Effect of Heating and Soaking Time with KNO_3 on Breaking Dormancy of Oil Palm Seeds (*Elaeis guineensis* Jacq.)

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Abstract. Oil palm (*Elaeis guineensis* Jacq.) is one of the plants that has a long dormancy period for germination because it has a thick and hard shell. Breaking dormancy is needed for seed production, so that it can accelerate the process of oil palm germination. The purpose of the study was to determine the effect of various heating durations and KNO_3 concentrations on the germination of oil palm seeds. The research was conducted at the Laboratory of Politeknik Kelapa Sawit Citra Widya Edukasi, the research time was in February 2024–May 2024. The treatments were arranged factorially with two factors in a completely randomized design. The first factor is the duration of heating at 40°C which consists of four levels namely: 20 days, 30 days, 40 days, and 50 days. Furthermore, soaking with KNO_3 for 24 hours was carried out according to the treatment, namely at concentrations of 0%, 0.2%, 0.4%, and 0.6%. The variables observed were the percentage of germination, maximum growth potential, and sprout emergence time. The results showed that the combination of heating duration and KNO_3 soaking can break dormancy in oil palm seeds. The treatment of 40 days heating time and 0.4% KNO_3 soaking is the best treatment for sprout emergence time (on day 20), germination percentage (55.56%), and maximum growth potential (77.78%).

1. Introduction

Oil palm (*Elaeis guineensis* Jacq.) is a plantation crop with the highest vegetable oil content among other vegetable oil producing crops. Oil palm is an important plantation crop that contributes significantly to Indonesia's foreign exchange earnings. Oil palm plantations are a lucrative source of income for some farming families, offer employment prospects and encourage the growth of oil palm-centered businesses in Indonesia [1]. Palm oil has a major contribution to the economic progress of the Indonesian people. The market prospects for processed palm oil are quite good, as there is a significant increase in demand every year, therefore, Indonesia as a tropical country with extensive land resources has great potential to

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cultivate oil palm plantations. The area of oil palm plantations from confirmed data that in 2021 the land area is 14,621,690 hectares, in 2022 it is 15,338,556 hectares, in 2023 it is 15,435,656 hectares, and in 2024 it is 15,763,738 hectares [2]. The increase in oil palm area results in an increase in demand for oil palm seeds.

Oil palm seed production has challenges in increasing the quantity of its output, especially in the early stages of germination, the germination process of oil palm seeds is hampered by their hard outer shell, resulting in dormancy [3]. That seeds that experience dormancy require a longer germination time unless the seeds undergo treatment to break the dormancy [4]. Seeds naturally have dormancy properties that allow their survival, but this dormancy can hinder seed production [5].

Dormancy refers to a state in which seeds do not germinate, despite being under ideal conditions for germination. This dormancy problem can be overcome with several available treatments, including the use of chemicals or scarification. These methods help increase water and gas permeability into the seed [6]. Many mechanical ways to overcome oil palm seed dormancy, including shell breaking, piercing, and stratification through heating [7]. Heating is an old technique used to overcome oil palm seed dormancy.

The heating method is believed to cause cracking of the hard and thick layer of the oil palm seed called the operculum. The cracked operculum can trigger the imbibition process in oil palm seeds, thus facilitating germination through continuous metabolic activity [8]. The method to end dormancy of oil palm seeds through heating takes a long time, from 40 to 80 days. The long duration of heating is caused by physical dormancy and physiological dormancy [7].

Oil palm seeds can be induced to end their dormancy period by applying growth regulators, such as potassium nitrate (KNO_3) through a soaking process. Potassium nitrate (KNO_3) is a chemical that is often used to induce the termination of seed dormancy and encourage seed germination [4]. KNO_3 effectively breaks the dormancy of oil palm seeds by softening the seed coat so that it facilitates the entry of water into the seed, this process accelerates the reactivation of seed cells so as to accelerate the transition out of dormant conditions [3].

Treatment to accelerate seed germination is important to do with methods that can break seed dormancy, so this study aims to determine the effect of heating time and KNO_3 immersion on the germination of oil palm seeds.

2. Materials and Methods

This research is an experimental study with a combination of heating and KNO_3 immersion treatment on breaking the dormancy of oil palm seeds (*Elaeis guineensis* Jacq.). This research was conducted at the Laboratory of Politeknik Kelapa Sawit Citra Widya Edukasi from February 2024–June 2024. This study used a factorial completely randomized design (CRD) consisting of two factors. The first factor is the heating period at 40°C which consists of four levels, namely: M1 = 20 days (1), M2 = 30 days (2), M3 = 40 days (3), and M4 = 50 days (4). The second factor is KNO3 concentration with four levels, namely: R1 = 0% (control) (1), R2 = 0.2% (2), R3 = 0.4% (3), and R4 = 0.6% (4). The treatment consisted of 16 treatment combinations and each treatment was carried out 3 times, and the number of samples for each replication consisted of 3 samples, so the number of samples used was 144 experimental units.

