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Growth Response and Physiology of Oil Palm Seedlings (*Elaeis guineensis* Jacg) of Yangambi Ppks Variety to Various Salinity Levels in the *Pre Nursery Phase*

[1] Alif Sanjaya
Plantation Cultivation Study Program, Faculty of Vocational, Indonesian Institute of Palm Oil Technology
[2] Eka Bobby Febrianto
Plantation Cultivation Study Program, Faculty of Vocational, Indonesian Institute of Palm Oil Technology
[3] Sri Murti Tarigan
Plantation Cultivation Study Program, Faculty of Vocational, Indonesian Institute of Palm Oil Technology
[4] Wagino
Plantation Cultivation Study Program, Faculty of Vocational, Indonesian Institute of Palm Oil Technology

Corresponding Author: *alifsanjaya222@gmail.com*

Abstract

Oil palm (Elaeis guineensis Jacq.) is a strategic plantation commodity in Indonesia, but the expansion of cultivation to marginal land, including saline land, requires tolerant planting material. This study aims to evaluate the growth and physiology response of oil palm seedlings of the DxP PPKS Yangambi variety to various salinity levels in the pre-nursery phase. The study used a non-factorial Group Random Design (RAK) with three levels of salinity treatment, namely 0 mmhos (S0), 5–6 mmhos (S1), and 6–7 mmhos (S2) NaCl, each repeated ten times. The observed parameters included plant height, stem base diameter, number of leaves, chlorophyll content, wet and dry weight, root volume, leaf volume, root length, and crown length. The data was analyzed using the Analysis of Variance (ANOVA) and continued with Duncan's Multiple Range Test (DMRT) at the level of 5%. The results showed that salinity treatment had no noticeable effect on most growth parameters, such as stem diameter, wet and dry weight, root and leaf volume, and root

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and crown length. The real effect was only seen on the height of the 8 MST age of the plant, the number of leaves of 9 and 11 MST, and the content of 11 MST age chlorophyll. In general, S2 treatment (6–7 mmhos NaCl) tends to produce the highest growth value in several parameters, so that DxP PPKS Yangambi oil palm seedlings are still able to grow and adapt to salinity conditions of up to 6–7 mmhos in the pre-nursery phase.

Keywords: oil palm, salinity, pre-nursery, growth, fisiologi

INTRODUCTION

Oil palm plantation development currently faces various obstacles, one of which is limited potential land. This situation encourages the use of marginal land, including land with high salinity levels, such as tidal flats. Tidal flats across Indonesia cover approximately 20.11 million hectares, of which 2.07 million hectares are potential tidal flats (Santoso & Fandi Hidayat, 2015).

Tidal flats generally have high dissolved salt content, which can inhibit plant growth by disrupting water balance and nutrient absorption (Kurniawan et al., 2023). Furthermore, salinity can cause physiological symptoms such as chlorosis, reduced leaf growth, and disrupted photosynthesis (Firmansyah, 2018).

During the nursery phase, particularly the pre-nursery stage, environmental conditions significantly determine the quality of the seedlings produced. Nursery development is a crucial initial stage in oil palm cultivation because it determines plant performance in subsequent growth phases (Theresia & Astuti, 2019). Seedlings that experience salinity stress early in their growth are likely to experience disruptions in morphological and physiological development, such as plant height, leaf number, and chlorophyll content.

Plants under salinity stress generally experience physiological and biochemical changes as a form of adaptation, one of which is an increase in proline content, which plays a role in maintaining cell osmotic balance (Larasani, 2021). Furthermore, chlorophyll levels are also an important indicator in assessing a plant's photosynthetic ability, which can be impaired by salinity stress (Safriyani, 2015). Plant response to this stress is strongly influenced by genetic factors, the environment, and the cultivation techniques used (Ningsih Tuty, 2023).

The DxP PPKS Yangambi oil palm variety is a superior variety widely used due to its high production potential and good agronomic characteristics (Resonya et al., 2020). However, information on the response of this variety to salinity stress during the nursery phase, particularly the pre-nursery phase, is still limited. Therefore, research is needed to assess the growth and

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physiological responses of oil palm seedlings to various levels of salinity.

