MUDIMA

Jurnal Multidisiplin Madani
ISSN 2808-5639

Vol 3, No 5, May 2023

JURNAL MULTIDISIPLIN MADANI

(MUDIMA)

Published by:
Formosa Publisher
Jl. Ir Juanda No. 56b,Lantai 2, Medan, Indonesia
Website: https://journal.formosapublisher.org

JURNAL MULTIDISIPLIN MADANI (MUDIMA)
Homepage: https://journal.formosapublisher.org/index.php/mudima
ISSN: 2808-5639 (Online)
Research Article

Volume 3, No 5, May (2023)	DOI: https://doi.org/10.55927/mudima.v3i5.4105	Page: 981-993

Viability and Growth of Sugar Palm (*Arenga pinnata* (Wurmb.) Merr.) on Various Seed Maturity Levels Using Natural Soaking Solutions

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ARTICLE INFO

Keywords: *Arenga Pinnata*, Viability, Growth, Seed Maturity Level and Soaking Solutions

Received : *5 April*
Revised : *18 April*
Accepted : *19 May*

ABSTRACT

Sugar palm (Arenga pinnata), a multi-purpose tree species (MPTS), has significant ecological and economic benefits. However, the imbalance between the benefits of this plant and its development is a concern. After reaching 50 years of age, the sugar palm tree can no longer reproduce, necessitating the need for cultivation. The primary challenge in cultivating this plant is its hard seed coat. While acidic ingredients have been used to break seed dormancy, natural ingredients are not commonly utilized. This study employed an experimental method with a completely randomized design (CRD). The study design included three factors: maturity level (K), soaking solution treatment (B), and soaking time (L). The parameters assessed in this study were maximum growth potential, germination capacity, leaf length, leaf area, number of leaves, stem diameter, stem length, primary root length, number of roots, and apical shoot length. The results indicate that soaking treatment did not significantly affect the parameters, except for root length. The maturity level treatment also did not significantly impact the parameters. However, K2 seeds (uniform yellow) showed better results in all parameters than other maturity levels, and B3 (100% coconut water) was the soaking solution that yielded positive results

INTRODUCTION

Sugar palm (Arenga pinnata (Wurmb.) Merr.) is classified as a multi-purpose tree species (Furqoni, 2014) native to Southeast Asia. The plant is widely distributed throughout Indonesia, particularly in hilly valley areas of small and large islands. It is known by various regional names such as "nao" in Lombok and Bima and "pola" in Sumbawa (Baharuddin & Taskirawati, 2009). This species has extensive benefits compared to other palm species. Its potential is significant for fulfilling food diversification needs, especially carbohydrates, sugar sources, and bio-ethanol production (Furqoni, 2014).

In the West Nusa Tenggara Province, specifically on Lombok Island, sugar palm is commonly used to produce sweet palm drinks, palm sugar, and fruit. In contrast, other benefits, such as palm fiber, sticks, rope, and other construction materials, are used as by-products. Female flower stalks are responsible for fruit production, while male flower stalks are tapped to obtain juice (Aji et al., 2020). The high potential of sugar palm provides an excellent prospect for farmers to increase their income. Jumardin (2013) reported that if farmers produce 83.21 liters/day of sap and 10.40 kg/day of palm sugar, they can earn a net income of Rp. 106,133.46 per day, and Rp. 2,122,669.20 per month. Furthermore, Fatriani et al. (2012) indicated that sugar palm trees aged 10-20 years could produce an average of 20.83 liters/tree/day, while palm trees aged 21-30 years can produce an average of 7.95 liters/tree/day. By maximizing silvicultural aspects and increasing land productivity, sugar palm can become a breakthrough in increasing farmers' income.

Despite the high potential of sugar palm, its cultivation is developing slower than its potential. This condition is due to the nature of sugar palm seeds having a long dormancy period of around 3-5 months and up to 1 year if the environment that supports dormancy breaking is improper. Marsiwi (2012) indicated that sugar palm seeds could germinate 5-6 months after sowing. Several studies have been conducted to break the dormancy of sugar palm seeds, such as scarification (skin scraping) and soaking with harsh chemicals, which have shown promising results. However, these methods are challenging to apply uniformly due to the tough skin of the seeds that slow down water infusion. Widyawati et al. (2009) suggested that the hardness of sugar palm seeds is due to the increase in lignin content as the seeds mature.

The harder the seeds, along with the ripening or maturity of the sugar palm seeds, become a significant obstacle in the germination process seedbed. Sutopo (2012) stated that physiologically ripe seeds have a maximum germination builder content compared to unripe seeds. Therefore, the need for a solution to this problem is required.

Several studies by previous researchers on viability and growth as a response from sugar palm seed soaking using various soaking solutions have been done, including: KNO_3 (Hartawan, 2016), H_2SO_4, HNO_3 and HCl (Firdaus, 2015), H_2SO_4, HCl and GA_3 (Puspitasari, 2019), and H_2SO_4 and KNO_3 (Rahmadani, 2022). Even though scarification and chemical treatments have shown promising results in several studies, these treatments are still difficult to be applied by the community. Therefore, research on the viability and growth of sugar palm plants still needs to be done, in particular, using materials easily found around the farmers.

The purpose of this study is to determine the effect of soaking treatment and the level of seed maturity, as well as the interaction between these two treatments, on the ability to germinate and grow of sugar palm (Arenga pinnata (Wurmb.) Merr.

