The mechanical and chemical scarification to break dormancy and increasing vigor of Sunan candlenut seed

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Abstract. The objective of this research is to identify a treatment that can break the dormancy and increase the vigor of candlenut seed (Reutealis trisperma (Blanco) Airy Shaw) seedling. Treatments were mechanical scarification and chemical scarification. Mechanical scarification was control (S0), cracking (S1), filing (S2), and sanding (S3). Chemical scarification was control (T0), immersion in 10% HCl (T1), 10% H2SO4 (T2), and 10% KNO3 (T3) for 20 minutes. Soon after treatment, the persistence of seed dormancy (weeks), speed growing (% etmal-1), and height of the seedling were observed. Cracking the seed was showed the highest growth rate among all treatments (2.44 % etmal-1). Mechanicals and chemicals scarification were effective to break seed dormancy. Persistence of seed dormancy mechanical and chemical scarification various between 3-5 weeks, meanwhile the control was 7 weeks. Seedlings with the treatment combination of cracking and soaking with 10% KNO3 were the highest in 1, 3, and 5 weeks after planting.

1. Introduction

Candlenut is one of the most popular plants in Indonesia because it has many functions. One of typical Indonesia’s candlenut is the Sunan candlenut. Sunan candlenut was classified into stone fruit because of its physical characteristics of hard skin, shell shape, and roughly curve outer surface [1]. Sunan candlenut cultivation is faced with seed dormancy problems occurring due to the hardness and water impermeability of the seed coat. Under normal conditions, the seeds can germinate after 3-4 months of planting [1]. Therefore, dormancy in Sunan candlenut seeds needs to be removed first before the seeds are going to be planted. One of the treatments to break dormancy is scarification. Treatment of scarification or injury to the seed coat is intended to facilitate water absorption, so that imbibition occurs. Imbibition is needed for enzyme reactivation, especially alpha-amylase, protease, and lipase, which plays a role in the process of overhauling food reserves so that germination occurs [2].

Scarification can be done mechanically or chemically. Examples of mechanical scarification include filing, stabbing, and cutting. Chemical scarification uses chemical materials such as H2SO4, KNO3, and HCl. These treatments have been shown to break some seeds’ dormancy. Breaking dormancy with H2SO4 with a concentration of 50% for 5 seconds is able to break the dormancy of Anona muricate seeds, increase the germination index (12.26) and reduce germination time (30.01) [3]. H2SO4 is also able to accelerate the germination of nutmeg seeds from 60 DAS to 14 DAS by immersing the seeds in 20% H2SO4 concentration [4]. The injury to the Sphaeralcea munroana seeds was able to break seed dormancy and produce the highest germination, namely 93% [5].

Single chemical and mechanical scarification treatments have been shown to break dormancy in several types of seeds having hardseed dormancy cases. However, the combination of the two treatments
has not been widely used. With mechanicals scarification, seeds become permeable by perforating and thinning the seed coat. This condition made the imbition process become easier. Meanwhile, mechanicals scarification softens the seed coat to facilitate the imbibi
tion process. When these two were combined, seeds will germinate easily and the dormancy was broken. This study aimed to see the effect of mechanicals and chemicals scarification on the breaking of the dormancy of Sunan candlenut seeds.

2. Materials and methods
The main ingredient used was Sunan candlenut seeds, which were taken directly from a single mother tree in Garut. The research was carried out in February-June 2020 in Sindanglaya, Bandung, West Jawa. This study used a two-factor completely randomized design.

The first factor was mechanical scarification treatment, which consisted of control (s0), cracking (s1), filing (s2), and sanding (s3). The second factor was chemical scarification consisting of control (t0), immersion in 10% HCl solution (t1), immersion in 10% H\textsubscript{2}SO\textsubscript{4} (t2) and immersion in KNO\textsubscript{3} 10% (t3). Each was soaked for 20 minutes. The treatment was repeated three times. After treatment, the seeds were germinated and planted in polybags measuring 20 cm x 40 cm.

Observations were made on the growth rate (% etmal\textsuperscript{-1}), dormancy persistence, and seedlings height of 1, 3, and 5 weeks after planting (WAP). The results were analyzed using analysis of variance and data having a real effect were further tested by Duncan’s Multiple Range Test at the 5% level.

3. Results and discussions
3.1. Growth rate (% etmal\textsuperscript{-1})
The results showed that there was no interaction effect between chemical and mechanical scarification. Mechanical scarification affected the growth speed of candlenut seeds, while the chemical was not affected. The treatment of seed cracking produced the highest average growth speed, which was 2.44% etmal\textsuperscript{-1}. The chemical scarification treatment showed no significant effect (Table 1).

| Mechanical scarification | Mean growth rate (% etmal\textsuperscript{-1}) |
|--------------------------|---------------------------------------------|
| Control (s0)             | 1.86 b                                      |
| Cracking (s1)            | 2.44 c                                      |
| Filing (s2)              | 1.59 b                                      |
| Sanding (s3)             | 0.94 a                                      |
| Chemical scarification   |                                            |
| Control (t0)             | 1.53 a                                      |
| Immersion in 10% HCl (t1)| 1.77 a                                      |
| Immersion in 10% H\textsubscript{2}SO\textsubscript{4} (t2)| 1.52 a|
| Immersion in 10% KNO\textsubscript{3} (t3)| 2.01 a|

Table 1. The effect of mechanical and chemical scarifications on growth rate

Numbers followed by lowercase letter are not significantly different based on Duncan’s Multiple Range Test at 5% level

The cracking treatment aimed to cause cracks in the seed coat, so that water could easily diffuse into the seeds and the seeds could germinate. Cracking of the seed coat was the most influential compared to other mechanical scarification treatments because the cracking of the Sunan candlenut seeds allowed water to diffuse into the seeds because the Sunan candlenut seeds had more gaps. This is in line with research conducted by [6], which shows that scarification treatment can increase the growth rate of nutmeg seeds compared to no scarification treatment. [7] also demonstrates that scarification techniques can cause daughter palm seeds to germinate more quickly, which is 10 days after planting.