Based on this description, this study aims to analyze the growth and physiological responses of oil palm seedlings of the Ppks Yangambi variety to various levels of salinity during the pre-nursery phase.

The results of this study are expected to provide scientific information as a basis for developing oil palm cultivation on saline soils and support the selection of varieties tolerant to salinity stress.

RESEARCH METHODS

This research was conducted in the laboratory and greenhouse of the Indonesian Palm Oil Technology Institute, Medan, from July to September 2025. A non-factorial randomized block design (RBD) was used with one treatment factor, salinity level. The treatments consisted of three levels: no NaCl as a control (S0), NaCl with a level of 5–6 mmhos (S1), and 6–7 mmhos (S2). Each treatment was replicated 10 times, with each unit consisting of 3 seedlings, resulting in a total of 90 seedlings observed.

The salinity solution was prepared by dissolving sodium chloride (NaCl) in water until it reached the appropriate electrical conductivity levels for the treatments: 0 dS m^{-1} (control), 5–6 dS m^{-1}, and 6–7 dS m^{-1}. The solution conductivity was measured using an EC meter to ensure compliance with the specified treatment levels. The solution was then used as irrigation water according to the dosage for each treatment.

This study focused on observing the growth and physiological responses of oil palm seedlings to salinity stress during the pre-nursery phase. The seedlings used were from oil palm seedlings of the Ppks Yangambi variety. The planting medium was prepared from sifted topsoil, mixed with compost until evenly distributed, and then placed in 14 x 22 cm polybags, filling them close to the rim. The seedlings were then planted and maintained with regular watering twice daily, in the morning and evening.

After the seedlings were approximately four weeks old and had grown stably, the salinity treatment was initiated by spraying them with NaCl solution at the prescribed concentration. This treatment was carried out routinely until the plants reached 12 weeks after planting. During the maintenance period, weeds growing in the polybags were manually removed to prevent them from interfering with seedling growth.

Parameters observed included plant height, stem diameter, number of leaves, and leaf chlorophyll content. Additionally, at the end of the study, observations were made on root length,

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root volume, and fresh and dry weight of the plants by removing the seedlings.

The observation data were then analyzed using analysis of variance (ANOVA) to determine the effect of the treatments. If significant differences were found, Duncan's Multiple Range Test (DMRT) was performed at the 5% level to determine differences between treatments.

RESULTS AND DISCUSSION

Oil palm seedling growth under salinity stress showed varying responses for each observed parameter. Based on the analysis of variance, NaCl irrigation treatments at various salinity levels generally had no significant effect on most growth parameters. However, several parameters showed a significant response at specific observation times. These results indicate that oil palm seedlings still have the ability to adapt to salinity conditions during the early seedling phase. All observation data included plant height, stem diameter, leaf number, chlorophyll content, plant biomass, organ volume, and root and shoot length.

1. Seedling Height

The treatments showed a significant effect on seedling height for several parameters and observation times. This indicates that the plant growth response to the treatments was not uniform at each growth stage. However, a significant effect on plant height was only observed at 8 weeks after planting; this is thought to be related to the plant's entry into active vegetative growth, where cell division and elongation continue. However, in other observations, the treatment effect did not show significant results. This may be due to the plants still being in the adaptation phase or the relatively uniform environmental factors are relatively uniform.

Table 1. Average High Yield of Oil Palm Seedlings

Treatment		Observation of Average Seed Height (MST)						
	5	6	7	8	9	10	11	**12**
Salinity level 0	9,09	11,25	13,52	15,49c	18,35	20,56	21,84	**23,82**
Salinity level 1	8,77	11,54	13,76	13,75a	18,71	20,71	22,10	**23,39**
Salinity level 2	9,42	11,80	14,33	14,33b	18,65	21,49	23,19	**24,74**

Table 1 shows the increase in oil palm seedling height for each week of observation (5–12

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WAP), but there were no significant differences between treatments for most of the observation period. Statistical tests revealed that the effect of salinity was only visible at 8 WAP, while no significant changes occurred at other ages. At the end of the observation period (12 WAP), treatment S2 (6–7 mmhos NaCl) showed the highest plant height at 24.74 cm, followed by treatment S0 (23.82 cm), and treatment S1 (23.39 cm). Plant height increases varied, with the highest increase at 9 WAP at 4.03 cm and the lowest at 12 WAP at 1.30 cm.