METHODS

Research Time and Location

This research was conducted at the greenhouse of the Department of Forestry-University of Mataram. The location lies between Latitude 08°35'7" S and Longitude 116°5'42" E and is 26 m above sea level. The research samples are analyzed at the Laboratory of Silviculture and Forest Product Technology, Department of Forestry-University of Mataram.

Seed Collection, Pre-treatment of A. Pinnata and Experimental Design, Tools, and Materials

The sugar palm seeds were collected from Bentek sub-village, West Pemenang Village, Pemenang District, North Lombok Regency. Based on the factor of maturity level, the sugar palm fruit obtained is divided into three maturity levels based on the fruit's color: yellowish-green, yellow, and brownish-yellow fruit. The seeds were extracted by moisturizing them for approximately one (1) month. According to Saleh et al. (2007 cit. Saleh, 2004), the longer the palm fruit is moistened, the better the fruit's ability to germinate by 10-30 days. The seeds and pulp can be separated using gloves to avoid contact with the pulp, which can cause irritation and itching on the skin.

The seed soaking solution consists of (1) organic chemical, namely CH3COOH, and (2) natural ingredients, namely juice of the sugar palm and coconut water. The CH3COOH required is 1% concentration. Meanwhile, sugar palm juice and coconut water were used directly with a concentration of 100% for soaking.

This study used a Factorial Completely Randomized Design (RALF) model with three factors consisting of three (3) levels of fruit maturity (K) (i.e., yellowish-green M-3(K1), yellow M-4 (K2), and yellow-brown M-5 (K3)), three (3) levels of the soaking solution factor (B) (i.e., CH_3COOH 1% (B1), 100% sugar palm juice (B2), and 100% coconut water (B3)), and four (4) levels of the soaking time factor (L) (i.e., 0 hours (control) (L0), 6 hours (L1), 12 hours (L2), and 24 hours (L3)). A combination of 3×3×4= 36 treatments was obtained from these three factors, making the total experimental unit of 36×3= 108 experimental poags.

Data Collection and Analysis

This study was conducted for 12 months. The parameters observed during the research included:

1. Maximum Growth Potential (MGP) (%): The maximum growth potential was calculated by counting the number of abnormal and normal seedlings at the end of the observation period using the following formula:

$$\textit{Maximum Growth Potential} = \frac{\textit{Number of seedlings at the end of the observation period}}{\textit{Number of seeds sown}} \times 100\%$$

2. Germination Capacity (GC) (%): Germinatin capacity can be calculated by counting the number of normal seedlings and then expressing it as a percentage using the following formula: *Ge*

$$\textit{rmination Capacity} = \frac{\textit{Number of normal seedlings observed}}{\textit{Number of seeds sown}} \times 100\%$$

3. Leaf Length (cm): Leaf length was measured using a ruler from the stem or plumule tip to the base of the leaf. Measurements were taken at the end of the observation period.

4. Leaf Area (cm2): Leaf area was calculated using a millimeter grid tracing each leaf side. Measurements were taken at the end of the observation period.

5. Number of Leaves: The number of leaves was counted for each plant. Measurements were taken at the end of the observation period.

6. Stem Diameter (cm): stem diameter was measured using calipers at a distance of 1 cm from the root growth point. Measurements were taken at the end of the observation period.

7. Stem Length (cm): stem length was measured from the root growth point to the plumule tip using calipers. Measurements were taken at the end of the observation period.

8. Primary Root Length (cm): The primary root measured was the most prominent and central compared to the others. Root length was measured using a ruler and taken at the end of the observation period.

9. Number of Roots: The number of roots counted includes primary and other large roots, not root hairs. It is measured at the end of the observation.

10. Apical Shoot Length (cm): Apical shoot length is measured near the seed to the base of the plumule or stem and measured at the end of the observation.

Data Analysis

The observation data were then analyzed using Analysis of Variance (ANOVA) at a significance level of 5%. To determine significant differences among each treatment, if there is a significant differ

ence in the diversity source during ANOVA analysis, further testing is conducted according to Duncan's Multiple Range Test (DMRT) at a significance level of 5%.

Results and Discussion

Viability Analysis

Viability analysis consists of maximum growth potential and germination power. Maximum growth potential is an estimation of the total number of seeds that will germinate. This estimation is done by counting the number of seeds that have germinated normally and those that have not germinated normally (in the case of aren seeds, these seeds are at the stage of breaking dormancy with the appearance of a white color circle until the plumule emerges, while normal germination is the germination that has leaves). Meanwhile, Suita & Syamsuwida (2015) explained that germination power is the proportion of normal germinated seeds from the total number of seeds sown. The results of the analysis of variance for viability in this study can be seen in Table 1.

