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Research Article

Relationship between Plant Physiological Traits, Application Time and Dosage of Liquid NPK Fertilizer on Oil Palm Seedling in Pre Nursery

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Abstract | Physiological properties greatly affect te effectiveness of fertilization through the leaves. This study aims to determine the response of application time and dose of liquid NPK fertilizer to physiological properties and growth of oil palm seedlings in *pre nursery*. This research was conducted from March to June 2024 in Wedomartani Village, Depok District, Sleman Regency, Yogyakarta at coordinate 7°45'01" S 110°26'32 " E with an altitude of 166.98 meters above sea level This study used the factorial complete randomized design (CRD) method. The first factor is the dosage of liquid NPK fertilizer, consisting of 4 levels, namely control, 75 ml, 100 ml and 125 ml. The second factor is the application time, which consist of 3 levels, namely at 09:00, 12:00 and 15:00. Data from the study were analyzed using variance analysis (Anova) at the 5% level. The results showed a significant interaction between the dose of 125 ml liquid NPK fertilizer and the application time in the afternoon at 15:00 on leaf area. The treatment of 100 ml liquid NPK fertilizer dose gives the most optimal plant growth results, characterized by an increase in plant heigh, root dry weight, stomatal opening width and P_2O_5 and K content in plants. The treatment of application time in the afternoon at 15:00 significantly affect physiological parameters such as chlorophyll content, stomatal opening width, NPK nutrient content and growth such as plant heigh, leaf area, crown dry weight and root dry weight. The treatment combination of 100 ml liquid NPK fertilizer dose at the time of application in te afternoon at 15:00 is the best treatment to improve the growth and physiological characteristics of oil palm seedlings in the *pre nursery*.

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Introduction

Oil palm is an important commodity crop for the plantation sector. According Ditjenbun, (2023) by 2023 the area of oil palm plantations in Indonesia will reach 16.83 million ha, so the availability of high-quality seedlings is very important. Quality optimal growth of oil palm seedlings affects the development and production of oil palm plants in the field. (Sigalingging *et al.*, 2018). Oil palm nursery systems are usually classified into two categories, namely single stage and double stage, consisiting of pre nursery and main nursery. The pre nursery starts when the seedlings are planted from seed until the age of three months. To produce quality seedlings that are agronomically superior and economically

profitable, it is important to pay attention to proper nursery techniques (Darmosarkoro, 2008).

Quality seedlings can be obtained by increasing the supply of nutrients for plants throught fertilization. Inorganic fertilizers for oil palm nurseries in the pre nursery because of their high nutrient content and fast dissolution and absorption by plants. NPK compound fertilizer is a widely used inorganic fertilizer. Research on the use of NPK fertilizers for oil palm seedlings in the pre nursery stage by Hastuti & Titiaryani, (2022) menunjukkan hasil bahwa pemberian pupuk showed that the application of liquid NPK fertilizer at a dose of 100 ml can increase plant height (cm) and plant dry weight (g), research was also conducted by Sinulingga et al., (2015) that the use of NPK fertilizers has an impact on the number of leaves (starnd) and plant height (cm) as well as in the research of Laia et al., (2021) showed that the use of NPK fertilizers has the potential to increase the number of leaves (starnd), plant heigt (cm), leaf area (cm^2), leaf length (cm), stem diameter (mm) and leaf width (cm) in oil palm seedlings in pre nursery.

Fertilization can be done throught roots and leaves, foliar fertilization is done by sparing liquid fertilizer on the leaves directly Patil & Chetan, (2018). Foliar fertilization is an effective fertilization method because liquid fertilizers easlily enter and are absorbed directly by plants through stomata (Farrasati *et al.*, 2021). Alshaal & El-Ramady, (2017), also added that, under stress conditions, the efficiency of nutrient absorption can be an alternative to evercome these limitations. Waseem et al., (2015) stated that the application of urea fertilizer through leaves is more effective, especially in conditions on soils that are inhibited by nitrogen absorption, in flooded land foliar application prevents nitrogen loss while in dry soils with low hummadity, leaf sparing helps plants absorp and utilize fertilizer optimally. The use of the right dose of liquid fertilizer aiums to get the best results. If the dose of liquid fertilizer applied is less than the nutrient needs of the plants, the results are also not optimal because the amount of nutrients needed by the plants is not met. Conversely, if the dose of liquid fertilizer applied to the plant exceeds the tolerance limit of te plant, growth will be inhibited because too many nutrients given can interfere with the plant's metabolic system. In addition, due to the large concentration difference between soil and plant roots, the osmosis process of the roots to absorp water nutrients form the soil can be disrupted (Maulana and Saleh, 2015). According Patil & Chetan, (2018) proper fertilization concentration is an important factor and has a great influence on improving yield parameters and quality in foliar fertilization.

