

The Effect Of Apokol Location And K₂O Administration On Physiological Characters, Viability And Growth Of Sugar Palm Plant Seedlings (*Arenga Pinnata* Merr.)

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Abstract

Sugar palm (*Arenga pinnata*) is a highly potential plant with almost all parts of the tree being useful. However, commercial development of sugar palm is hampered by the limited availability of high-quality seeds. Sugar palm seeds experience dormancy due to their impermeable nature, requiring chemical methods such as soaking in a solution of Potassium Nitrate KNO₃ to break the impermeability of the testa tissue. In addition, variations in the apocol position in sugar palm seeds indicate genetic differences, so the apocol position has the potential to be useful as a marker for superior varieties. This study aims to improve the viability of sugar palm seeds by investigating the effect of KNO₃ concentration and apocol position. The study was conducted at the Andalas University Experimental Garden from September 2024 to February 2025. The method used was a Factorial Randomized Block Design (RBD) with two factors and three replications. The first factor was the apocol position, divided into four quadrants (1 to 4). The second factor was the KNO₃ concentration (0.5%), 1%, and 1.5%). Data were analyzed using ANOVA followed by DMRT (5%). The results showed a significant interaction between KNO₃ concentration and apocol position on growth and physiological parameters, including apocol emergence time, coleoptile length, primary root length, normal germination, and overall growth parameters. Specifically, 1% KNO₃ concentration was the most effective treatment for improving physiological characteristics, viability, and seedling growth. In addition, Quadrant IV was identified as the best apocol position for these characteristics. The optimal combination of KNO₃ treatment and apocol selection can significantly improve the propagation of sugar palm seeds.

Keywords: dormancy, watertightness, seed coat, sugar palm, seed vigor

1. Introduction

The sugar palm (*Arenga pinnata* Merr.) is a potential plantation commodity in Indonesia due to its high economic value and versatile nature. Almost all parts of the sugar palm tree can be utilized, from the roots for medicine, the trunk for building materials, the leaves and fibers for crafts, to its main products, sap, starch (sago), and sugar palm fruit. However, this these enormous potential faces serious threats due to uncontrolled exploitation. Increased logging for starch extraction without a corresponding replanting effort has caused the sugar palm population in the wild to decline drastically (Ruslan et al. 2018). One of the main obstacles to the widespread development of sugar palm cultivation is the difficulty in providing high-quality seedlings in large quantities. Most of the seedlings used by farmers currently rely on wild seedlings. Technically, a crucial problem in the supply of sugar palm seedlings lies in the seeds' very hard, impermeable skin. This anatomical condition inhibits water imbibition and oxygen diffusion into the embryo, resulting in prolonged physical dormancy (Dewantara, 2017). Without special treatment to break this dormancy, the germination rate of sugar palm seeds will remain low and take a very long time. Dormancy in sugar palm seeds can be overcome through a combination of physical and chemical methods. Physical scarification by destroying the testa tissue (seed coat) has proven effective in opening the way for water to enter the impermeable seeds (Wijayanti, 2023). In addition, the use of chemicals such as Potassium Nitrate (KNO_3) is often applied to stimulate germination metabolism by increasing the hormone gibberellin. Previous research showed that soaking sugar palm seeds in a 1% KNO_3 solution for 24 hours can increase the germination rate by up to 88.33% compared to the control, which only reached 36.67% (Siregar et al. 2016). However, determining the correct concentration is a determining factor, as too high a concentration risks causing toxicity to the embryo (Silalahi, 2017). On the other hand, efforts to increase sugar palm production are also hampered by the lack of clear physical markers for early selection of superior varieties. One indicator that is beginning to be considered is the position of the apocol, the spongy tissue where shoots and roots emerge. Differences in apocol position are thought to reflect certain genetic characteristics that can influence the physiological performance of seedlings (Anwar et al. 2024). However, the specific influence of apocol location on the viability of sugar palm seeds still requires further study. Based on this background, this study aimed to examine the effect of apocol location and KNO_3 administration on the success of dormancy breaking and the viability of sugar palm seeds. The study was conducted at the Experimental Garden, Campus III, Andalas University, Dharmasraya, to obtain accurate data to support sustainable palm sugar cultivation.