Table 1. Analysis of Variance (ANOVA) Results on Viability of Sugar Palm Seeds

No	Parameter	Maturity	Solution	Time	Interaction			
					Maturity * Solution	Maturity * Time	Solution * Time	Maturity *Solution*Time
1	MGP (%)	ns	ns	ns	ns	ns	ns	ns
2	GC (%)	ns	ns	ns	ns	ns	ns	ns

Note: * Indicates an Interaction Effect, Ns (Not Significant)

Table 1 shows that all viability parameters measured in this study were not significant. This means that the application of treatments from each factor or combination did not have significantly different effects from each other. However, visually, the differences between the treatments can be seen by comparing the average values of each treatment. The differences in the average values are as follows:

Maximum Growth Potential (MGP)

Maximum germination potential (MGP) is the percentage of normal and abnormal germinated seeds from the total number of sown seeds. This parameter determines the number of seeds that will germinate at a particular time during the research period or at the end of the observation period. MGP, in the case of sugar palms, is particularly important in assessing the quality of seeds because it can determine whether a seed can germinate within a specified time. Therefore, the treatments given are essential for evaluating the quality of seeds, particularly at different maturity levels. The average MGP percentage values of the Aren seeds for each treatment can be seen in Figure 1.

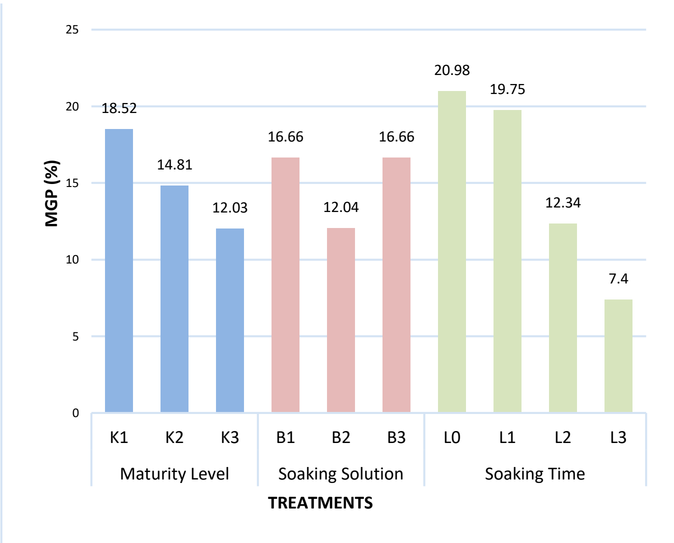

Figure 1. Graph of Differences in Average Maximum Growth Potential Values at the Treatment of Maturity Level (K), Soaking Solution (B), and Soaking Time (L).

Figure 1 shows that the highest percentage of maximum germination potential (MGP) value at maturity level 1 (K1) was 18.52%, followed by K2 (14.81%) and K3 (12.03%). These values indicate the low germination percentage in the sugar palm seed, which requires a long time to germinate, as stated by Marsiwi (2012). This finding is also consistent with the study by Usman (2009, cited in Aji *et al.*, 2020), which showed that the MGP (%) of sugar palm seeds with maturity levels M-3 (K1), M-4 (K2), and M-5 (K3) without scarification had different values. M-3 had the highest MGP value (31.7%) compared to M-4 (25.0%) and M-5 (28.3%). The poor treatment to break seed dormancy might have caused this result, which prevented uniform and significant germination.

Based on this study, applying natural materials was ineffective in improving the total germination of sugar palm seeds. This ineffectiveness is evident in the average MGP percentage of B1 and B3 (16.66%) and B2 (12.04%). However, B1 (1% acetic acid) and B3 (100% coconut water) were better than B2 (100% sugar palm juice), indicating the low quantity of acetic acid and the positive effect of coconut water on the germination of sugar palm seeds, possibly due to its constituents that promote seed germination.

On the other hand, the factor of soaking time showed that the non-soaked seeds (L0) had the highest MGP value compared to the soaked seeds. The average MGP percentage decreased with the longer soaking time. In this case, a longer soaking time negatively affected MGP, but it is expected to affect other parameters positively.

Germination Capacity (GC)

Germination capacity (GC) is the percentage of normal seedlings from the total seeds sown. This parameter is intended to determine the number of seeds that will germinate at a particular time during the study or at the end of the observation period. The value of GC will be lower than the maximum potential growth percentage, as GC calculation only considers normal seedlings. The average value of GC percentage in sugar palm seeds for each treatment can be seen in Figure 2.

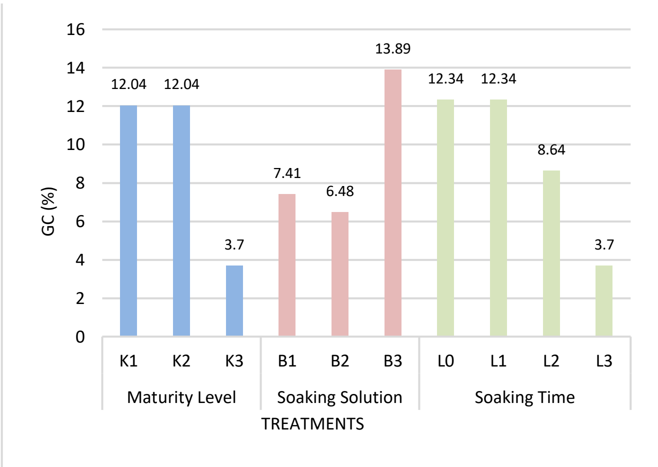

Figure 2. Graph of Differences in Average Germination Values in the Treatment of Maturity Level (K), Soaking Solution (B), and Soaking Time (L).