3.2. Dormancy persistence
Dormancy persistence showed how deep the dormancy in the seed. When the seed took a long time to grow, it means the dormancy was very deep. The scarification treatments both chemically and mechanically had a significant effect on shortening the dormancy persistence. Cracking and immersion
treatment in 10% KNO₃ shortened seed dormancy to only 2 weeks, while the control reached 7 weeks (Figure 1). In the 3rd week, seeds, with cracking, cracking, and immersion in 10% HCl, 10% H₂SO₄, and KNO₃, grew rapidly, while others still (Figure 2). In the 4th and 5th week, seed with filing, combination filing and chemical scarification, sanding, a combination of sanding and chemical scarification treatments started to grow (Figure 4 and 5). The last seed with treatment combination between cracking and immersion 10% KNO₃ grew in the 4th week. Meanwhile, control started to grow in the 6th week (Figure 5).

**Figure 1.** Numbers of seeds grow on each treatment in the 2nd week

**Figure 2.** Numbers of seeds grow on each treatment in the 3rd week
Figure 3. Numbers of seeds grow on each treatment in the 4th week

Figure 4. Numbers of seeds grow on each treatment in the 5th week
The combination between the strong acid treatment and the seed would make the water easier to migrate into the seed coat. The strong acid helped soften the seed coat, then the filing and cracking treatment of the seed coat left the seeds with many gaps for water entry. Water started the imbibition process and then the seed grew.
3.3. Seedling height

There was an interaction effect between mechanical and chemical scarification treatments on seedling height at ages of 1, 3, and 5 WAP. In general, the cracking and soaking of seeds with 10% KNO₃ produced the highest seedlings each week (Table 2).

Table 2. The effect of mechanical and chemical scarification on seedling height

| Mechanical scarification | Chemical scarification | Average of seedling height (cm) 1 WAP | Average of seedling height (cm) 3 WAP | Average of seedling height (cm) 5 WAP |
|--------------------------|------------------------|--------------------------------------|--------------------------------------|--------------------------------------|
|                          | Control (t0)           | Immersion in 10% HCl (t1)            | Immersion in 10% H₂SO₄ (t2)          | Immersion in 10% KNO₃ (t3)           |
| Control (s0)             | 0,00 a A               | 11,33 a B                            | 7,67 ab B                            | 9,17 a B                            |
| Cracking (s1)            | 9,67 b A               | 11,5 a A                             | 12,00 b A                            | 16,33 b B                            |
| Filing (s2)              | 9,33 b A               | 11,17 a A                            | 11,50 b A                            | 9,00 a A                             |
| Sanding (s3)             | 8,50 b A               | 11,00 a B                            | 7,17 a A                             | 8,00 a A                             |
|                          | Control (t0)           | Immersion in 10% HCl (t1)            | Immersion in 10% H₂SO₄ (t2)          | Immersion in 10% KNO₃ (t3)           |
| Control (s0)             | 0,00 a A               | 17,67 b C                            | 12,17 a B                            | 16,00 ab BC                          |
| Cracking (s1)            | 13,17 b A              | 13,00 a A                            | 14,50 ab A                            | 18,83 b B                            |
| Filing (s2)              | 13,83 b A              | 15,67 ab a                           | 16,50 b A                            | 14,17 a A                            |
| Sanding (s3)             | 14,5 b A               | 15,83 ab a                           | 13,83 ab A                           | 13,50 a A                            |
|                          | Control (t0)           | Immersion in 10% HCl (t1)            | Immersion in 10% H₂SO₄ (t2)          | Immersion in 10% KNO₃ (t3)           |
| Control (s0)             | 11,00 a A              | 20,17 b B                            | 16,17 a B                            | 19,17 ab B                           |
| Cracking (s1)            | 16,17 b A              | 15,67 a A                            | 17,83 a AB                            | 20,83 b B                            |
| Filing (s2)              | 15,83 b A              | 18,00 ab AB                           | 20,00 a AB                            | 19,50 ab AB                           |
| Sanding (s3)             | 17,17 b A              | 18,33 ab A                           | 16,83 a A                            | 16,50 a A                            |

Numbers followed by the same lowercase letters (vertical) and uppercase letters (horizontal) are not significantly different based on Duncan’s Multiple Range Test at 5% level.
The content of N and K in KNO₃ affects the photosynthesis process and the resulting photosynthate production. N and K nutrients are more needed by plants because these elements can be used in a short time and are used for vegetative growth, especially the development of roots, stems, and leaves [8].

KNO₃ also functions to increase growth hormone activity in seeds as a substitute for light and temperature and to accelerate the acceptance of oxidants in seeds [9]. KNO₃ solution is a solution interacting with temperature in stimulating seed germination [10]. This is in line with the research of [11], which shows that the interaction between scarification and KNO₃ immersion has an optimal effect on the percentage of germination, growth speed, and root length of sugar palm seeds.

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