2. Materials and Methods

This research was conducted at the Seed Technology Laboratory and Experimental Field of Andalas University, Campus III, Dharmasraya, West Sumatra, from September 2024 to February 2025. The materials used included sugar palm seeds (*Arenga pinnata* Merr.) and KNO_3 solution with concentrations of 0.5%, 1%, and 1.5%. The growing medium was sterile sand, and the tools used included a seedbed, burlap sacks, buckets, a hand sprayer, an oven, a desiccator, pipettes, rulers, and other laboratory equipment.

The study used a two-factorial Randomized Block Design (RBD) with three replications. The first factor was the position of the apocol based on the quadrant (0–90°, 90–180°, 180–270°, and 270–360°). The second factor was the concentration of KNO_3 (0.5%, 1%, and 1.5%). In total there were 12 treatment combinations, each consisting of 20 seeds soaked for 18 hours.

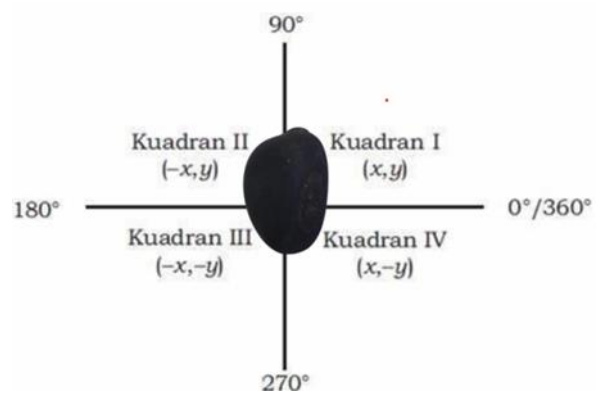


Figure 1. Schematic Illustration of the Division of the Position of the Aren Seed Apokol (*Arenga pinnata* Merr.) Based on Four Quadrants.

The research implementation includes several stages: (1) selection and preparation of seeds from one parent tree; (2) making KNO_3 solution according to concentration; (3) soaking seeds for 18 hours; (4) planting seeds in sterile sand media into the seedbed; (5) maintenance with regular watering.

Observations were made on three groups of key variables. First, physiological characteristics, including membrane leakage and seed water content, were observed to assess the level of cellular damage caused by scarification and chemical treatments. Second, seed viability was measured through apocol emergence time, apocol length, coleoptile length, primary and secondary root length, germination test, and tetrazolium test to evaluate the success of dormancy breaking. Third, seedling growth, including seedling height, stem diameter, and leaf area (gravimetric method), was used to measure overall seedling quality. Data were analyzed using analysis of variance (F test). If there was a significant effect between treatments, a Duncan Multiple Range Test (DMRT) was used at a 5% significance level to identify the best treatment.

3. Result and Discussion

Membrane Leakage

The results of the analysis of variance showed that there was no interaction between KNO₃ concentration and the position of the apokol on the leakage of the sugar palm seed membrane. However, the KNO₃ concentration treatment had a significant effect on the leakage of the sugar palm seed membrane. Data on the leakage of the sugar palm seed membrane can be seen in Table 1.

Table 1. Leakage of sugar palm seed membranes at several KNO₃ concentrations and the location of the apokol position.

Apokol Position (o)	KNO ₃ concentration (%)			Average (%)
	0.5	1	1.5	
Quadrant 0-90	31.83	31.66	34	32.49
Quadrant 90-180	31.16	30.83	33.5	31.83
Quadrant 180-270	31.16	31.16	34.33	31.77
Quadrant 270-360	31.5	31.66	33.00	32.05
Average	31.42B	31.33B	33.71A	

CV: 2.86%

Based on the analysis of variance, the KNO₃ concentration treatment significantly affected the membrane leakage and seed moisture content. The highest membrane leakage was found in the 1.5% KNO₃ treatment at 33.71 μ mhos, while the lowest leakage was

found in the control (0%) at 24.33 μ mhos. This indicates that excessively high chemical solution concentrations can trigger osmotic pressure that damages the integrity of the seed cell membrane.