Figure 2 shows that the average value of germination capacity varies depending on the treatment, indicating that each treatment has different abilities. For example, the highest germination capacity was found in treatments k1 and K2 (12.04%), while the lowest was in K3 (3.7%). This result suggests that K1 and K2 have almost the same germination ability, whereas K3 showed the lowest value due to the hard seed coat. Widyawati (2009) explained that sugar palm seeds become harder as they age. Furthermore, among the three soaking materials, B3 had the highest value (13.89%), followed by B1 (7.41%), and the lowest was B2 (6.48%). This result is in line with the potential of seed germination, as explained previously. The use of soaking solution in this research is lower than that of previous research. Rozen et al. (2016) reported that the use of chemical soaking solutions such as H2SO4 3% results in a GC of 15,2 %, KNO3 3% results in a GC of 16,0 % and HCl 3% results in a GC of 14,4 %.

Out of all the soaking periods tested, treatments L0 and L1 had the highest value of 12.34% in improving germination capacity. However, the capacity decreased for L2 and L3, which involved longer soaking periods. As a result, treatment L1 was found to be the most effective due to the dominance of B3 over the other materials. Increasing the soaking time beyond this may not be advantageous.

Growth Analysis

Plant growth occurs when new plant organs are formed. The optimal fulfillment of supporting factors, both internal genetic and external environmental factors, is necessary for healthy plant growth. The height or level of these supporting factors can impact the growth of plant organs, including leaves, roots, and stems. Table 2 shows the analysis of variance results for the growth of sugar palm seedlings.

Table 2. Analysis of Variance (ANOVA) Results for the Growth of Sugar Palm Seedling

No	Parameter	Maturity	Solution	Time	Interaction			
					Maturity * Solution	Maturity * Time	Solution * Time	Maturity *Solution * Time
1	Apical Shoot Length (cm)	ns	ns	ns	ns	ns	ns	ns
2	Number of Roots	ns	ns	ns	ns	ns	ns	ns
3	Primary Root Length (cm)	ns	ns	**s**	ns	ns	ns	ns
4	Stem Diameter (cm)	ns	ns	ns	ns	ns	ns	ns
5	Stem Length (cm)	ns	ns	ns	ns	ns	ns	ns
6	Leaf Length (cm)	ns	ns	ns	ns	ns	ns	ns
7	Number of Leaves	ns	ns	ns	ns	ns	ns	ns
8	Leaf Area (cm^2)	ns	ns	ns	ns	ns	ns	ns

Note: * indicates an interaction effect, s (significant), ns (not significant)

Table 2 shows that all measured growth parameters in this study were not significant, except for soaking time on the number of roots. Therefore, for non-significant parameters, no further tests were conducted, while post hoc tests using Duncan's Multiple Range Test (DMRT) were performed for significant parameters. In non-significant parameters, differences in mean values can be observed by comparing the average values in each treatment. The differences in mean values are as follows:

Apical Shoot Length (cm)

The apical serves as the pathway for nutrient supply from the seed to initiate germination. When the endosperm is dissected, it appears hollow, and once its growth ceases, the primary root or radicle emerges. Subsequently, the endosperm swells, and the plumule emerges. Thus, the apical serves as the source of nutrition for the potential germination, as the root hairs have not yet emerged. Without root hairs, the sugar palm seedling obtains nutrients from the stored food reserves in the seed. The average length of the apical shoot in sugar palm seeds under each treatment can be observed in Figure 3.

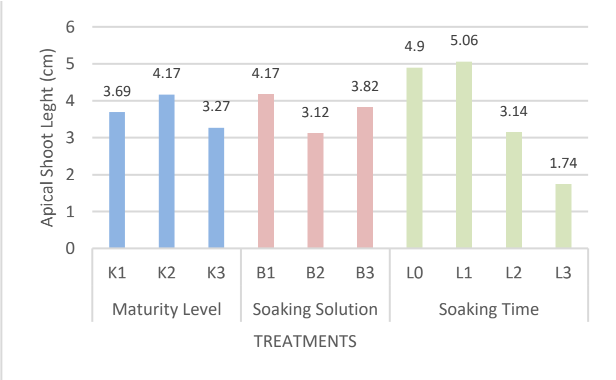

Figure 3. Graph of Differences in Average Values of Apical Length in the Treatment of Maturity Level (K), Soaking Solution (B), and Soaking Time (L)

Figure 3 shows that the average length of the endosperm exhibits varying values. Among the maturity levels, K2 demonstrated the highest average endosperm length, measuring 14.17 cm, compared to K1 and K3. Consistent with Chaerani (2016), the length of the apical shoot in both scarified and non-scarified seeds did not exhibit a significant difference. These results suggest that the observed effects were insignificant regardless of the treatment. Regarding the soaking solution, the highest value was recorded for B1 (4.17 cm), while the lowest was observed for B2 (3.12 cm). In terms of soaking time, the longest time (L1) resulted in the highest apical shoot length (5.06 cm), whereas the shortest time (L3) yielded the lowest value (1.74 cm).

Number of Roots

The seedling roots of sugar palm plants possess a primary root or taproot and smaller roots that will develop into fibrous roots. The abundance of roots plays a crucial role in facilitating water transport to plant organs. Therefore, this parameter can be correlated with other parameters, such as leaves and stems. The average number of roots in sugar palm seeds under each treatment condition can be observed in Figure 4.