Fertilizatin is also done by paying attention to the time of application because it is related to the opening and closing of the stomata so that the absorption of the fertilizers by the stomata is maximized Patil & Chetan, (2018). Seeing most plants with hypostomata properties, where stomata are mor abundant on the abaxial surface of the leaves so that foliar fertilization is carried out by applying fertilizer to the lower surface of the leaves in the morning or evening (Muir, 2015).

In oil palm leaves, stomata open most at 09:00 to 17:00 (Corley & Tinker, 2015). Oil palm is a C4 plant that has the property of stomata opening during the day to support CO_2 absorption for photosynthesis and then closing at night to prevent inefficient transpiration of water vapor. Stomatal movement patterns are driven by light availability an time of day (Vialet-Chabrand *et al.*, 2017). Stomata start to open in the morning until midday (noon) and then start to close in the afternoon to evening (Christman *et al.*, 2007). Stomatal density and index are responsive to changes in sunlight intensity and air humadity (Corley and Tinker, 2015). Therefore, this study examined the relationship between plant physiological traits, liquid NPK fertilizer dosage and application time on oil alm seedlings in the pre nursery

Materials and Methods

Experimental design

This study used the experimental method of factorial complete randomized design (RAL). The first factor is the dose of liquid NPK fertilizer consisiting of 4 levels namely; (D0) control, (D1) 75 ml, (D2) 100 ml and (D3) 125 ml with a concentration 0,3% (3 g/l water). The second factor is application time wich consist of 3 levels namely; (W1) at 09:00, (W2) atl 12:00 and (W3) at 15:00. The treatment comination was 3 x 4 = 12 with 4 replications resulting in 48 plats.

Preparation of NPK fertilizer solution

The solution was made by weighting NPK 15-15-15

Fertilizer with a consentration 0,3% (3 g/l water). Next, the fertilizer was applied in doses of 75 ml, 100 ml dan 125 ml through the leaves on the underside of the leaves. The fertilizer application was done once a week starting from one-month-old seedlins to three-month-old seedlings.

Physiological and growth observations

Plant height and number of leaves were observed once a week starting from one-month-old seedlings. Other variables observed at the end of the study were physiological properties (chlorophyll content, NPK nutrient content in plant,stomatal opening width and number of stomata) and growth (leaf area, stem diameter, root dry weight and crown dry weight). The data obtained were analyzed using Analysis of Variance (ANOVA). If the analysis of variance showed a significant effect, then continued further tests with DMRT at a significance level of 5% using SPSS.

Results and Discussion

Dose response of liquid NPK fertilizer on physiological traits and growth of oil palm seedlings in pre nursery

The results of analysis of variance (ANOVA) showed that the dose of liquid NPK fertilizer significantly affected the physiological characteristics and growth of oil palm seedlings in the pre-nursery. Physiological traits greatly affect the effectiveness of fertilization done through the leaves at the carrying part of the leaf.

Table 1: *Dosage Response of LIQUID npk Fertilizer on Physiological Traits and Growth of Oil Plam Seedlings in Pre Nursery*