Seed moisture content increased with increasing KNO₃ concentration. Seeds soaked in 1.5% KNO₃ had the highest moisture content (32.45%) compared to 0.5% (28.12%). The hygroscopic nature of KNO₃ facilitates faster water absorption (imbibition) through the hard, impermeable seed coat.

Seed membrane leakage can be caused by several things, such as deterioration during storage, mechanical injury, death of the outermost cotyledon cells, changes in protein and fat structure due to hydrolysis and oxidation, and decreased carbohydrate, protein, and fat content due to respiration, thus reducing cell integrity (Rolin et al. 2024). KNO₃ compound is an inorganic salt whose administration can increase respiration (Anandia et al. 2014). Ultimately, KNO₃ administration can reduce the integrity of cell membranes, causing membrane leakage. In addition, KNO₃ is also an oxidizing agent, so its administration also causes seed oxidation and changes in the protein and fat structure in the cotyledons, resulting in membrane leakage.

Seed Water Content

The results of the analysis of variance showed that there was no interaction between the KNO₃ concentration and the apokol position on the water content of sugar palm seeds. However, the KNO₃ concentration treatment had a significant effect on the water content of sugar palm seeds. Data on the water content of sugar palm seeds can be seen in Table 2.

Table 2. Water content of sugar palm seeds at several KNO₃ concentrations and location apokol position

Apokol Position (o)	KNO ₃ concentration (%)			Average (%)
	0.5	1	1.5	
Quadrant 0-90	31.52	31.11	32.63	31.75
Quadrant 90-180	31.81	32.18	33.42	32.47
Quadrant 180-270	32.05	32.17	33.46	32.56
Quadrant 270-360	31.96	32.52	32.54	32.34
Average	31.84B	32.25B	33.02A	

CV: 1.72%

Table 2 shows that the increase in KNO₃ concentration at each Apokol position increases the percentage of water content. The 1.5% concentration gave the best results, namely 33.02% seed water content, followed by 0.5 and 1% concentrations which were not significantly different, respectively, at 31.84% and 32.25%. On the other hand, the difference in Apokol position gave results that were not significantly different,

with the highest water content in quadrant III at 32.56% and the lowest in quadrant I at 31.75%.

This can be caused by KNO₃ is a salt compound that Hygroscopic. Hygroscopic compounds are compounds that can absorb water and water vapor in the air (Siswati et al. 2019). Soaking seeds in a high-concentration KNO₃ solution makes them more hygroscopic, allowing them to absorb more water than seeds with a lower KNO₃ concentration.

Seeds soaked with KNO₃ will experience dormancy breaking, after which water, oxygen, and KNO₃ solution absorbed into the seeds, thus making seeds are also hygroscopic. As a result, they can absorb more water than seeds that are not soaked. High concentrations of KNO₃ can certainly increase seed water absorption compared to lower concentrations. Water content in seeds plays a crucial role in various physiological processes that determine seed viability and vigor. After soaking with KNO₃, seeds become more hygroscopic and able to absorb higher amounts of water (Rahmatika & Sari, 2020). This increase in water content directly affects metabolic activity within the seeds.

Water is a universal solvent and the primary medium for various enzymatic reactions that occur during seed metabolism. Increasing water content plays a crucial role in activating key enzymes necessary for germination, such as hydrolytic enzymes, which break down food reserves in the form of carbohydrates, proteins, and fats into simpler molecules that are easily mobilized for embryo growth (Ferdiawan et al. 2019). The process of activating these enzymes is crucial for the success of the

initial stages of seed growth. In the context of KNO₃ treatment, the increase in water levels that occurs can have a positive physiological effect, especially because of KNO₃ helps accelerate water imbibition and triggers the dormancy-breaking process. With optimal hydration conditions, seeds can respire, synthesize proteins, and divide cells more efficiently. However, the concentration of KNO₃ must be used appropriately, because too high a dose can actually inhibit the germination process and disrupt the balance of seed metabolism.

