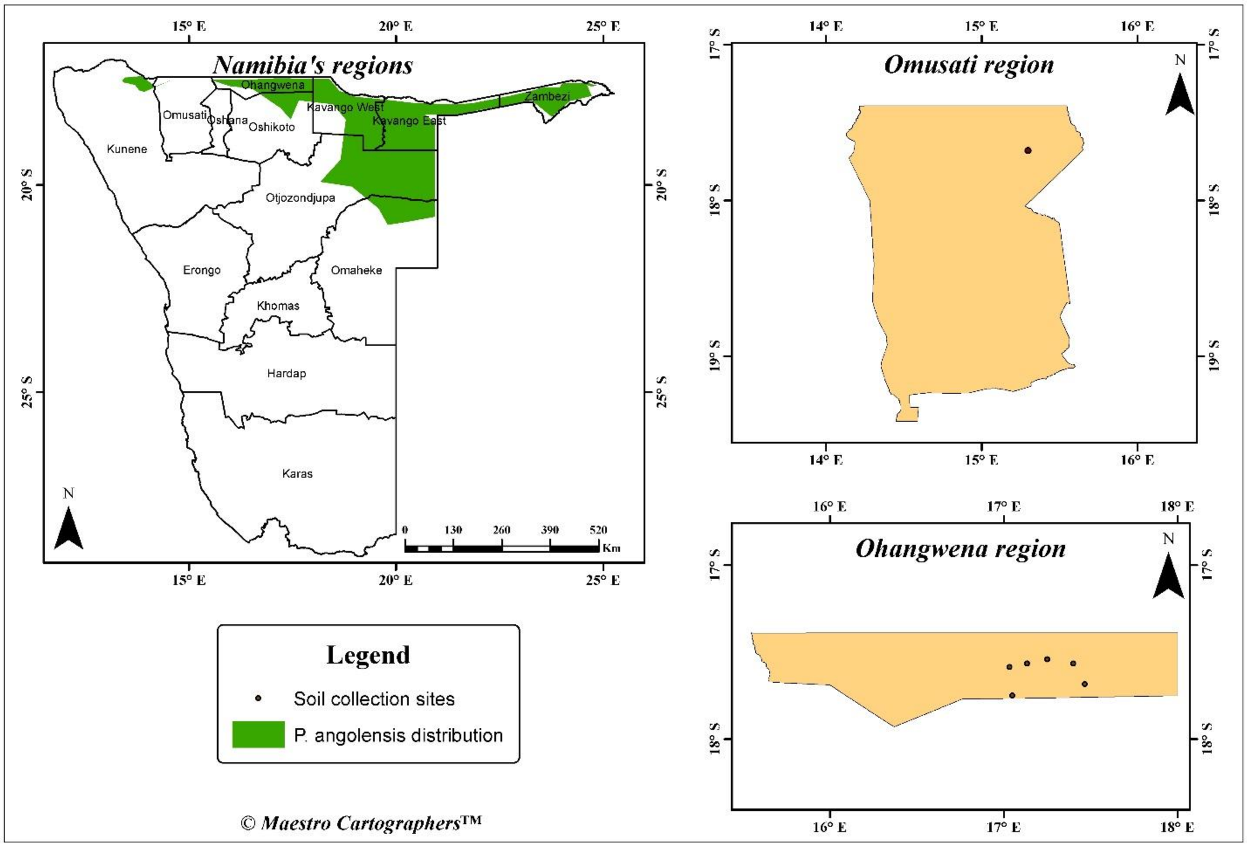

Figure 1: (a) Distribution of *P. angolensis* in Namibia (NBRI 2024) and (b) potting media collection sites

Seeds collection and handling

In July 2023, mature fruits of *P. angolensis* were collected from healthy, matured, naturally growing trees found in communal areas of Ohangwena region. Although these fruits were collected from Oshekasheka and Ohameva villages, only those from Ohameva village (located at latitude 17° 35. 6841"S and longitude 017°05. 1224" E) were eventually used for sowing. This decision was made because the tree at Ohameva village produces quality seeds, as it can be observed due to the larger size of the fruits and the freshness and size of the seeds extracted from them. In order to ensure seed viability, only seeds produced during the 2023 season were collected in the field. After collection, pods have been stored in a store room for a period of three weeks to allow for a complete seed drying under a room temperature. After three weeks, seeds were extracted from the pods and sorted in order to remove all damaged, immature and distorted seeds. Healthy and matured seeds were then used for sowing. All the seeds were soaked in tap water for 24 hours in order to remove all distorted seeds. The sinking seeds were all considered viable and the floating ones were considered not viable. The sinking seeds were dried for 12 hours in an open sun in order to reduce the moisture content.