The equipment used in this research are incubator, tray, plastic, sprayer, knife, label, glass bottle, 100 ml beaker glass, bucket, measuring cup, digital scale, plastic, and raffia rope. The materials used in this study were seu supreme variety oil palm seeds, distilled water, water, KNO3, and fungicide solution.

The seeds used were physiologically mature seeds. The seeds were obtained from PT Sasaran Ehsan Mekarsari (SEM) which had been peeled from the coir, washed thoroughly, and soaked using Dithane M-45 fungicide. Before heating, the seeds were put into clear plastic tied with raffia. Each plastic contained three oil palm seeds. The seeds were heated in an incubator at 40ºC in accordance with the treatments carried out, namely 20 days, 30 days, 40 days, and 50 days.

KNO_3 solution was made using several concentrations, namely 0%, 0.2%, 0.4%, and 0.6%. The KNO_3 solution was made by weighing 2 grams for 0.2%, 4 grams for 0.4%, and 6 grams for 0.6%, then dissolving it in distilled water until it reached a volume of 1000 ml in each treatment. While the 0% concentration only uses 1000 ml of distilled water. Soaking was carried out after the KNO_3 solution was made, before soaking with KNO_3 solution, the seeds were soaked first with Dithane M-45 fungicide with a concentration of 0.2% (2 $g.l^{-1}$) for 2 hours, then the seeds were dried and then soaked with KNO_3 solution for 24 hours according to the treatment, namely in control conditions, 0.2% concentration, 0.4% concentration, and 0.6% concentration. Seeds that have been soaked are then drained and germinated in the germination box. The germination process must pay attention to the humidity, if the paper is not moist or dry then spraying with water is done.

The parameters observed were sprout emergence time, germination power, and maximum growth potential. The sprout emergence time is calculated every 10 days when the sprouts start to grow, namely 10, 20, 30, 40, and 50 days after germination. This time is needed to know when the germinated oil palm seeds can germinate and to know when the oil palm seeds germinate quickly.

Germination power was measured by calculating the percentage of normal sprouts at the first to last selection stage. The calculation of normal sprouts is done every 10 days until the 50th day of germination. Observations made include normal sprouts. The formula for calculating seed germination power can use the formula according to [7] as follows

$$Germination\ Power\ (\%) = \frac{\sum \boldsymbol{seeds\ that\ germinate\ normally}}{\sum \boldsymbol{germinated\ seeds}}\ x\ 100\% \qquad (1)$$

Maximum growth potential is information about seeds that can germinate. Observations made include sprouts that can grow, namely normal sprouts and abnormal sprouts. The maximum growth potential value can be calculated using the formula according to [7] as follows

$$Maximum\ Growth\ Potential\ (\%) = \frac{\sum \boldsymbol{normal\ sprouts} + \sum \boldsymbol{abnormal\ sprouts}}{\sum \boldsymbol{germinated\ seeds}}\ x\ 100\% \qquad (2)$$

Observation data were processed by statistical analysis at the 5% level using statistical tools software STAR (Statistical tool for Agricultural Research). If the F-test results are significant, then the further test used is Duncan's Multiple Range Test (DMRT) with α 5%.

3. Results

Based on the results of the analysis of variance, the treatment with several periods of heating with a temperature of 40ºC and soaking with several concentrations of KNO_3 has a significant effect on germination power, maximum growth potential, and sprout emergence time. The interaction of 40 days of heating and 0.4% KNO_3 soaking was the best interaction that gave the highest results on the observation of sprout emergence time (Table 1), germination power (Table 2), and maximum growth potential (Table 3). The results showed that the treatment of 40 days heating time and 0.4% KNO_3 soaking was able to provide the highest value for the observation, namely the fastest sprout emergence time occurred on day 20, germination power of 55.56%, and maximum growth potential of 77.78%.

Table 1. Interaction Effect of Heating Time and Immersion with KNO_3 on the Emergence Time of Oil Palm Sprouts

Time of Sprout Emergence				
Treatment	R1	R2	R3	R4
20 Day After Application				
M1	0.00 a	0.00 a	0.00 b	0.00 a
M2	0.00 a	0.00 a	0.00 b	0.00 a
M3	0.00 a	0.00 a	0.67 a	0.00 a
M4	0.00 a	0.00 a	0.00 b	0.00 a

Remark: *M1 = 20 Days Heating, M2 = 30 Days Heating, M3 = 40 Days Heating, M4 = 50 Days Heating, R1 = 0% Concentration, R2 = 0.2% Concentration, R3 = 0.4% Concentration, R4 = 0.6% Concentration, Numbers accompanied by the same letter at the same observation time are not significantly different based on Duncan's Multiple Range Test (DMRT) at the 5% Level.