Maximum Growth Potential

The results of the analysis of variance showed that there was no interaction between the KNO₃ concentration and the apokol position on the maximum growth potential of sugar palm seeds. However, the KNO₃ concentration treatment had a significant effect on the maximum growth potential of sugar palm seeds. Data on the maximum growth potential of sugar palm seeds can be seen in Table 3

Table 3. Maximum growth potential of sugar palm seeds at several KNO₃ concentrations and apokol positions

Apokol Position (o)	KNO ₃ concentration (%)			Average (%)
	0.5	1	1.5	
Quadrant 0-90	73.33	78.33	70.00	73.89
Quadrant 90-180	73.33	78.33	75.00	75.55
Quadrant 180-270	75.00	80.00	76.67	77.22
Quadrant 270-360	75.00	80.00	73.33	76.11
Average	74.17B	79.17A	73.75B	

CV: 5.56%

Based on the table above, the apokol position treatment did not show a significant effect on the maximum growth potential (PTM) of the tested seeds. Conversely, variations in KNO₃ concentration significantly affected the PTM value. A concentration of 1% was recorded as producing the highest PTM, namely 79.17%, and significantly different compared to concentrations of 0.5% and 1.5%. Meanwhile, a concentration of 1.5% produced the lowest PTM, namely 73.75%. These findings indicate that selecting the right KNO₃ concentration is essential to optimize seed viability and ensure better initial growth under experimental conditions.

These results align with research by Hartawan (2016), which found that 1% KNO₃ increased seed germination potential by up to 86.67%. KNO₃ plays a crucial role in breaking dormancy by increasing water absorption and stimulating early seed metabolism. Under these conditions, seeds can begin germination more quickly and exhibit a more stable physiological response.

However, excessively high KNO₃ concentrations should be avoided as they can cause toxic effects that can lead to reduced growth. Another study by Wijaya (2019) supports these findings by demonstrating that KNO₃ treatment at optimal concentrations consistently increased germination and early seedling growth vigor. However, excessive concentrations actually reduced metabolic efficiency, preventing seeds from germination to their full potential. These findings emphasize that determining the correct KNO₃ dosage is crucial for achieving optimal seed quality.

Furthermore, research by Nugroho et al. (2020) showed that administering KNO₃ at the correct concentration can accelerate the synthesis of growth hormones such as gibberellins and cytokinins, which play a crucial role in root elongation and early shoot formation in plants. These findings indicate that in addition to increasing germination, KNO₃ also functions to support the overall early development of plants. Another study by Rahmadani et al. (2021) further

supports these results by reporting that KNO₃ treatment at a concentration of 1% yielded the best results for germination percentage and early growth of sugar palm seedlings.

Based on the research results, it can be concluded that the apokol position treatment did not significantly affect the maximum growth potential (PTM). However, the application of KNO₃ at an optimal concentration played a significant role in increasing the PTM of sugar palm plants. A concentration of 1% produced the highest PTM value of 79.17%, indicating that this dose is the best choice in accelerating the initial growth of seeds. Conversely, the use of KNO₃ at a concentration that is too high (1.5%) caused a decrease in PTM, possibly due to toxicity effects on the seeds. Therefore, selecting the appropriate dose is crucial to support optimal growth of sugar palm plants.

Apokol Appearance Time

The results of the analysis of variance showed that there was an interaction between the concentration of KNO₃ and the position of the apokol on the emergence time of the apokol of the sugar palm seeds. Data on the emergence time of the apokol of the sugar palm seeds can be seen in Table 4.

Table 4. Time of emergence of apokol in sugar palm seeds at several KNO₃ concentrations and the position of the apokol.