Experimental design and layout

The experiment was laid in a completely randomized design (CRD) at Ogongo forestry nursery. The study involved the use of three seed treatments which are nicking, soaking and control. Nicking was done by rubbing the seed against a stone to remove a small part of the seed coat, while soaking was carried out by soaking the seeds in warm water 40 ℃ for 10 minutes. The untreated seeds were used as the control. Each treatment was replicated four times and under each replication there were 66 polythene bags.

Sowing

Seeds were sown directly in black polythene bags measured 29 cm in length and 15 cm wide. The preference for black polythene bags stems from their ability to absorb more heat compared to other colors, which proves beneficial for plant growth, especially in cooler climates. Additionally, the dark color of these bags shields plant roots from potentially harmful light exposure. Furthermore, the larger size of these bags contributes to their capacity for retaining moisture, which is particularly advantageous in hot climates where plants require higher water levels for optimal growth. In each polythene bag, three seeds were sown at a depth of 3-4cm. Sowing seeds at this particular depth encourages seedlings to emerge more rapidly and facilitates the growth of sturdy root systems. There were 264 seeds sown for each treatment giving a total of 792 seeds used in this experiment.

Data collection

The number of seeds germinated was collected over a period of ten weeks. Germination percentage (GP), mean germination time (MGT), coefficient of velocity of germination (CVG) and germination index (GI) was recorded once per week from the day of first germination to the end of the germination period.

Germination percentage refers to the proportion of seeds that successfully germinate under controlled conditions, typically expressed as a percentage of the total seeds tested. This metric provides crucial information about seed quality and their potential to germinate and develop into healthy seedlings.

$$\text{Germination } \% = \frac{Number\ of\ germinated\ seeds}{Total\ number\ of\ seed\ sown} \times 100 \ \ldots\ldots\ldots\ldots.. (1)$$

Mean germination time is the average time required for seeds to germinate under particular conditions. MGT offers insights into the speed and consistency of germination, which are essential for evaluating seed quality, forecasting crop emergence, and optimizing planting schedules.

$$\text{Mean germination time} = \frac{\Sigma(\boldsymbol{n}\times\boldsymbol{t})}{\boldsymbol{\Sigma}\mathbf{n}} \ \ldots\ldots\ldots\ldots.. (2)$$

The coefficient of velocity of germination measures the speed and uniformity of germination. CVG is useful for assessing and ensuring the consistency and quality of seed germination.

$$\text{Coefficient of velocity of germination} = \left(\frac{\boldsymbol{\Sigma}\mathbf{n}}{\boldsymbol{\Sigma}(\mathbf{n}\times\boldsymbol{t})}\right) \ \ldots\ldots\ldots\ldots.. (3)$$

The germination index measures how quickly and uniformly seeds germinate over time, often expressed as a numerical percentage. GI enables researchers and plant growers to compare different treatments, seed lots, or environmental conditions based on the speed and uniformity of seed germination.

$$\text{Germination index} = \sum \left(\frac{\boldsymbol{ni}}{\mathbf{ti}}\right) \ \ldots\ldots\ldots\ldots.. (4)$$

Data Analysis

Data analysis was performed using Statistical Package for the Social Sciences (SPSS) computer software. Data was tested for normality using Shapiro-Wilk test. Collected data was subjected to a parametric one-way analysis of variance (ANOVA) after seeing that the data was normally distributed. A significance level of $\alpha = 0.05$ was used as the minimum acceptable probability for the difference between the treatments. This significant level provides a reasonable level of statistical power, especially when combined with an appropriate sample size and effect size. It ensures that the study has a good chance of detecting true effects or relationships.

RESULTS

The study showed that, the maximum germination percentage (31.82%) was recorded in untreated seeds (table 2), followed by the seeds that were soaked in warm water 40℃ for 10 minutes, which achieved the germination percentage of 24.24%. The lowest germination percentage (14.77%) was recorded in seeds that were nicked. The p-value shown in table 2 indicates the germination metrics results from the ANOVA.

Table 2: Results of germination metrics for three different seed treatments.

Treatment	GP		GRI		MGT		MGR		CVG		GI	
	Mean	Std error	Mean	Std error	Mean	Std error	Mean	Std error	Mean	Std error	Mean	Std error
Nicking	14.77	6.47	0.90	0.35	19.09	3.33	0.05	0.01	5.69	0.88	0.60	0.23
Soaking	24.24	2.70	1.16	0.17	27.04	1.92	0.04	0.00	3.75	0.26	0.76	0.11
Control	31.82	2.23	1.58	0.16	25.28	1.28	0.04	0.00	3.98	0.19	1.04	0.11
p-value	**0.06**		**0.20**		**0.09**		**0.06**		**0.06**		**0.20**	

The seed emergence was recorded over 10 weeks. Results showed that for all treatments, there was no germination during week one of sowing (Figure 2 below). Germination only started during the second week of sowing. Seed germination was poor in all treatments beyond week 7, however it was notable to observe that, seeds that are nicked before sowing stopped germinating at week 8, while those that were treated with warm water and control, they continued at least until week 10. Even after10 weeks, some seeds in control treatment were still germinating. An additional 2% of seed germination was observed in untreated seeds at week 12. Analysis of variance revealed no significant difference (p=0.230) in germination percent among different seed treatments.