Observation Parameters	Application Time		
	9:00	12:00	15:00
Chlorophyll content (ml/l)	61,09 b ± 1,36	61,68 b ± 2.01	62,61 b ± 3,14
Morning stomatal count (unit/mm2)	59,00 a ± 4,93	61,67 a ± 7,40	62,08 a ± 7,25
Morning stomatal opening width (µm)	6,01 b ± 0,35	6,49 ab ± 1,03	6,97 a ± 0,96
Number of stomata during the day (unit/mm2)	57,67 a ± 4,59	59,50 a ± 4,29	61,17 a ± 7,09
Daytime stomatal opening width µm)	3,17 b ± 0,82	3,25 b ± 0,61	3,70 ab ± 0,64
Number of stomata in the afternoon (unit/mm2)	64,83 a ± 4,60	68,92 a ± 7,83	70,25 a ± 8,32
Afternoon stomatal opening width (µm)	6,46 b ± 0,37	7,56 a ± 0,92	8,18 a ± 1,61
Seedling height (cm)	23,92 b ± 3.17	26,10 ab ± 2.53	28,56 a ± 2,91
Number of leaves(helai)	3,33 a ± 0,49	3,50 a ± 0,67	3,75 a ± 0,50
Rod diameter (mm)	7,17 a ± 0,93	7,68 a ± 0,86	7,93 a ± 1,15
Crown dry weighy (g)	0,47 b ± 0,09	0,63 a ± 0,15	0,70 a ± 0,23
Root dry weight (g)	0,17 b ± 0,06	0,23 ab ± 0,08	0,26 a ± 0,06

Description : Number followed by the same letter in the same row no significant difference
Source : Primary data 2024

The effect of NPK fertilizer doses of 100 ml and 125 ml gave the same effect on the parameters of the chlorophyll content (ml/l), number of stomata (units/mm^2), stomatal opening width (µm), seedlings height (cm), number of leaves (strand), stem diameter (mm), crown dry weight (g) and root dry weight (g) (Tabel 1). This is because the results of the analysis of NPK nutrients content in plants with these treatments are not significantly different. The results of the analysis of the content of NPK nutrients in seedlings with 100 ml dose of liquid NPK fertilizer treatment have a nutrient content of N (2,96%); P_2O_5 (0,6462) and K_2O (132,04 ppm) while the content of NPK nutrients in the 125 ml dose treatment is N (3,18%); P_2O_5 (0,3996) and K_2O (112,95 ppm). (Tabel 1) also shows that the 75 ml fertilizer dose treatment gives the lowest effect in all physiological and growth parameters, this is because the nutrient needed by te seedlings are not sufficient to improve the physiological and growth of the seedlings in a accordance with the opinion Maulana & Saleh, (2015) if the dose of liquid fertilizer given is less than the nutrient needs of plants, the results are also not optimal because the metabolism of the amount of nutrients needed by plant is not fulfilled.

If the need for nitrogen nutrients for leaf growth and chlorophyll formation in seedlings is sufficient, it will produce hifh levels of leaf chlorophyll as well. This is

accordance with the research of Albari et al., (2018) that nitrogen nutrients affect the formation of protein, chlorophyll and leaves. So with high chlorophyll levels can produce more biomass which is then allocated to the growth of plant height and plant dry weigt. Mohidin et al., (2015) argue that the application of N fertilizer can increase plant heigt, stem diameter and number of leaves of oil palm.

Tabel 2. Response of Application Time Treatment to Physiological Traits and Growth of Oil Palm Seedling in Pre Nursery

Observation Prameters	Application Time		
	9:00	12:00	15:00
Morning stomatal count (unit/mm2)	62,54 pq ± 3.41	61,43 q ± 0,81	63,76 p ± 3,52
Morning stomatal opening width (µm)	61,94 p ± 5,93	59,38 p ± 3,53	63,25 p ± 7,75
Number of stomata during the day (unit/mm2)	6,51 q ± 0,61	6,09 q ± 0,40	7,07 p ± 1,10
Daytime stomatal opening width µm)	59,25 p ± 5,60	59,06 p ± 4,29	61,88 p ± 5,52
Number of stomata in the afternoon (unit/mm2)	3,61 pq ± 0,66	3,15 q ± 0,97	3,92 p ± 0,56
Afternoon stomatal opening width (µm)	67,75 p ± 5,14	66,56 p ± 3,52	70,44 p ± 10,21
Seedling height (cm)	7,27 q ± 0,96	6,95 q ± 0,65	8,12 p ± 1,59
Number of leaves(helai)	26,02 pq ± 4.09	25,51 q ± 2,64	28,10 p ± 3,04
Rod diameter (mm)	3,50 p ± 0,63	3,44 p ± 0,51	3,69 p ± 0,60
Crown dry weighy (g)	7,58 p ± 0,90	7,28 p ± 0,96	7,93 p ± 1,93
Root dry weight (g)	0,56 q ± 0,19	0,52 q ± 0,08	0,74 p ± 0,21
Morning stomatal count (unit/mm2)	0,22 p ± 0,07	0,21 p ± 0,05	0,26 p ± 0,10