Apokol Position (o)	KNO ₃ concentration (%)		
	0.5	1	1.5
Quadrant 0-90	28.3a A	25.33a C	27.00a B
Quadrant 90-180	26.33b A	23.67b B	24.00c B
Quadrant 180-270	25.33b A	23.33b B	24.33bc AB
Quadrant 270-360	25.33b A	21.00c B	25.33b A

CV: 3.11%

The data shows a significant effect of the treatment of apokol position and KNO₃ concentration on the growth of sugar palm plants. where the time of apokol emergence varies with an average range of 21 to 28.33 days after planting (DAP). Observations revealed that the fastest time for apokol emergence, which is an average of 21 DAP. occurred in the apokol position of quadrant IV with a KNO₃ concentration of 1%. This optimal result is significantly different compared to the

treatment of KNO₃ and KNO₃ concentration in the same quadrant, confirming the effectiveness of the KNO₃ dose. In contrast, the treatment of apokol position in quadrant I showed the longest response, where the time for apokol emergence reached 28.33 DAP at a KNO₃ concentration of 0.5%, this result was not significantly different from the KNO₃ concentration of 1.5% in quadrant I.

In the apokol position of quadrant II, the fastest apokol emergence time was recorded at 23.67 HST at a concentration of KNO₃. which was significantly different from the 1.5% KNO₃ treatment but not significantly different from 0.5% KNO₃. Meanwhile, in quadrant III, the fastest apokol emergence time was 23.33 HST, also at a concentration of 1% KNO₃ which showed no significant difference with concentrations of 0.5% and 1.5%. Comprehensively, the KNO₃ concentration treatment had a significant effect on the time of apokol emergence. In aggregate, apokol appeared fastest at a concentration of 1% KNO₃ in quadrant IV with an average of 21 HST, this result was not significantly different from quadrants II and III but was statistically significantly different from quadrant I.

The 0.5% KNO₃ concentration treatment consistently showed the longest apokol emergence time, centered on the apokol position of quadrant I with an average time of 28.33 days after planting, and this result was not significantly different from the apokol positions of quadrants II, III, and IV at the same concentration. Interestingly, the 1.5% KNO₃ concentration treatment resulted in a relatively fast apokol emergence time in quadrant II, with an average of 24 days after planting, which was significantly different from quadrants I and IV. This faster emergence time, both at doses of 1% and 1.5%, is strongly suspected to be related to the mechanism of KNO₃ in overcoming seed dormancy, especially through its ability to damage the impermeable outer layer (seed coat) of sugar palm. This damage is very important because it facilitates the entry of water into the seed (imbibition), which is the initial and crucial step in the initiation of the germination process. Thus, the administration of KNO₃ is effective in accelerating the water imbibition process, which ultimately accelerates the germination time of sugar palm seeds. This is supported by research by Kartika et al. (2015) which concluded that KNO₃ can increase the effectiveness of the gibberellin hormone in triggering seed germination.

Coleoptile Length, Primary Root Length, and Secondary Root Length

The results of the analysis of variance showed that there was an interaction between the concentration of KNO₃ and the position of the apokol on the length of the coleoptile, primary roots, and secondary roots of the sugar palm plant. Data on the growth of the sugar palm plant can be seen in Table 5.

Table 5. Length of coleoptile, primary root and secondary root at several KNO₃ concentrations and apocol positions

Apokol Position (o)	KNO ₃ concentration(%)	P. Coleoptile	P. Primary Root	P. Secondary Roots
Quadrant 0-90	0.5	8.60b A	9.20b A	12.90
	1	10.53b A	13.40a A	13.33
	1.5	9.80b A	13.56a A	11.53
Quadrant 90-180	0.5	10.33a B	10.50b A	10.56
	1	11.46ab A	14.83a A	13.40
	1.5	9.53b B	10.00a A	10.83
Quadrant 180-270	0.5	9.40ab B	18.53a A	10.60
	1	12.20a A	15.33a AB	14.90
	1.5	11.16a A	10.40a B	12.46
Quadrant 270-360	0.5	9.53ab C	19.26a A	12.50
	1	12.40a A	17.93a AB	15.36
	1.5	11.20a B	14.13a B	13.16