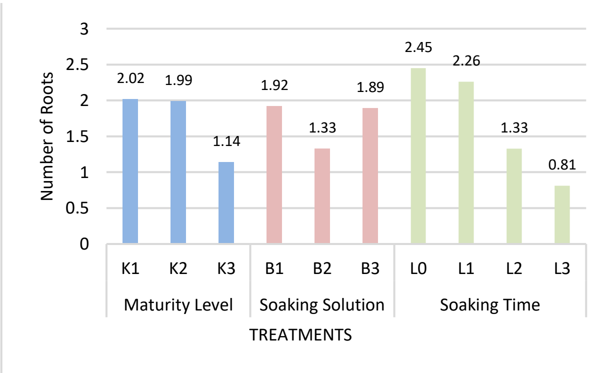

Figure. 4. Graph of Differences in Average Values of Root Quantity in the Treatment of Maturity Level (K), Soaking Solution (B), and Soaking Time (L)

Figure 4 displays the treatment conditions for sugar palms with different maturity levels, where K1 (2.02) exhibits the highest value, and K3 (1.14) has the lowest value. Regarding the soaking materials, the highest value is observed in B1 (1.92), followed by B3 (1.89), while the lowest value is found in B2 (1.33). These results indicate that soaking the seeds in coconut water positively influences the number of roots. Furthermore, considering the soaking time, it is evident that a longer soaking period leads to a decrease in the number of roots.

The number of roots was unaffected by the maturity or soaking treatments. This condition is similar to the results of Furqoni's study in 2014, which used different treatments and found that light intensity did not impact the number of roots.

Primary Root Length (cm)

The main root in sugar palm plants is called the primary root, which is responsible for providing stability to the plant. The deeper the primary root goes into the soil, the stronger it anchors the plant. During sugar palm germination, the primary root is the first to emerge, followed by smaller roots growing alongside it. Figure 5 shows the average length of the primary root in sugar palm seeds for each treatment.

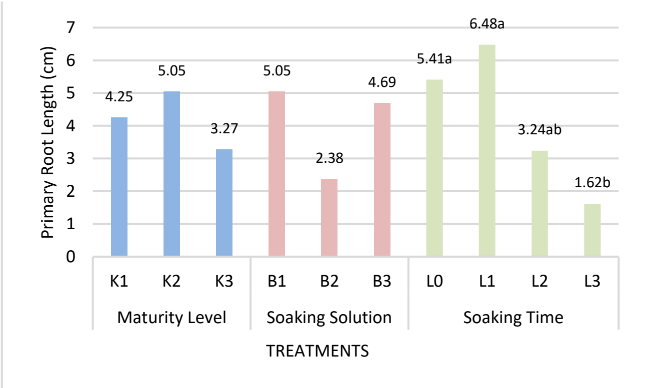

Figure 5. Graph of Differences in Average Values of Primary Root Length in the Treatment of Maturity Level (K), Soaking Solution (B), and Soaking Time (L)

The data presented in Figure 5 indicates that K2 had the highest value (5.05 cm) in the maturity level treatment, while K3 had the lowest value (3.27 cm). In the soaking solution treatment, the highest value was found in B1 (5.05 cm), whereas the lowest value was recorded in B2 (2.83 cm). The soaking time significantly impacted each level, with no significant difference observed between treatments L0, L1, and L2. Treatments L2 and L3 were also not significantly different, but treatments L0 and L1 differed significantly from L3. The longest soaking time was observed in treatment L1 (6.48 cm), and the average length of roots decreased from L2 to L3. Hence, a soaking time of L1 was the most favorable compared to L0, L2, and L3 under these conditions.

The study conducted by Furqoni (2014) stated that the length and number of primary roots were not affected by the treatment of shading intensity. Similarly, in this study, the maturity treatment and soaking material did not have an effect on the number of roots. However, the soaking time had a significant impact, with L1 showing the highest value.

Stem Diameter (cm)

The results of the analysis of variance in Table 2 indicate that all the treatments administered did not have a significant effect on the stem diameter of sugar palm seedlings. This finding can be attributed to the slow growth of sugar palms, resulting in a minimal increase in stem diameter for each plant. However, the differences between the treatments can be observed from the average values at each treatment level. The average stem diameter values for sugar palm seedlings under each treatment are presented in Figure 6.

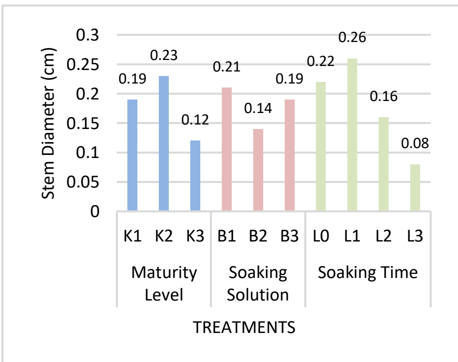

Figure 6. Graph of Differences in Average Values of Stem Diameter in the Treatment of Maturity Level (K), Soaking Solution (B), and Soaking Time (L)

Based on Figure 6, it can be observed that all treatments resulted in different average values for each treatment. Regarding maturity level, the highest value was obtained in K2 (0.23 cm), while the lowest value was recorded in K3 (0.12 cm). Regarding the soaking solution treatment, the highest value was found in B1 (0.21 cm), and the lowest was observed in B2 (0.14 cm). Similarly, the highest value was obtained in L1 (0.26 cm) in the soaking time treatment, while the lowest value was observed in L3 (0.08 cm).