Description : Number followed by the same letter in the same row no significant difference
Source : Primary data 2024

Fertilizer application at 15:00 in the afternoon showed the best effect in all parameters (Tabel 2). This happens because the stomata open the widest in the afternoon so that more nutrients are absorbed. The results of the study are in accordance with the opinion of Yono et al., (2019) that the width of the stomatal opening of oil palm plants in the afternoon shows the best stomatal opening compared to the afternoon and morning. According (Meirina et al., (2009) fertilization in the morning and afternoon showed the best results than fertilization in te afternoon. However, between the two, the afternoon fertilization gave good results overall.

Table 3. Treatment of Dosage of Liquid NPK Fertilizer and Application Time on Physiological Traits and of Soil Plam Seedlings in Pre Nursery

NPK dosage (ml)	Application Time (Hours)			
	9:00	12:00	15:00	Rerata
Control	100,96 d	120,42 bcd	114,04 cd	111,81
75 ml	154,64 ab	133,41 abcd	144,95 abc	144,33
100 ml	139,30 abcd	134,06 abcd	162,11 a	145,16
125 ml	116,66 bcd	135,49 abcd	171,71 a	141,29
Average	127,89	137,86	141,19	(+)

Description : Number followed by the same letter in the same row no significant difference
Source : Primary data 2024

There is a real interaction between the dose of liquid NPK fertilizer and application time on the leaf area of oil palm seedlings in the pre-nursery (Tabel 3). This means that the leaf area of seedlings is influenced by the combination of liquid NPK fertilizer dosage and application time used and both influence each other. The combination of 125 ml dose of liquid NPK fertilizer applied at 15:00 in the afternoon produced the largest leaf area of 171 cm^2 compared to the other treatments. This is because in this treatmen the seedlings palm oil containts nitrogen nutrients in plants that play a role in

expanding the leaf area so as to increase photosynthesis. This is in line with the research of Albari et al., 2018) that sufficient ntogen nutrients can be utilized by plant for vegetative development such as the formation of protein, chlorophyll an leaves.

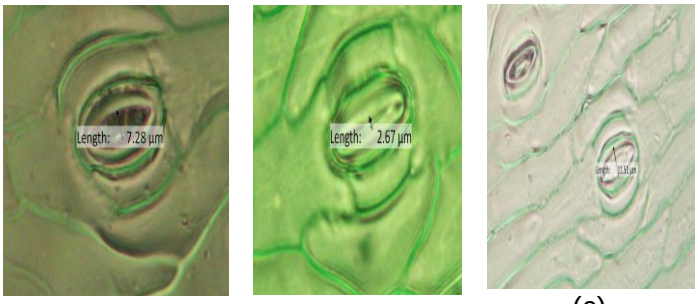
Tabel 4. Analysis of N, P and K Levels in Plants

NPK fertilizer dosage	Application Time	NPK Nutrients Content Analysis		
		N (%)	P_2O_5	Kadar K (ppm)
Control	Morning	2,11	0,3340	61,30
	Afternoon	1,87	0,2999	56,64
	Evening	2,6	0,3474	63,59
75 ml liquid NPK fertilizer dosage	Morning	2,82	0,3623	79,94
	Afternoon	2,65	0,3602	65,14
	Evening	2,6	0,3821	63,42
100 ml liquid NPK fertilizer dosage	Morning	2,96	0,4183	76,15
	Afternoon	2,13	0,3581	34,78
	Evening	2,96	0,6462	132,04
125 ml liquid NPK fertilizer dosage	Morning	2,82	0,5438	98,44
	Afternoon	2,77	0,3894	60,05
	Evening	3,18	0,3996	112,95

Source : Primary data 2024

The highest nitrogen nutrient content was found in the 125 ml dose of liquid NPK fertilizer treatment and application time at 15:00 at 3,18% and the highest P_2O_5 and K_2O nutrient content was found in the 100 ml dose of liquid NPK fertilizer treatment and application time at 15:00 at 0,6462 and 132.04 ppm respectively (Tabel 4). These results show the importance of choosing the rigt dose according to the nutritional needs of plant so that fertilization can increase the parameters observed by Krysztoforski, (2018) and also the right application time to maximize fertilizer efficiency. Application of the right dose of fertilizer in the afternoon, when the stomata open wider, allows nutrients to be absorbed and utilized by plants.