Analysis of variance showed that the effect of KNO₃ concentration on coleoptile length was influenced by the apocol position (an interaction occurred). At a concentration of 0.5%, coleoptile length varied; quadrant II recorded the highest value, while quadrant IV tended to be shorter. An increase to 1% generally had a positive effect in almost all apocol positions, with higher average values and significant differences compared to 0.5%. Increasing the concentration to 1.5% was often unfavorable, even resulting in a decrease in coleoptile length in some quadrants (such as II and IV), indicating a potential toxic effect. Significant differences between treatments (marked with different letters) confirmed the interaction between KNO₃ concentration and apocol position. Determining the most effective KNO₃ concentration must consider the orientation of the apocol position at planting. A 1% KNO₃ concentration was the longest because it can accelerate dormancy breaking without damaging the seeds (Alfino, 2018). The optimal dose of KNO₃ increases water imbibition and initial seed metabolism, although excessive concentrations can have negative impacts (Hartawan, 2016; Sutopo, 2004).

The longest primary root length occurred in quadrant IV with a KNO₃ concentration of 0.5% (19.26 cm), significantly different from the 1.5% treatment. Conversely, the shortest primary roots were found in quadrant II with a concentration of 1.5% (10.00 cm). Longer primary roots increase water and nutrient absorption, which is essential for plant survival (Santoso et al. 2020). KNO₃ application can stimulate root growth by increasing auxin hormone synthesis (Wijaya, 2019) and peroxidase enzyme activity, which strengthens root tissue (Prasetyo et al., 2021). A concentration of 0.5% provides benefits for early root development, while a higher concentration of 1.5% is suspected to be toxic, resulting in shorter roots.

The single concentration treatment significantly affected the secondary root length of sugar palm seedlings. Based on the results, a 1% KNO₃ concentration produced the highest average secondary root length (14.25 cm). This optimal 1% concentration proved effective in providing the best stimulation for secondary root growth and germination. Conversely, a 1.5% concentration showed a decrease in secondary root length. This indicates that excessively high concentrations can inhibit growth. This decrease is likely

due to the nature of KNO₃, which at high concentrations increases osmotic pressure around the roots, thereby inhibiting the absorption of needed nutrients.

Normal Seed Germination Test

The results of the analysis of variance showed that there was an interaction between the concentration of KNO₃ and the position of the apokol on the germination power test of normal sugar palm seeds. The data can be seen in Table 6.

Table 6. Normal seed germination test at several KNO₃ concentrations and apokol positions

Apokol Position (o)	KNO ₃ concentration (%)		
	0.5	1	1.5
Quadrant 0-90	65.00 a AB	68.33 b A	61.66 b B
Quadrant 90-180	63.33 a B	73.33 ab A	71.66 a A
Quadrant 180-270	68.33 a A	71.66 ab A	67.66 ab A
Quadrant 270-360	68.33 a B	75.00 a A	63.33 b B

CV: 3.11%

Based on the table above, the highest germination rate of sugar palm plants was found in quadrant IV treatment with a concentration of 1%, namely 75%. This shows a significant difference compared to the 1.5% concentration treatment. Conversely, the lowest germination rate was found in quadrant I treatment with a concentration of 1.5%, which only reached 61.66%. This difference indicates that the combination of apokol position and KNO₃ concentration significantly affects the seed's ability to initiate the germination process. Research by Rahmawati et al. (2023) confirmed that high germination rate is generally correlated with the physiological condition of the seed, especially internal nutrient content and optimal hydration levels during the imbibition process. The administration of KNO₃ is known to increase the seed's capacity to absorb water, thereby accelerating the activation of important enzymes that play a role in breaking down food reserves. With increased enzymatic activity, seeds are able to initiate the initial growth process more quickly and efficiently, resulting in a better germination percentage.

Furthermore, research by Pranoto & Yulianti (2023) found that administering KNO₃ at a concentration of 1% can increase the synthesis of the hormone gibberellin, which plays a role in breaking seed dormancy. This hormone is responsible for stimulating cell division and embryo elongation, thus supporting a faster and more efficient germination process. In addition to chemical and nutritional factors, environmental conditions such as temperature and humidity also play an important role in plant germination. Temperatures that are too low or too high can slow down enzyme activity in the seeds, thus inhibiting the germination process. Therefore, in addition to administering KNO₃, proper environmental

management is also necessary to achieve optimal germination.