The analysis showed that, for most of the observation period, the NaCl irrigation treatment did not significantly affect plant height, although there were differences between treatments. This indicates that oil palm seedlings can still grow well under salinity conditions of 6–7 mmhos.
Physiologically, the processes of cell division and elongation are correlated with nutrient availability, particularly nitrogen. Nitrogen is responsible for the formation of amino acids and proteins necessary for cell growth (Usodri Shifa et al., 2021).

Salinity reduces the water potential of the medium, making it difficult for roots to absorb water. Furthermore, the accumulation of Na+ and Cl− in plant tissues can cause ion toxicity (Febrianto et al., 2019). Salinity can also cause nutritional imbalances because nutrient absorption and distribution within the plant are disrupted.
Under saline conditions, the three main constraints to plant growth are osmotic stress, ion toxicity, and nutrient imbalance (Febrianto et al., 2019).

The oil palm seedlings in this study were still able to adapt and grow taller, although there was no significant difference. Therefore, it can be concluded that, although the S2 treatment tended to produce numerically better plants, NaCl irrigation at levels of 6–7 mmhos did not significantly affect the growth of tall oil palm seedlings.

2. Diameter of the base of the stem

In the parameters of the stem base diameter, the NaCl treatment did not have a noticeable effect, but the S2 treatment showed a tendency to produce the largest diameter (7.74 mm) compared to other treatments.

Table. 1 Average Result of Seedling Bump Diameter

Treatment	Observation of Average Diameter of Plant Hump Plant (MST)							
	5	6	7	8	9	10	11	**12**
Salinity level 0	5,00	5,91	6,15	6,25	6,96	7,34	7,67	**7,69**
Salinity level 1	4,72	5,51	6,25	6,45	6,83	7,19	7,53	**7,55**

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Salinity level 2	4,89	5,53	6,09	6,29	6,97	7,46	7,70	**7,74**

The NaCl watering treatment does not really affect the diameter of the base of the stem of the oil palm seedlings, as shown in table 2. The rod diameter value increased weekly, but did not show a significant difference between treatments.

At the end of the 12 MST observations, the S2 treatment (6–7 mmhos NaCl) produced the highest stem base diameter of 7.74 mm, followed by the S0 treatment of 7.69 mm, and the S1 treatment with the lowest diameter of 7.55 mm. At age 6 MST, the highest increase in stem diameter was 0.78 mm, while the lowest increase was 0.26 mm at age 12 MST. (Usodri Shifa et al., 2021) (Usodri Shifa et al., 2021).

Salinity conditions cause the accumulation of Na+ and Cl− ions, which can cause ion imbalances in plant tissues and disrupt metabolic processes, leading to suboptimal growth (Bisri et al., 2026). Furthermore, a more negative soil water potential prevents plants from absorbing water. As a result, cell turgor pressure decreases and cell enlargement is inhibited..

Nonetheless, oil palm seedlings continue to show the ability to adapt to given salinity conditions, so that stem diameter growth continues without significant differences between treatments, although S2 treatments are numerically more often shown higher values.