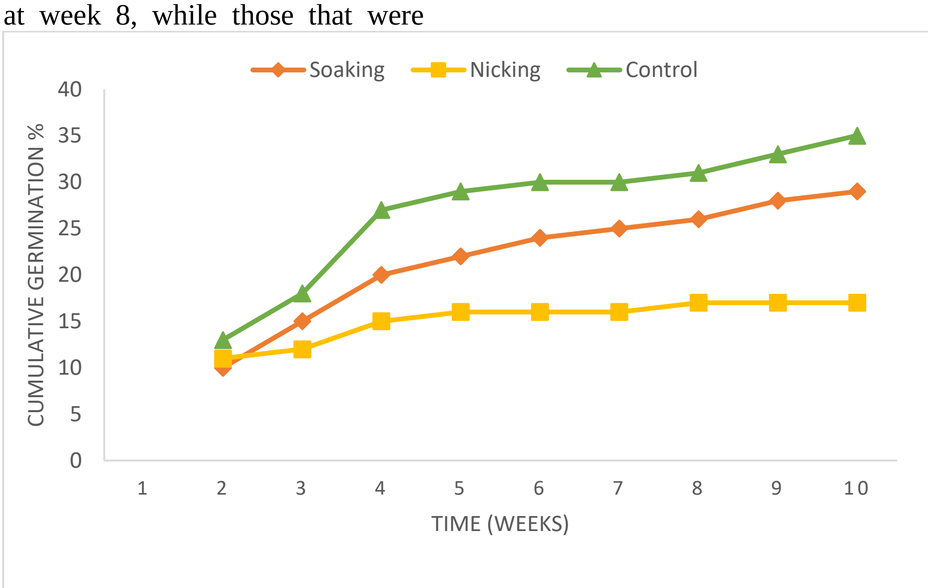

Figure 2: Cumulative germination percentage throughout the germination period of *P. angolensis* under three seed treatments

Mean germination time, coefficient of velocity of germination and germination index

The results indicated that the mean germination time (MGT) was highest for the soaking treatment at 27.04, followed by the control treatment at 25.28, and the lowest MGT was observed in the nicking treatment at 19.09 (Table 2). Regarding the coefficient of velocity of germination (CVG), the nicked seeds had the highest CVG at 5.69, followed by the control treatment at 3.98. Seeds subjected to soaking treatment had the lowest CVG. The germination index (GI) was highest in the control treatment at 1.04, followed by the soaking treatment at 0.76, and the lowest GI was found in the nicking treatment at 0.60.

DISCUSSION

Based on the results, the germination percentage of *P. angolensis* seeds in the nursery condition was very poor. This is indicated by the highest number of un-germinated seeds across all treatments which is (76%) as compared to the germinated ones (24%). The low germination percent, mean germination time, coefficient of velocity of germination and germination index across all seed treatments in this study could be attributed to various factors such as seed dormancy, type of seed treatments as well as environmental factors (heat, shade, rainfall, etc.) to which the seeds were subjected to.

The propagation of seedlings of many native leguminous woody species in tree nurseries is negatively affected by impermeable and hard seed coats, which prevent inhibition (Latiwa *et al*., 2023)**.** High dormancy is one of the factor that could have attributed to low germination rate of *P. angolensis* seeds in this study. The result shows that germination of *P. angolensis* seeds can last up to 10 weeks. Some seeds especially those that were not treated maintained their viability in the soil despite continuous watering and rain. Untreated seeds were still seen to be germinating even after the study was over. This phenomenon can be attributed to seed dormancy which characterized seeds of most species under the family *Fabaceae* (Latiwa *et al*., 2023). This result is supported by De Cauwer and Younan, 2015 who indicated that, in controlled environments, seeds of some indigenous trees like that for *P. angolensis* started germinating after twelve days, however, this germination continued for over a year and reach a higher germination percentage. Nicking and soaking seeds in warm water proved not to break the seed dormancy of this tree species. As a result, seeds that were nicked ended up rotting in the soil and stopped germinating at week 8. Different plant species have unique ways of regulating dormancy. This means that what triggers dormancy in one species might not affect another in the same way. Additionally, seed dormancy varies depending on the seed's maturity level and its moisture content (Azad *et al*., 2010). Azad *et al*., 2010 and Mojeremane *et al*., 2020 proposed different methods of breaking seed dormancy in some species in order to improve the germination rate and increase the germination process. Under natural environment, seed dormancy in native species can be broken with fire and extreme temperature (Luna *et al.*, 2009).