Based on the research results, it can be concluded that the treatment of apokol position and KNO₃ concentration has an effect on the germination of sugar palm plants. A KNO₃ concentration of 1% produced the highest germination in quadrant IV (75%), indicating that the use of KNO₃ in optimal doses can increase seed viability. Conversely, the use of KNO₃ with a higher concentration (1.5%) showed lower germination, possibly due to the effect of nitrogen toxicity that inhibits seed metabolism. Therefore, choosing the right dose is very important in increasing the germination of sugar palm plants. In addition, environmental factors such as temperature, humidity, and seed hydration play an important role in increasing germination success. With good environmental management and appropriate use of KNO₃, the germination of sugar palm seeds can be optimized to obtain healthy and high-quality seedlings.

Seedling Height and Stem Diameter

The results of the analysis of variance showed that there was an interaction between the concentration of KNO₃ and the position of the apokol on the stem diameter of the sugar palm plant. Data on seedling height and stem diameter of the sugar palm plant can be seen in Table 7. Analysis showed that the treatment of apokol position and KNO₃ concentration had a significant effect on the height of sugar palm seedlings, with the highest yield (25.93 cm) achieved in quadrant IV with a KNO₃ concentration that was significantly different from the concentration of 1.5%. This high yield was due to the optimal dose of KNO₃ which provides essential nitrogen to support protein synthesis, cell division (Setiawan et al. 2021), and increases photosynthetic efficiency through optimal chlorophyll production (Lestari & Nugroho. 2022), thus stimulating vertical growth of seedlings. Conversely, a higher KNO₃ concentration (1.5%) resulted in the shortest seedling height (17.86 cm in quadrant III), indicating the possibility of nitrogen toxicity inhibiting metabolism.

On stem diameter. Analysis showed that the treatment of apokol position and KNO₃ concentration significantly affected the stem diameter of sugar palm seedlings, with the highest stem diameter (4.7 cm) achieved in quadrant IV treatment with a KNO₃ concentration of 1%, and the lowest (3.2 cm) in quadrant II with a KNO₃ concentration. The results trend showed that increasing the KNO₃ concentration from 0.5% to 1% increased stem diameter in all apokol positions, but there was a decrease in size at a concentration of 1.5%, indicating the effect of excessive application (Erlambang et al. 2018). The increase in growth at the optimal dose of 1% was associated with the ability of KNO₃ to break dormancy, increase seed water content, and the role of potassium and nitrogen content in supporting vegetative growth and metabolism (Usodri et al. 2021). Meanwhile, the significant difference in stem diameter between apokol positions with an increasing trend from quadrant I to IV indicates the influence of genetic factors that

determine the innate growth potential of seeds, in line with the concept that growth characteristics are an
interaction between genes and the environment (Ediwirman et al. 2025).

Table 7. Seedling height and stem diameter at several KNO3 concentrations and apokol position

Apokol Position (o)	KNO3 concentration (%)	Seedling Height	Stem Diameter
Quadrant 0-90	0.5	21.83	4.00a A
	1	22.2	4.16a A
	1.5	19.36	3.36b B
Quadrant 90-180	0.5	19.09	3.86a A
	1	22.13	4.40a A
	1.5	18.43	3.20b B
Quadrant 180-270	0.5	20.05	3.26b B
	1	20.02	4.50a A
	1.5	17.86	4.06a A
Quadrant 270-360	0.5	23.9	4.10a B
	1	25.93	4.70a A
	1.5	19.01	4.00a B

Leaf Area

The results of the analysis of variance showed that there was an interaction between the concentration of

KNO₃ and the position of the apokol on the leaf area of the sugar palm plant. These data can be seen in Table 8.

