Improving germination with pre-sowing technique on 
*Caliandra calothyrsus* Meissn

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Abstract. Red Calliandra (*Caliandra colothyrsus*) is a high-quality energy wood raw material that can be produced rapidly. It's ideal for making wood pellets. The need for wood pellets is on the increase globally. For the production of wood pellets continuity, sufficient materials were required, requiring the development of red calliandra cultivation. The long duration of the seed germination process due to the hard seed coat is an obstacle in the generative propagation of red calliandra. This study aimed to determine the best treatment for red calliandra dormancy breaking and simultaneous germination. A factorial fully randomized design (F-CRD) with two treatment factors was used in this study. The first factor is type of solution (P) with three levels consisting of: P1: soaking in water; P2: immersion with MSG solution (12 grams/liter); P3: immersion in young coconut water (100%). The second factor is the length of immersion time (T) with three levels consisting of: T1: soaking time for 8 hours; T2: immersion time for 12 hours; T3: immersion time for 16 hours. Each treatment consisted of 20 seeds, which were replicated three times for a total of 540 seeds. The initial day of germination, length of germination, percentage of germination, and germination rate index were all measured. The results showed that the most optimal germination for red Calliandra found in the P1T1 treatment (soaking in water for 8 hours). It can be shown from all observed parameters

1. Introduction

Red calliandra is a plant with several advantages that is well-known in Indonesia. The red calliandra plant is utilized as a protective plant, land reclamation and conservation, green manure, bee feed, and high-quality fodder for animals as well as other leguminosae in some areas [1]. Red calliandra, as a raw material for energy wood, can generate high-quality energy raw materials rapidly and efficiently, especially for the production of wood pellets [2]. The demand for wood pellets in the domestic market has risen significantly in the previous 2-3 years. In the tea drying business, the tofu industry, and other food sectors, the pellets are utilized as a gas substitution [3].

Wood pellets made from sawdust are a biomass-based fuel that may be used as a substitute for coal, but are more ecologically friendly because lower the CO₂ emissions. Many international market demands come from South Korea and Japan, but pellet availability is still limited on a global scale. Wood pellet output in Indonesia is still limited; the Ministry of Environment and Forestry reported 42,922.26 tons in January-May 2019, and only a small portion of it came from wood raw materials [3,4]. The wood-based pellet industry has just recently continued to widen, but raw materials were in limited supply. This fact promotes sustainable red calliandra on a large scale [3]. Calliandra can be propagated or generatively, however generative propagation is more common. The long duration of
the seed germination process is an obstacle to the generative cultivation technique of red calliandra. The thick shells provide high resistance to the absorption of water and air into the embryo, resulting in seed growth inhibition [5].

The invigoration method, particularly optimizes seed viability so that the seeds can sprout quickly, is one of the efforts to accelerate the growth of red calliandra seeds. Invigoration is a physical, physiological, and biochemical treatment that promotes seed viability and allows seeds to develop quickly and simultaneously in a variety of conditions [6]. Giving natural growth regulators, such as young coconut water, is an effort to accelerate seed germination. Coconut water contains cytokinin (5.8 mg/l), auxin (0.07 mg/l), gibberellins, and other substances that can promote seed germination and growth [7].

Soaking calliandra seeds in a solution of MSG (12 grams/liter) for 12 hours was the most effective treatment for red calliandra seed germination [8]. Furthermore, the optimum treatment for seed germination was discovered to be soaking the seeds with hot water and then allowing them to soak overnight before planting [2]. Another treatment that improves germination is soaking in hot water for 2-5 minutes, followed by soaking in cold water for 12-24 hours [5]. The aim of this study was to find the best treatment for breaking red calliandra dormancy and simultaneous germination.

2. Method

This research was conducted in the greenhouse of the Faculty of Agriculture, Universitas Sumatera Utara. The research was designed using a Factorial Completely Randomized Design (F-CRD) with two treatment factors. The first factor is type of solution (P) with three levels consisting of: P1: soaking in water; P2: immersion with MSG solution (12 grams/liter); P3: immersion in young coconut water (100%). The second factor is the length of immersion time (T) with three levels consisting of: T1: soaking time for 8 hours; T2: immersion time for 12 hours; T3: immersion time for 16 hours. Each treatment consisted of 20 seeds and was repeated 3 times (r = 3), so that the number of seeds used was 540 seeds.