Based on the findings of this study, maturity level and soaking treatment do not influence stem diameter. However, referring to the research conducted by Furqoni (2014), it is evident that the variable affecting stem diameter is the intensity of light received by the sugar palm seedlings. Seedlings exposed to higher light intensity tend to have smaller stem diameters than those with lower light intensity.

Stem Length (cm)

The sugar palm plant belongs to the monocotyledonous group of plants. During the seedling stage, the stem or trunk and nodes have not yet formed; they are only represented by leaf blades (Rozen *et al.*, 2016). Therefore, in this study, the term "stem length" refers to the portion starting from the base of the root to the tip of the first remnants of plumule in the sugar palm plant. Measuring the stem length in this way is necessary because the stem in sugar palm seedlings is not clearly defined when they are small. In addition, during the early stages, the fronds exhibit dominant vertical growth, which may mistakenly be referred to as the stem. However, it should be noted that the fronds do not function as the actual stem. The average stem length values for the sugar palm seedlings under each treatment condition can be seen in Figure 7.

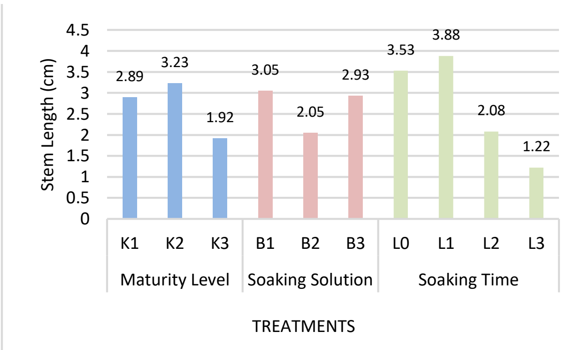

Figure 7. Graph of Differences in Average Values of Stem Length in the Treatment of Maturity Level (K), Soaking Solution (B), and Soaking Time (L).

Figure 7 shows that all treatments show different values. Regarding maturity level treatment, the highest value is observed in treatment K2 (3.23 cm), while the lowest value is recorded in K3 (1.92 cm). The highest value for the soaking solution treatment is obtained in B1 (3.05 cm), whereas the lowest is observed in B2 (2.05 cm). While regarding the soaking time, the highest value is found in L1 (3.88 cm), while the lowest is observed in L3 (1.22 cm). Rozen *et al.* (2016) explained that plant height or stem height correlates with the germination speed of the seeds, meaning that seeds that germinate earlier tend to have taller stems compared to those that germinate later. However, when comparing with parameters such as MGP and GC, the seeds with the highest values are found in K1. Additionally, according to the study conducted by Aji *et al.* (2020), examining the embryo length in K1, it is higher than the other treatments. Moreover, when considering the stem length parameter, K2 performs better than K1. Therefore, the maturity level of the seeds influences the stem length growth, even though K1 exhibits faster growth compared to K2.

Leaf Length (cm)

The analysis of variance results in Table 2 indicates that all treatments analyzed did not have a significant effect on the length of sugar palm seedling fronds. However, differences between treatments can be observed by examining the average values for each treatment level. The average length of fronds in sugar palm seedlings for each treatment can be seen in Figure 8.

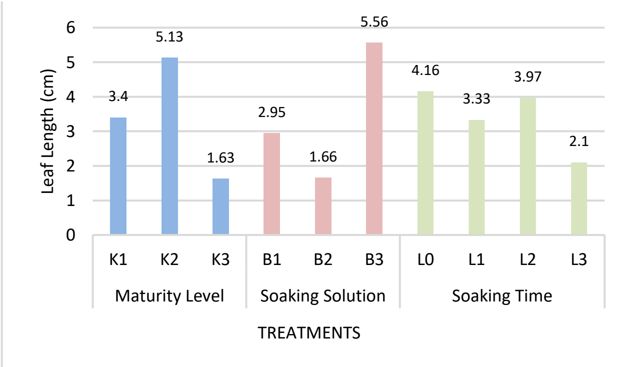

Figure 8. Graph of Differences in Average Values of Leaf Sheath Length in the Treatment of Maturity Level (K), Soaking Solution (B), and Soaking Time (L)

Figure 8 illustrates that all treatments yield different average values for each treatment. The highest value is observed in treatment K2 (5.13 cm), while the lowest is in K3 (1.63 cm). In the soaking solution treatment, the highest value is obtained in B3 (5.56 cm), and the lowest is recorded in B2 (1.66 cm). Furthermore, in the soaking time treatment, the highest value is observed in L0 (4.16 cm), while the lowest is in L3 (2.10 cm).

Based on the findings of this study, the maturity level and soaking treatment do not significantly affect the length of fronds. However, referring to the study by Furqoni (2014), it is evident that the variable influencing the length of fronds is the intensity of light received by the sugar palm seedlings. Seedlings exposed to higher light intensity exhibit shorter fronds than those with lower light intensity. Additionally, fronds that develop earlier tend to be shorter than those that grow later

Number of Leaves

The average number of leaves in sugar palm seedlings under each treatment condition can be observed in Figure 9.