Table 8. Leaf area of sugar palm seedlings at several KNO₃ concentrations and the position of the apokol

Apokol Position (o)	KNO ₃ concentration (%)		
	0.5	1	1.5
Quadrant 0-90	2.39b B	2.97ab A	2.01b B
Quadrant 90-180	3.05a A	2.34c B	2.81a AB
Quadrant 180-270	2.31b A	2.63bc A	2.47ab A
Quadrant 270-360	2.73ab A	3.18a A	2.19b B
CV: 11.51%			

There was a significant interaction between KNO₃ concentration and apokol position on the leaf area of sugar palm seedlings, indicating that the leaf area response is highly dependent on the combination of both factors. The highest leaf area was recorded in quadrant IV treatment with a 1% KNO₃ concentration, although the response pattern varied: quadrants I and IV reached a peak at 1%, while quadrant II reached a peak at 0.5%. This variation in response indicates that the apokol position affects the effectiveness of KNO₃ absorption, which is very important because it determines the area of entry of the solution to the embryo (Hartawan, 2016). Differences in apokol position are also related to physiological differences in response to nutrients, light exposure, and growth of hormone distribution. The role of KNO₃ in increasing potassium availability is known to increase the efficiency of light use and stimulate leaf growth (Wijonarko et al. 2014) and produce the highest leaf length (Anwar et al. 2024). Thus, determining the optimal combination of KNO₃ concentration and apokol position is crucial to maximize the leaf area of sugar palm seedlings.

combined with KNO₃ concentrations of K₁ (0.5%), K₂ (1%), K₃ (1.5%).



Figure 3. Comparison of the height of sugar palm seedlings in the Apokol position of quadrant 2 (P₂) combined with KNO₃ concentrations of K₁ (0.5%), K₂ (1%), K₃ (1.5%).

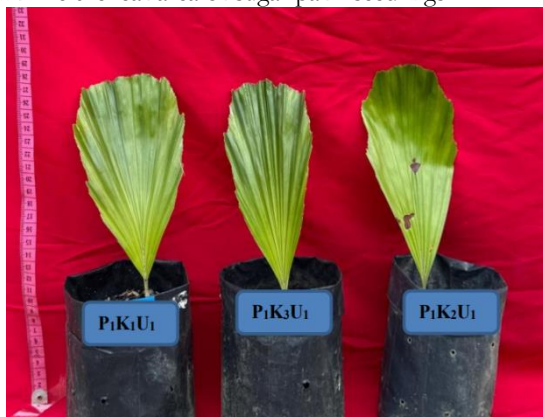


Figure 2. Comparison of the height of sugar palm seedlings in the apokol position of quadrant I (P₁)

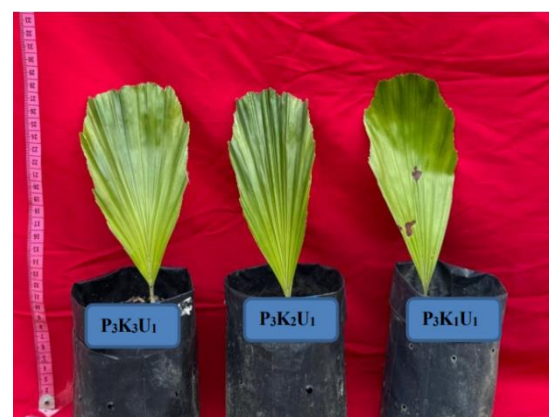


Figure 4. Comparison of the height of sugar palm seedlings in the Apokol position of quadrant 3 (P₃)

combined with KNO₃ concentrations of K1 (0.5%), K2 (1%), K3 (1.5%).



Figure 5. Comparison of the height of sugar palm seedlings in the apocol position of quadrant 4 (P4) combined with KNO₃ concentrations of K1 (0.5%), K2 (1%), K3 (1.5%).

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4. Conclusion

Based on the experimental results, it can be concluded that there is a significant interaction between the concentration of KNO₃ and the position of the apocol which affects all observation parameters, including the time of apocol emergence, apocol length, coleoptile length, primary root length, normal seed germination test, stem diameter, and leaf area of sugar palm seedlings.

Specifically, the treatment of 1% KNO₃ and the position of the apocol in Quadrant IV proved to be the best combination that provided a superior response to the physiological characteristics, viability, and growth of sugar palm seedlings. Therefore, the use of optimal KNO₃ concentration and the determination of the correct position of the apocol are crucial in optimizing the initial growth of sugar palm seedlings

5. Acknowledgement

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