3. Number of Leaf Strands

The results of observations showed that the number of plant leaves experienced a real effect at the age of 9 MST and 11 MST. At the end of observation, the S2 treatment produced the highest number of leaves, which was 3.20 leaves,	**Observation of Average Number of Leaf Strands (MST)**							
	5	6	7	8	9	10	11	**12**

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while the S1 treatment showed the lowest number of 3.03 leaves. This suggests that each treatment responds differently to the growth of the number of leaves.The pattern of leaf number development is presented. Treatment								
Salinity level 0	1,80	1,90	2,27	2,47	2,86c	2,93	3,13 b	**3,13**
Salinity level 1	1,70	2,00	2,13	2,46	2,50a	2,77	2,93a	**3,03**
Salinity level 2	1,97	2,00	2,13	2,47	2,66b	2,90	3,20c	**3,20**

Table. 2 Yield of the Number of Leaves

Numerically, there are differences between treatments, but the results of statistical analysis show that there is no noticeable difference for the most part. This shows that salinity treatment of up to 6–7 mmhos NaCl has not affected the number of oil palm seedlings. Physiologically, the number of leaves is closely related to the process of cell division and differentiation, which is influenced by the availability of nutrients, especially nitrogen.

Nitrogen is also responsible for the formation of chlorophyll and proteins, as well as plant tissues that support leaf growth (Gamal Syahrial, 2022).

Plant genetic factors also affect leaf formation, which determines how many leaves can be produced. As a result of the accumulation of salt ions in plant tissues in
salinity conditions, leaf growth can be stunted (Febrianto et al., 2019).

The amount of energy available for the formation of new organs, such as leaves, decreases due to the decrease in photosynthesis, plants are still able to adapt through physiological

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mechanisms at a certain level of salinity, so leaf formation still occurs, although not optimal, S2 treatment shows a tendency of higher leaf counts, NaCL watering treatment as a whole does not have a noticeable impact on the number of leaves of oil palm seedlings.

4. Leaf Chlorophyll Content

The results of observations on the chlorophyll content of leaves in each treatment given during the study are presented in detail in the following table.

Table. 3 Average Yield of Leaf Chlorophyll Content

Treatment	Pengam Average Leaf Chlorophyll Content (MST)				
	8	9	10	11	**12**
Salinity level 0	45,25	45,71	46,43	49,34 a	**52,31**
Salinity level 1	42,65	44,60	44,75	45,61 b	**53,10**
Salinity level 2	43,56	45,57	46,49	48,93 b	**52,36**

Table 4 shows that NaCL watering treatment had an unnoticeable effect on leaf chlorophyll content at most observation times, except at age 11 MST which showed a marked difference between treatments. At the end of observation (12 MST), the S1 treatment (5–6 mmhos sodium chloride) showed the highest chlorophyll content of 53.10 SPAD, followed by the S2 treatment of 52.36 SPAD and the S0 treatment of 52.31SPAD.

Numerically, there are differences between treatments, but the results of statistical analysis show that there is no noticeable difference for the most part. This shows that salinity treatment of up to 6–7 mmhos of NaCl has not affected the chlorophyll content in oil palm seedlings. A plant's ability to photosynthesize is physiologically linked to the amount of chlorophyll in the plant. Chlorophyll is often used as an indicator of the physiological condition of plants because it plays a role in the absorption of light energy used for the synthesis of carbohydrates (Gamal Syahrial, 2022).

Plant stress on salinity conditions can interfere with a variety of physiological processes, including photosynthesis, respiration, and protein synthesis (Febrianto et al., 2019). In plant tissues, the accumulation of Na+ and Cl− ions can damage the structure of chloroplasts and inhibit the formation of chlorophyll, resulting in imperfect photosynthesis. However, the difference between treatments is not significant at a certain salinity level because plants are still able to adapt by maintaining chlorophyll content through physiological mechanisms (Santoso et al., 2023)

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5. Heavy wet and dry headings and roots

The results of observations on wet and dry weight of the crown and roots of the seedlings in each treatment given during the study are presented in detail in the following table.