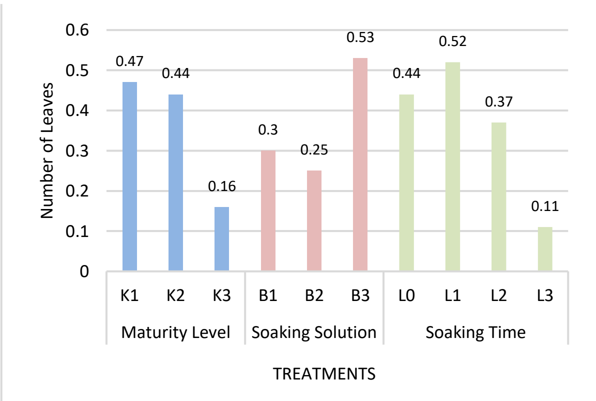

Figure 9. Graph of Differences in Average Values of Leaf Count in the Treatment of Maturity Level (K), Soaking Solution (B), and Soaking Time (L)

Figure 9 shows that all treatments have different average values for each treatment condition. The highest value for maturity level treatment is observed in K1 (0.47 leaves), while the lowest value is recorded in K3 (0.16 leaves). For the soaking material treatment, the highest value is obtained in B3 (0.53 leaves) and the lowest in B2 (0.25 leaves). Furthermore, in the soaking time treatment, the highest value is observed in L1 (0.52 leaves) and the lowest in L3 (0.11 leaves). The growth rate of sugar palm seedling leaves is considerably slow compared to other species in the Aracaceae family. The growing environment greatly influences the leaf growth rate in sugar palms during stem development. However, the growth rate typically ranges from 3 to 6 leaves per year (Furqoni, 2014, cited in Smits, 1996). Additionally, the light intensity does not affect the leaf count in sugar palm plants (Furqoni, 2014). Therefore, in this study, maturity level and natural soaking do not significantly affect the leaf count.

Leaf Area (cm^2)

The average leaf area values for sugar palm seedlings under each treatment condition can be seen in Figure 10.

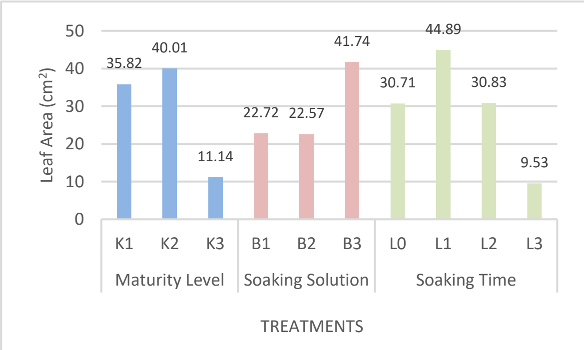

Figure 10. Graph of Differences in Average Values of Leaf Area in the Treatment of Maturity Level (K), Soaking Solution (B), and Soaking Time (L).

Figure 10 illustrates that all treatments yield different average values for each treatment condition. The highest value for maturity level treatment was observed in K2 (40.01 cm2), while the lowest value was recorded in K3 (11.14 cm2). In the soaking material treatment, the highest value was obtained in B3 (41.74 cm2), and the lowest was observed in B2 (22.57 cm2). Similarly, in the soaking time treatment, the highest value was found in L1 (44.89 cm2), and the lowest was observed in L3 (9.53 cm2).

Based on the findings of this study, maturity level, and soaking have no significant effect on leaf area. However, the research conducted by Furqoni (2014) revealed that the variable affecting leaf area is the intensity of light received by sugar palm seedlings. Seedlings grown under 56% shading had a higher leaf area than those grown under shading intensities above or below 56%. The graph shows that seedlings with higher leaf areas will likely exhibit better growth, particularly in K2, due to their larger leaf area than other maturity levels. This condition is attributed to the broader area available for food processing, allowing for a greater allocation to other organs such as the roots and stems.

Furqoni (2014) also stated that sugar palm seedlings with longer leaf blades have a larger leaf area than those with shorter leaf blades. The present study verifies this finding, as evidenced by the positive relationship between leaf blade length and leaf area. Furthermore, a larger leaf area is observed in k2, with a higher leaf blade length.

Conclusion

Based on this research, several conclusions can be drawn are as follow: (1) The soaking treatment did not have a significant effect on all germination and growth parameters of *A. pinnata* (Wurmb.) Merr plants, except for the root length, which was affected by the soaking time; (2) The maturity level treatment did not have a significant effect on all germination and growth parameters of *A. pinnata* (Wurmb.) Merr plants; (3) The interaction between treatments did not have a significant effect on all germination and growth parameters of *A. pinnata* (Wurmb.) Merr plants; and (4) Although the treatments did not have a significant effect, it can be concluded that the K2 treatment (uniform yellow) yielded better results in all parameters compared to other maturity levels. As for the soaking material, B3 (100% coconut water) provided positive results.

REFERENCES

Baharuddin & Taskirawati I. (2009). Non timber forest product. Faculty of Forestry, University of Hasanuddin. Makassar.

Chairunisaa A. (2013). Three Factor Experiments with Repeated Measurement. Thesis. Mathematic Program, Department of Mathematic Education, Faculty of Mathematic and Natural Science, State University of Yogyakarta. Yogyakarta.

Devi MG. (2013). Globular embryo induction in sugar palm plants (*Arenga pinnata* (Wurmb) Merr.). Thesis. Department of Agronomy dan Horticulture, Faculty of Agriculture, IPB University. Bogor.

Aji MLA, Sutriono R, & Diansyah A. (2020). Dormancy breaking of sugar palm (*Arenga pinnata* (Wurmb.) Merr.) seeds at different maturity levels using submersion method. Jurnal Belantara, 3(1): 12-24.