The research procedure was carried out through 5 stages of activities those were planting media preparation, seed soaking, sowing the seed, maintenance activities and data observation. The planting media for red calliandra germination are combined topsoil and coconut fiber powder with a ratio of 1:1. The media is mixed until evenly distributed and then placed into polytube. The soaking activities were conducted through soaking the seeds using a solution of MSG (12 gr/liter), young coconut water (100%), and water. The duration of each immersion was 8 hours, 12 hours, and 16 hours. Sowing seed are carried out in a poltube that already contains planting media. One tub of germination can contain 20 red calliandra seeds. Maintenance activities is carried out to provide suitable conditions for red calliandra germination process. The activities are watering and controlling pests and diseases. Observation and data collection were conducted during soaking process until the seed growth.

Data analysis was carried out using the F test in MS Excel to see the differences between treatments on the observed observation parameters. If the F test is significant, it is continued with the Tukey test. The observation parameters in this study were: the first day of germination, length of germination, percentage of germination and germination rate index. The First day of germination: record the beginning of germination that occurs in each treatment and replication. Length of germination: the average length of germination, starting from normal germinate until the end of the observation.

Percentage of germination was calculated using the formula as follows [9]:

\[ PG = \frac{\text{n}}{\text{N}} \times 100\% \]  \hspace{1cm} (1)

\( \text{n} \) = number of seeds that germinate;
\( \text{N} \) = number of seeds sown

Index of Germination rate index was calculated using the formula as follows [10]:

\[ IGR = \frac{\text{G1/D1} + \text{G2/D2} + \text{G3/D3} + \cdots + \text{Gn/Dn}}{\text{N}} \]  \hspace{1cm} (2)
IRG = Index of Germination Rate
G = number of seeds that germinate on a given day
D = time corresponding to the amount; n = number of days at final calculation

3. Results and Discussion

3.1. First Day of Germination
The first day of germination was quite variable and did not exhibit uniformity throughout all treatments, however many were found to germinate on the sixth day. The P1T1 treatment experienced the fastest germination on day 4 (after soaking in plain water for 8 hours), while the P1T3 treatment experienced the slowest germination on day 12 (soaking in plain water for 16 hours). The results of statistical analysis are presented in Table 1.

| Source of Variation | SS   | df | MS   | F     | P-value | F crit |
|---------------------|------|----|------|-------|---------|--------|
| P                   | 0.96 | 2  | 0.48 | 0.52  | 0.60    | 3.55   |
| T                   | 2.07 | 2  | 1.04 | 1.12  | 0.35    | 3.55   |
| Interaction         | 38.59| 4  | 9.65 | 10.42 | 0.00    | 2.93   |
| Within              | 16.67| 18 | 0.93 |       |         |        |
| Total               | 58.2963| 26 |      |       |         |        |

Based on the F test, it can be seen that there is a significant different in the interaction between a single factor, while the single factor is not significantly different. As a result, the treatment will only be effective if used in combination with both the type of soaking factor and the duration of immersion. The Tukey test was performed to determine the source of the difference, with the results given in Figure 1.

![Figure 1. Tukey's test for the first day of germination (values followed by the same alphabets are not significantly different at a level of 95% confidence)](image)

Figure 1 shows that the first day of germination for P1T1, P2T1, P2T2, P2T3, P3T1, P3T2, and P3T3 remained within the same range. Unfortunately, P1T3 is the treatment that results in the latest day of first day germination. Imbibition is an important point in seed hydration that contributes to the initiation of biochemical changes that lead to germination [11]. P1T1 (soaking into water for 8 hours) showed the best optimal treatment for first day germination time.
The process of seed germination involves a complex series of morphological, physiological, and biochemical changes. The first stage of seed germination begins with the seed absorbing water, softening of the seed coat, and hydration of the protoplasm. The second stage begins with cellular and enzyme activities and increases the seed's respiration rate. The third stage involves the breakdown of substances like carbohydrates, lipids, and proteins into soluble forms, which are then translocated to the growth point. The fourth stage is the assimilation of carbohydrates, lipids, and proteins in the meristematic area provide energy for component synthesis and cell development. The fifth stage is sprout growth, which occurs at the growth point through the mechanisms of cell division and elongation [9].