Table 2. Effect of Interaction of Heating and Soaking Time with KNO_3 on Germination of Oil Palm Seeds

Germination Power (%)				
Treatment	R1	R2	R3	R4
20 Day After Application				
M1	0.00 a	0.00 a	0.00 b	0.00 a
M2	0.00 a	0.00 a	0.00 b	0.00 a
M3	0.00 a	0.00 a	22.22 a	0.00 a
M4	0.00 a	0.00 a	0.00 b	0.00 a
30 Day After Application				
M1	0.00 a	11.11 a	0.00 b	0.00 a
M2	0.00 a	0.00 a	22.22 b	0.00 a
M3	0.00 a	22.22 a	55.56 a	0.00 a
M4	0.00 a	22.22 a	11.11 b	0.00 a

Remark: *M1 = 20 Days Heating, M2 = 30 Days Heating, M3 = 40 Days Heating, M4 = 50 Days Heating, R1 = 0% Concentration, R2 = 0.2% Concentration, R3 = 0.4% Concentration, R4 = 0.6% Concentration, Numbers accompanied by the same letter at the same observation time are not significantly different based on Duncan's Multiple Range Test (DMRT) at the 5% Level.

Table 3. Interaction Effect of Heating and Immersion Duration with KNO_3 on Maximum Growth Potential of Oil Palm Seeds

Maximum Growth Potential (%)				
Treatment	R1	R2	R3	R4
20 Day After Application				
M1	0.00 a	0.00 a	0.00 b	0.00 a
M2	0.00 a	0.00 a	0.00 b	0.00 a
M3	0.00 a	0.00 a	22.22 a	0.00 a
M4	0.00 a	0.00 a	0.00 b	0.00 a
30 Day After Application				
M1	0.00 a	11.11 a	0.00 b	0.00 a

M2	0.00 a	0.00 b	44.44 a	0.00 a
M3	0.00 a	11.11 a	66.67 a	0.00 a
M4	0.00 a	22.22 a	11.11 b	0.00 a
40 Day After Application				
M1	0.00 a	11.11 a	0.00 c	0.00 a
M2	0.00 a	11.11 a	44.44 b	11.11 a
M3	0.00 a	11.11 a	77.78 a	33.33 a
M4	0.00 a	22.22 a	11.11 c	0.00 a
50 Day After Application				
M1	0.00 a	11.11 a	0.00 c	0.00 c
M2	0.00 a	22.22 a	55.55 ab	33.33 ab
M3	0.00 a	22.22 a	77.78 a	44.44 a
M4	0.00 a	33.33 a	33.33 b	11.11 bc

Remark: *M1 = 20 Days Heating, M2 = 30 Days Heating, M3 = 40 Days Heating, M4 = 50 Days Heating, R1 = 0% Concentration, R2 = 0.2% Concentration, R3 = 0.4% Concentration, R4 = 0.6% Concentration, Numbers accompanied by the same letter at the same observation time are not significantly different based on Duncan's Multiple Range Test (DMRT) at the 5% Level.

4. Discussion

4.1 Sprout emergence time

Based on the results of data analysis, it can be seen that the influential treatment occurs in the interaction of 40 days heating time (M3) and 0.4% KNO_3 immersion (R3) on the time of sprout emergence. The interaction of 40 days heating time and 0.4% KNO_3 immersion can accelerate the emergence of sprouts at 20 Day after application with a germination percentage of 0.67%. Oil palm seeds heated for 40 days have a faster time for initial germination, which is on day 4 after heating treatment compared to heating in the 50–90 day heating treatment, starting to germinate on days 6 to 9 [9]. Scarification treatment with sanding one side of the seed and a concentration of 0.4% KNO_3 gave the fastest germination time value of 5.69 days in contrast to other KNO_3 concentrations in the scarification treatment [10]. The interaction of 40 days of heating and 0.4% KNO_3 soaking is thought to accelerate the emergence of radicle and plumula by making improvements to the factors that support the germination process such as the activation of several enzymes after water absorption. KNO_3 can play a role in encouraging chemical reactions that lead to germination and stimulate enzyme activity [11].