Fatriani, Sunardi, & NS FP. (2012). Effect of Age Tree Palm (*Arenga pinnata* Merr.) Against Production Nira in Pulantan Village, Awayan District, Balangan Regency, South Kalimantan Province. Jurnal Hutan Tropis, 13(1): 11-17.

Firdaus (2015). The effect of several dormancy breaking treatments of aren (Arenga pinnata Wurmb. Merr.) seeds on viability and vigor and seed growth. Thesis. Faculty of Agriculture, University of Andalas. Indonesia.

Furqoni H. (2014). Seed Characterization and Germination of Aren (Arenga pinnata (Wurmb.) Merr.) and Response of Seedling Growth to Shade Intensity. Thesis. Graduate School of IPB University. Bogor. Indonesia.

Hanafiah KA. (2014). Theory and application of trial design: Third Edition. Faculty of Agriculture, Sriwijaya University, Palembang. PT Raja Grafindo Persada. Jakarta.

Hartawan R. (2016). Scarification and KNO3 break dormancy and increase the viability and vigor of aren (Arenga pinnata Merr.) seeds. Jurnal Media Pertanian, 1(1): 1-10.

Ichsan. 2014. Determining of alcohol gauge concentrate and acetate acid in nira (sugar palm liquid) due to storage period on space temperature. Jurnal Kesehatan Ilmiah Nasuwakes, 7(1): 1-8.

Irmayanti. (2016). Effect of soaking and planting media on germination and growth of sugar palm seedlings (*Arenga pinnata*). Thesis. Forestry Program. University of Mataram. Mataram. Indonesia.

Jumardin. (2013). Financial analysis of traditional palm sugar (Arenga pinnata) production. Thesis. Forest Product Technology Program, Department of Agriculture Technology. Samarinda State Agricultural Polytechnic. Samarinda. Indonesia.

Lasut TL. (2012). Good cultivation of sugar palm (*Arenga pinnata* (Wurmb) Merr.). Texas A&M University, IPB University, University of Udayana and University of Sam Ratulangi.

Marsiwi T. (2012). Several ways of treating sugar palm (Arenga pinnata Merr) seeds to break dormancy. Department of Agronomy, Faculty of Agriculture, University of Gadjah Mada. Yogyakarta. Indonesia.

Mudiana D. (2006). Germination of *Syzygium cumini* (L.) Skeels. Jurnal Biodiversitas, 8(1): 39-42.

Nurika I, & Hidayat N. (2001). Production of acetic acid from coconut water by continuous fermentation using a bio-oxidation column (study of particle height in a column and aeration speed). Jurnal Teknologi Pertanian, 2(1): 51-57.

Permatasari A. (2013). Viability of cucumber seed (Cucumis sativus L.) under optimum and suboptimum conditions after invigoration treatment. Thesis. Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University. Bogor. Indonesia.

Permentan. 2014. Guidelines for good palm cultivation (*Arenga pinnata* Merr). Appendix to the Regulation of the Minister of Agriculture Number 133/Permentan/OT.140/12/20134.12011 concerning guidelines for good palm cultivation (Arenga pinnata Merr). Minister of Agriculture, Republic of Indonesia. Jakarta.

Puspitasari AD. (2019). The effect of scarification combined with soaking of seeds in H2SO4, HCL and GA3 solution on the viability of aren (Arenga pinnata Merr.) seeds. Thesis. Agroecotechnology Program, Faculty of Agriculture, University of Siliwangi. Indonesia.

Rahmadani R. (2022). Effect of H2SO4 and KNO3 concentrations on the breaking of dormancy and growth of aren (Arenga pinnata (Wurmb.) Merr.) Seeds. Thesis. Agroecotechnology Program, Faculty of Andalas, University of Andalas. Indonesia.

Rozen, Thaib R, Darfis I & Firdaus. (2016). Seed dormancy breaking of palm (Arenga pinnata) with various treatments and the evaluation of the growth of seedlings in the field. Prosemnas Masy. Biodiv. Indonesia, 2(1): 27-31.

Saleh MS, Adelina E, Maemunah, Nuraeni, Idham, Samudin, S, & Alam N. (2007). Development of sugar palm seed technology research (Arenga pinnata (Wurmb.) Merr) at University of Tadulako. Palu. Proceedings of the National Seminar on Research. 91-95.

Schmidt L. (2000). Guidelines for seeds handling of tropical and subtropical forest plants. Directorate General of Land Rehabilitation and Social Forestry. Ministry of Forestry. Jakarta.

Sutopo L. (2012). Seed technology: Revised Edition. Faculty of Agriculture, University of Brawijaya. Rajawali Press. Jakarta.

Usman MA. (2006). Effect of maturity level and dormancy breakdown of sugar palm (Arenga Pinnata (Wurmb.) Merr.) seeds in different media conditions. Thesis. Plant Breeding and Seed Technology Program, Faculty of Agriculture, IPB University. Bogor.

Utomo B. (2006). Seed ecology scientific papers. Department of Forestry Teaching Staff. Faculty of Agriculture, University of North Sumatera. Medan. Indonesia.

Widyawati N, Tohari, Yudono P, & Soemardi I. (2009). The permeability and germination of sugar palm seeds (Arenga pinnata (Wurmb.) Merr.). Jurnal Agronomi Indonesia, 37(2): 152-158.