Table. 4 Average Wet and Dry Heavy Yield of Crown and Roots

Treatment	Wet Weight Title	Dry Weight Title	Heavy Wet Roots	Heavy Dry Roots
Salinity level 0	2,52	0,57	0,58	**0,13**
Salinity level 1	2,41	0,54	0,65	**0,14**
Salinity level 2	2,60	0,60	0,82	**0,16**
Test F	tn	tn	tn	**tn**

Table 5 shows that NaCL watering treatment does not actually affect wet and dry weight on the crown and roots of oil palm seedlings. Nevertheless, the mean values differed between treatments, indicating different tendencies. The S2 treatment (6–7 mmhos NaCl) had the highest values for all parameters, with a wet crown weight of 2.60 g, a dry crown weight of 0.60 g, and a root dry weight of 0.82 g, respectively. On the other hand, the S1 treatment for the head (2.41 g and 0.54 g) and the S0 treatment for the root (0.58 g and 0.13 g).

Although the S2 treatment may produce better results, statistical analysis shows that the difference is not significant.

A plant's wet weight physiologically indicates the water content in the plant's tissue, while dry weight indicates the accumulation of dry matter resulting from photosynthesis. Therefore, dry weight is usually used as the main measure of plant growth (Muarif abdul ridho, 2023).

As a result of salinity conditions, the process of absorption of water and nutrients by the roots is disrupted. This is suspected to be the cause of the inconsistency between the treatments. Salinity can reduce groundwater capacity, making it difficult for plants to absorb water. In addition, the accumulation of Na+ and Cl− ions can disrupt the ion balance in plant tissues and suppress metabolic activity, including photosynthesis (Febrianto et al., 2019).With this decrease in photosynthesis, the accumulation of plant biomass is reduced.

In contrast, the activity of growth hormones such as auxins and the availability of nitrogen elements, which contribute to the formation of cell protoplasm and proteins, also affect the formation of plant biomass (Muarif abdul ridho, 2023).However, under salinity conditions, biomass growth is not optimal because some of the plant's energy is diverted to the adaptation

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mechanism to stress.

Therefore, although S2 treatment resulted in an increase in wet weight and dry weight, NaCL watering statistically had no significant impact on plant biomass parameters. This shows that oil palm seedlings can still survive in certain salinity conditions, but have not been able to increase growth significantly.

6. Leaf and root volume

The results of observations on the volume of leaves and roots in each treatment given during the study are presented in detail in the following table.

Table. 5 Average Volume and Root Yield

Treatment	Leaf Volume	Root Volume
Salinity level 0	4,45	0,35
Salinity level 1	4,80	0,41
Salinity level 2	5,00	0,54
F test	Ur	Ur

Table 6 shows that NaCL watering treatment does not affect the leaf and root volume of oil palm seedlings. The S2 treatment (6–7 mmhos NaCl) had the highest leaf volume of 5.00 cm3, followed by the S1 treatment of 4.80 cm3, and the S0 treatment as a control of 4.45 cm3.

The root volume showed that the S2 treatment produced the highest value of 0.54 cm3, followed by the S1 treatment of 0.41 cm3, and the S0 treatment of 0.35 cm3. Although the S2 treatment yielded the highest scores numerically, the results of statistical analysis showed that this difference was not significant.

This shows that salinity reduction of up to 6–7 mmhos of NaCl has not shown a significant impact on the growth of the volume of vegetative organs of plants, both leaves and roots.

In salinity conditions, plants experience osmotic stress due to increased salt concentrations in the growing medium, which makes it more difficult for water to be absorbed by the roots. On the other hand, leaf volume is physiologically related to the surface area of photosynthesis, while root volume is related to the plant's ability to absorb water and nutrients

Salinity can also increase the rate of root respiration, which makes plants require more energy to maintain the balance of ions in the cell. The process of adaptation to salinity stress diverts energy that should be used for growth. This inhibits the optimal growth of roots and leaves. Instead, plants produce osmotic compounds, such as proline and free amino acids, to maintain

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the pressure of the cell's turgor pressure, as a mechanism of adaptation to saline conditions (Febrianto et al., 2019)

The plant's level of stress and tolerance are each highly influential in this adaptation response. Therefore, although certain salinity treatments increase leaf and root volume, NaCL treatment statistically does not affect either of these parameters. This shows that oil palm seedlings can still withstand salinity conditions to a certain degree without significantly changing the volume of their vegetative organs.