4.2 Germination power

Based on the results of data analysis, it shows that the interaction of 40 days of heating (M3) and 0.4% KNO_3 immersion (R3) is the best interaction that gives the highest results on germination (Figure 1). The interaction at 20 Day after application had visible growth in seeds with an average value of 22.22% compared to other treatments that had not germinated. The interaction at 30 Day after application had an average of 55.56%. M3R3 treatment can support the germination of oil palm seeds. In line with the before research, that the highest germination of oil palm in the Yangambi variety was obtained in the treatment of heating for 40 days and enzyme immersion treatment, which was 81.67% compared to the treatment of

heating for 50 and 60 days which also carried out enzyme immersion but with different times [12]. The most effective concentration of KNO_3 solution for tamarind seeds is 0.4% for 24 hours with 93% viability [13]. Soaking with 0.4% KNO_3 and sanding scarification gave the best germination percentage of 40.00% [14]. The KNO_3 0.3% treatment for 48 hours in the 0 week storage period had the highest germination of 83.5% compared to other concentrations [15].

Figure 1. 40 Days Heating Time with 0% (a), 0.2% (b), 0.4% (c), 0.6% (d) KNO_3 Immersion at 50 Days After Application.

The interaction of all periods of heating time with 0% KNO_3 immersion is the treatment that produces the lowest germination rate until the end of observation, which is 0.00%. Breaking dormancy in oil palm seeds by heating takes a long time, namely 40–80 days, the length of time heating occurs because oil palm seeds not only experience physical dormancy but also experience physiological dormancy [7]. Not only that, germination can also be influenced by many factors. The germination of a seed is determined by many factors, including humidity, temperature, oxygen levels, and light [16]. The structure of the palm seed itself is also a factor in different germination rates. The shell of oil palm has a thick and hard structure, the presence of a cover or micropyle at the emergence of sprouts so that it is impermeable to water and gas, with inappropriate treatment water and gas cannot be absorbed into the seed properly so that the germination process is inhibited [17].

4.3 Maximum growth potential

Based on the results of data analysis, it shows that the treatment of 40 days of heating (M3) and soaking 0.4% KNO_3 (R3) is the best interaction that gives the highest results on maximum growth potential. M3R3 interaction at 20 Day after application has begun to occur seed growth based on the treatment that has been done with an average maximum growth potential of 22.22%. Heating treatment for 40 days has the highest percentage of germination growth in oil palm cultivar BRS C7201 at 81% and is not specifically different from cultivar BRS C2328 at 69% [18]. The use of KNO_3 with a concentration of 0.4% on tamarind seed germination can increase the maximum growth potential by 95.55% [19]. Soaking with 0.4% KNO_3 and piercing treatment is the best interaction on the maximum growth potential of oil

palm seeds by 56.66%, and if no mechanical scarification is done, the use of 0.4% KNO_3 produces the highest maximum growth potential [14].

The treatment at 30 Day after application increased maximum growth potential, especially in the treatment of 40 days heating time (M3) and 0.4% KNO_3 immersion (R3) with an average value of 66.67%, but not significantly different from the 30 days heating time (M2) and 0.4% KNO_3 immersion (R3) which was 44.44%. In addition, there was also additional growth in 0.2% KNO_3 immersion (R2) with several heating duration treatments. KNO_3 immersion with a concentration of 0.2% for 24 hours has been able to produce high maximum growth potential values in the 4 and 6 week storage periods of 95.5% and 96.0% [15]. The treatment at 40 Day after application experienced an increase in maximum growth potential in the M3R3 treatment to 77.78%. In addition, the soaking of 0.6% KNO_3 (R4) has occurred seed growth with a combination of several treatments of heating duration. Giving concentrations of KNO_3 and coconut water to oil palm seeds can increase the maximum growth potential at concentrations of 0.2%, 0.4%, and 0.6% with values of 93.3%, 101.2%, and 109.1% [3]. Based on this study, each addition of KNO_3 concentration can increase the maximum growth potential, but in this study soaking with 0.6% is thought to experience growth inhibition because the concentration used is too high and has been warmed up beforehand so that at this concentration the seeds experience longer growth. A higher concentration of KNO_3 (0.6%) can slow down the emergence of oil palm sprouts, which is 28 days because it can affect the process of water absorption into the seeds through diffusion events, where the higher the concentration of KNO_3, the smaller the concentration of water in the solution which will cause less water to enter the seeds soaked in KNO_3 solution [6]. The best treatment at 50 Day after application is still in the M3R3 treatment, which is 77.78%, but the value does not increase from the previous observation because the seeds are still dormant. While in the soaking of 0.6% KNO_3 (R4) there was an increase in growth again in M3R4, which was 44.44%. The seeds began to germinate even though it took longer than the 0.4% concentration.

5. Conclusions

The treatment of heating time and soaking with KNO_3 can break the dormancy of oil palm seeds. The treatment of breaking dormancy has a very significant effect on the observation parameters, namely the time of emergence of sprouts, germination power, and maximum growth potential. The treatment of 40 days of heating and 0.4% KNO_3 soaking is the best interaction treatment of the other treatments shown by the time of emergence of sprouts (20 day after application), germination power (55.56%), maximum growth potential (77.78%).

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