3.2. Length of germination
Length of germination is the average length of germination, starting from normal germinate until the end of the observation (Table 2). The length of germination was quite varied, did not show uniformity for all treatments. The shortest length of germination time occurred in three days on P1T3 treatment (soaking in plain water for 16 hours), while the longest length of germination occurred in eleven days on P1T1 treatment (soaking in plain water for 8 hours).

| Source of Variation | SS   | df | MS  | F   | P-value | F crit |
|---------------------|------|----|-----|-----|---------|--------|
| P                   | 5.56 | 2  | 2.78| 1.44| 0.26    | 3.55   |
| T                   | 1.56 | 2  | 0.78| 0.40| 0.67    | 3.55   |
| Interaction         | 36.89| 4  | 9.22| 4.79| 0.01    | 2.93   |
| Within              | 34.67| 18 | 1.93|     |         |        |
| Total               | 78.67| 26 |     |     |         |        |

According to the F test, there is a significant different in the interaction between a single factor, but the single factor is not significantly different. As a result, the treatment will only be effective if it is used in combination with the type of soaking factor and the duration of immersion. The Tukey test was performed to determine the source of the difference, with the results given in Figure 2. Figure 2 shows that the duration of day of germination for P1T2, P1T3, P2T1, P2T2, P2T3, P3T1, P3T2, and P3T3 remained within the same range. The P1T3 pre-sowing technique is the most effective (soaking into water for 16 hours).

![Figure 2](image)

Figure 2. Tukey's test for length of germination (values followed by the same alphabets are not significantly different at a level of 95% confidence)
3.3. Percentage of germination

Data on germination percentage was gathered at the end of the observation. The results revealed that the percentage of germination was quite variable, with no uniformity through any treatments. P2T3 treatment (soaking in MSG solutions for 16 hours) resulted in the lowest percentage of germination, whereas P3T3 treatment resulted in the highest percentage of germination (soaking in young coconut water for 16 hours). Table 3 presents the results of the statistical analysis.

| Source of Variation | SS    | Df | MS     | F   | P-value | F crit |
|---------------------|-------|----|--------|-----|---------|--------|
| P                   | 2229.63 | 2  | 1114.81 | 17.97 | 0.00    | 3.55   |
| T                   | 24.07   | 2  | 12.04   | 0.19 | 0.83    | 3.55   |
| Interaction         | 4609.26 | 4  | 1152.31 | 18.57 | 0.00    | 2.93   |
| Within              | 1116.67 | 18 | 62.04   |      |         |        |
| Total               | 7979.63 | 26 |        |      |         |        |

According to the F test, there is a significant difference in the interaction between a single factor, but the single factor is not significantly different. As a result, the treatment will only be effective if it is used in combination with the type of soaking factor and the duration of immersion. Tukey test (figure 3), showed that the highest percentage of germination was P3T3 but not significant difference with P1T1. The optimal pre sowing technique is the P1T1 (soaking into water for 8 hours).

![Figure 3](image-url)

**Figure 3.** Tukey's test for percentage of germination (values followed by the same alphabets are not significantly different at a level of 95% confidence)

3.4. Index of germination rate

The index of germination was quite varied, did not show uniformity for all treatments. The fastest index of germination rate occurred on P3T3 treatment (soaking in young coconut water for 16 hours), while the lowest index of germination occurred on P1T3 treatment (soaking in plain water for 16 hours). The results of statistical analysis are presented in Table 4.
Table 4. Analysis of variance on the index of germination rate parameters

| Source of Variation | SS  | df  | MS  | F    | P-value | F crit |
|---------------------|-----|-----|-----|------|---------|--------|
| P                   | 0.89| 2   | 0.45| 16.32| 0.00    | 3.55   |
| T                   | 0.03| 2   | 0.01| 0.54 | 0.59    | 3.55   |
| Interaction         | 2.34| 4   | 0.59| 21.40| 0.00    | 2.93   |
| Within              | 0.49| 18  | 0.03|      |         |        |
| Total               | 3.76| 26  |     |      |         |        |

According to the F test, there is a significant difference in the interaction between a single factor, but the single factor is not significantly different. As a result, the treatment will only be effective if it is used in combination with the type of soaking factor and the duration of immersion. Tukey test result (Figure 4) showed that, the highest index of germination rate was P3T3 but not significant difference with P1T1. The optimal pre sowing technique is the P1T1 (soaking into water for 8 hours).

Figure 4. Tukey's test for index of germination rate (values followed by the same alphabets are not significantly different at a level of 95% confidence)

4. Conclusions

The percentage of germination, first day germination and the index of germination rate were optimal in the 8-hour water immersion treatment. The optimal length of germination days in the treatment of water immersion for 16 hours. Based on all observed parameter, water immersion for 8 hours is the recommended treatment and will result in maximum germination.

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