7. Root Length and Title

The results of observations on root length and crown in each treatment given during the study are presented in detail in the following table.

Table. 6 Average yield length of header and root

Treatment	Title Length	Root Length
Salinity level 0	23,52	20,47
Salinity level 1	24,21	21,65
Salinity level 2	24,32	20,80
F test	**ur**	**Ur**

Table 7 shows that NaCL watering treatment did not significantly affect the root length or crown of oil palm seedlings. However, the mean values differed between treatments in the root length parameters, the S1 treatment (5–6 mmhos NaCl) showed the highest value, 21.65 cm; the S2 treatment showed the lowest value, 20.80 cm, and the S0 treatment as a control showed the lowest value, 20.47 cm.

The results of statistical analysis showed that this difference was not significant even though the S1 and S2 treatments tended to result in longer root and crown lengths than controls. This shows that oil palm seedlings can adapt to salinity conditions of up to 6 to 7 mmhos NaCL without experiencing significant growth disruption (Febrianto et al., 2019).

Physiologically, the length of the roots and crown is influenced by the plant's ability to absorb water and nutrients. In environments with high salinity levels, the groundwater potential becomes more negative, which makes it difficult for the roots to absorb water. This causes a decrease in the pressure of the cell's turgor, which inhibits cell elongation. In addition, the accumulation of Na+ and Cl− ions can cause an imbalance of ions in plant tissues and interfere with plant growth metabolism (Febrianto et al., 2019).

Nutrient components such as calcium (Ca) and potassium (K) are responsible for

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supporting plant tissue growth and maintaining the integrity of cell membranes. Under saline conditions, an increase in the Na+/Ca2+ ratio can reduce calcium uptake, which impacts root and crown growth (Firmansay, 2017)

Under salinity stress conditions, the vegetative growth of plants is limited due to decreased absorption of these nutrients. Therefore, although numerically it is seen that certain salinity treatments cause root length and crown to increase, this effect does not statistically show a significant effect. As a result, the plant growth response remains considered tolerant of given salinity conditions.

DISCUSSION RESULTS

The results showed that the provision of salinity up to 6–7 mmhos NaCl in the pre-nursery phase generally did not have a significant effect on most growth and physiological parameters of oil palm seedlings of the DxP PPKS Yangambi variety. Significant effects were only found on plant height at 8 weeks post-planting (WAP), number of leaves at 9 and 11 weeks post-planting (WAP), and chlorophyll content at 11 weeks post-planting (WAP). This indicates that oil palm seedlings are still able to maintain growth in mild to moderate saline conditions.

Physiologically, salinity stress can inhibit water and nutrient absorption due to the accumulation of Na+ and Cl− ions in the growing medium (Febrianto et al., 2019). However, the oil palm seedlings in this study were still able to maintain vegetative growth and chlorophyll content. The S2 treatment (6–7 mmhos NaCl) even tended to produce the highest growth values for several parameters, indicating physiological adaptation to salinity stress.

The main contribution of this study is to provide preliminary scientific information on the tolerance of DxP PPKS Yangambi oil palm seedlings to salinity stress in the pre-nursery phase, which has been limited in previous studies. These findings strengthen the potential use of the DxP PPKS Yangambi variety on marginal saline land and can form the basis for developing oil palm cultivation strategies that are more adaptive to stressful environmental conditions, particularly in tidal areas and areas affected by seawater intrusion.

CONCLUSION

The results showed that NaCl irrigation at various salinity levels generally did not affect most oil palm seedling growth parameters. These included stem base diameter, fresh and dry weight of the crown and roots, leaf and root volume, root and crown length, and only a few specific parameters and observation times, namely the height of the oil palm seedlings.

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In general, the salinity treatment with a dose of 6–7 mmhos NaCl (S2) tended to show higher average growth values compared to the other treatments for several parameters, although these differences were not statistically significant.

This indicates that oil palm seedlings can still tolerate salinity conditions up to this level. Therefore, the application of NaCl at only 6 to 7 mmhos did not significantly impact the growth of oil palm seedlings in the early nursery phase.

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