The key factor affecting mean germination time is the ability of the treatment to modify the seed coat's permeability to water and gases. A lower mean germination time (MGT) indicates faster germination. Nicking allows for quicker water and gas exchange, overcoming the dormancy caused by a hard or impermeable seed coat. This direct approach shortens the time needed for the seeds to absorb water and begin germination, leading to a faster mean germination time. A higher MGT indicates slower germination. Soaking seeds in water softens the seed coat, but this process is slower compared to nicking. A higher coefficient of velocity of germination (CVG) signifies faster and more uniform germination. The high CVG observed in the nicking treatment aligns with the reduced mean germination time (MGT). The physical breach of the seed coat accelerates the germination process, resulting in quicker and more uniform germination. Soaking results in a moderate CVG, enhancing germination speed compared to the control but is less effective than nicking. The differences in the germination index for the three treatments can be attributed to how each method affects the seed coat and the seed's ability to absorb water and initiate germination. A higher germination index indicates high rate and speed of germination. Control appears to be the most effective treatment for improving the germination index, it allows seeds to germinate according to their natural timing without causing mechanical damage, leading to a higher germination index. Nicking, while intended to aid germination, might introduce stress that offsets its benefits, resulting in a lower germination index compared to the other treatments.

In addition to dormancy, the type of treatment a seed receives also seems to have played a role in the low germination rate of *P. angolensis* seeds of this study. It is occasionally possible to ascertain that certain seeds germinated more quickly under specific treatment conditions than under others. Various authors (Latiwa *et al*., 2023, De Cauwer and Younan, 2015, Peter *et al*., 2021 and Tselakgosi, 2021) revealed that, nicking was the most effective seed treatment for *P. angolensis*. However, in the case of this study, untreated seeds showed a better germination percent among the two seed treatments. Shackleton, 2002 revealed a different trend, whereby the untreated seeds achieved the lowest germination percent. This study implies that nicking and soaking seeds in warm water were the treatments that resulted in the lowest germination percentage. Results also indicated that, seed treatments nicking and soaking did not improve the germination percentage of this species, therefore it can be concluded that, better germination of these seeds can occur without any treatment.

Despite dormancy and type of seed treatment, another factors that seems to have contributed to low seed germination is environmental factors (rainfall, heat, shade and light) under which the seeds are sown. Rainfall seems to be the main factor that contributed to the poor germination of seeds, most especially to the nicked seeds. Nicking appears to have caused a lot of seeds to rot because sowing was carried out during the rainy season and most of the time the polythene bags were wet due to rain and the compounded effect of the nursery shade net. The results imply that a choice of seed treatment need to take into consideration the environment and the season during which sowing is conducted. This is particularly important when seedlings are raised in the nursery where light penetration and aeration is limited by the shade-net. The crucial role played by light and shade in *P. angolensis* germination observed in this study support the observation of other authors. For example, a study by Vermeulen, 1990 reports that, *P. angolensis* is a light demanding species, which even though it may persist in a moderate shade it is likely to stagnate at a later stage. Similarly, a nursery experiment by Graz, 2004 shown that *P. angolensis* seeds germinated better in the absence of shade.

This study highlights the complex interaction of factors influencing the germination of *P. angolensis* seeds in nursery conditions. Despite efforts to reduce dormancy through various treatments such as nicking and soaking, the germination percentage remained low, pointing to the resilience of seed dormancy in this species. This study also revealed variations in both the mean germination time, coefficient of velocity of germination and germination index among the three seed treatments. All treatments exhibited relatively long MGT values. This emphasizes how carefully considering seed biology and environmental dynamics is essential when devising propagation methods. Environmental factors, particularly rainfall and light availability, emerged as important determinants of germination success, highlighting the importance of site-specific considerations in nursery management. In the end, integrating knowledge of seed dormancy, treatment efficacy, and environmental conditions will be essential for enhancing the propagation and conservation efforts of native woody species like *P. angolensis.*

CONCLUSION AND RECOMMENDATIONS

This study set out to determine the effect of seed treatments on germination percentage of *P. angolensis* in a nursery environment. The results of this study show that, the control treatment achieved both the highest germination percentage and germination index. The nicking treatment resulted in the shortest mean germination time and uniform germination. Therefore, future researchers should consider using untreated seeds of *P. angolensis* due to its superior germination percentage and germination index as well as its reasonable mean germination time.

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