Stomata opened the widest in the evening reaching 11,51µm and followed by the morning stomatal opening width of 7,28 µm while the afternoon showed the smallest stomatal opening width of only 2,67µm (Figure 1).



(a) (b) (c)

Figure 1: *Stomatal opening width (µm) (a) morning, (b) afternoon and (c) evening*

During the day the stomat partially close to avoid excessive evaporation because in conditions of water shortage, ABA will reach a consentrastion high enough to cause the release of ions and inhibition of glucose uptake by stomata during the day soo as to reduce the width of the stomatal opening (Daszkowska-Golec and Szarejko, 2013). The results are in accordance with the opinion of Salisbury & Ross, (2003) that stomatal opening is updated by time. In the morning the uptake of K^+ and H_2O ions is more than at nigjt. Thus, in the morning the stomata open and at night the stomata close.

Tabel 4. Analisis Korelasi Pengaruh Kandungan Unsur Hara Kalium Terhadap Lebar Bukaan Stomata Pagi, Siang dan Sore Hari

Correlations

		Unsur_Hara_Kalium	Lebar_Bukaan_Stomata_Pagi
Unsur_Hara_Kalium	Pearson Correlation	1	.708*
	Sig. (2-tailed)		0.010
Lebar_Bukaan_Stomata_Pagi	Pearson Correlation	.708*	1
	Sig. (2-tailed)	0.010	
Unsur_Hara_Kalium	Pearson Correlation	1	.583*
	Sig. (2-tailed)		0.047
Lebar_Bukaan_Stomata_Siang	Pearson Correlation	.583*	1
	Sig. (2-tailed)	0.047	
Unsur_Hara_Kalium	Pearson Correlation	1	.675*
	Sig. (2-tailed)		0.016
Lebar_Bukaan_Stomata_Sore	Pearson Correlation	.675*	1
	Sig. (2-tailed)	0.016	

*. Correlation is significant at the 0.05 level (2-tailed).

The content of potassium nutrients is positively correlated with the width of stomatal openings in the morning, afternoon and evening, which means that the content of potassium nutriens is closely related to the width of stomatal openings (Table 5). The results of this study are in accordance with te opinion Corley & Tinker, (2015) that potassium deficiency can increase stomatal resistance in oil palm seedlings. Conversely, if potassium nutriens are available, the stomata will open optimally. This is accordance with the results of the analysis of potassium levels in the evening application higher than the morning and afternoon applications. Jezek & Blatt, (2017) also argue that potassium nutrients in the form of K^+ ions are the main factor in stomatal opening.

Conclusion and Recomendasion

Based on the results of the analysis of the dose of liquid NPK fertilizer and the time of application on the physiological characteristic and growth of oil palm seedlings in the pre nursery, it was concluded that there was a significant interaction between the treatment of liquid NPK fertilizer at a dose of 125 ml/plant and application time at 15:00 in the evening on leaf area parameters of oil palm seedlings in the pre nursery. The application time at 15:00 also significantly affected various physiological parameters such as chlorophyll content, stomatal opening width, NPK nutrient content, and plant growth including plant height, leaf area and crown dry weight. In addition, a dose of 100 ml/plant of liquid NPK fertilizer gave the most optimal growth results, which were characterized by an increase in plant height, canopy dry weight, stomatal aperture width, and phosphorus an potassium nutrient contents.

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Novelty Statement

Liquid NPK fertilizer application in the evening is more effective than morning and afternoon

application in improving te physiological and growth of oil palm seedling in the pre nursery.

Author's Contribution

Suci Setya Ningsih: Planning the research, conducting the research and writing the publication.
Sri Suryanti : Supervising the implementation of research, directing and correctin the writing for publication,
Fariha Wilisiani: Supervising the implementation of research, directing and correctin the writing for publication,

Conflict of interest

The authors have declared no conflict of interest

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