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Research Article

Growth Performance of Adaptive Oil Palm Seedlings on Marginal Soils through the Application of Cow Biourine

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Abstract

Background and Objective: Oil palm is one of the leading plantation crops compared to other plantation crops, because its processed products generate high economic value and contribute to the country's foreign exchange earnings. The purpose of this study was to produce oil palm seedlings that are adaptive to marginal growing media with the addition of liquid organic fertilizer from cow biourine.

Materials and Methods: This study used a Complete Randomized Block Design (CRBD) factorially and the data were analyzed using Analysis of Variance (ANOVA), thereby obtaining the best adaptive oil palm varieties on various marginal soils as follows: (A1) Adaptive Themba varieties on sub-ultisol soil at a depth of 0-50 cm, (A2) Adaptive Icalix varieties on sub-ultisol soil at a depth of 51-100 cm, (A3) Adaptive Spring varieties on sub-ultisol soil at a depth of 101-150 cm, (A4) Adaptive Spring to Marginal Histosol Soil and (A5) Adaptive Themba to Marginal Entisol Soil. The marginal soil characteristics used in this study are less fertile soils in dryland soils for second-layer ultisols and wetland soils in histosols and entisols and Cattle Biourine. Data were analyzed by ANOVA, with significance determined at 5 and 1% levels based on F-values. **Results:** The results of the diversity analysis show that the interaction between adaptive oil palm seedling treatments and cow urine application (I) had a very significant effect on the wet weight of seedlings and root weight and a significant effect on root volume. **Conclusions:** It is recommended that adaptive varieties be used through interaction between themba varieties in entisol growing media with 40% cow biourine concentration treatment (A5B2), which gives a positive response to plant growth.

Key words: Oil palm seedlings, marginal soil, cow biourine, growth performance, organic fertilizer, nursery technology

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is the most commonly cultivated plantation crop, especially in smallholder plantations. The flagship commodity of plantation crops with high economic value is oil palm, in the form of *crude palm oil* (CPO) and *palm kernel oil* (PKO), which are the main oils compared to other plantation crops. According to Limaho *et al.*¹, in 2020, palm oil contributed 15 billion USD in foreign exchange, while in 2021 it increased to 40 billion USD, making Indonesia the world's largest CPO producer. One of the initial activities in oil palm cultivation is palm germination to produce quality oil palm seedlings, as good seedling conditions will affect oil palm production when the plants reach maturity.

The problem encountered during palm germination lies in the planting medium, given that the availability of soil as a planting medium has been decreasing year by year, especially fertile topsoil and ultisol and oxisol topsoil, which have been widely used by palm oil farmers. The solution to overcome this problem is to use marginal soils such as entisols, histosols, second-layer ultisols, oxisols and other marginal soils as a growing medium for oil palm seedlings. For this reason, in addition to the use of growing media, there needs to be support for the use of adaptive superior varieties that are resistant to stress conditions in marginal soils. Adaptive oil palm seedlings are superior seedlings resulting from DxP variety crossbreeding that have the genetic ability to grow and develop even when planted in less than ideal or critical soil conditions, such as unsupportive soil structure, nutrient-poor soil and acidic soil. According to Mejia-Alvarado *et al.*², adaptive cultivars are cultivars that have characteristics that distinguish them from other oil palm cultivars in their ability to modulate their physiological and biochemical processes in response to environmental stress in order to grow and develop.

Planting media play an important role in the growth and development of palm seedlings, especially the use of marginal soil media, which have low fertility, such as low pH, low nutrient content and low cation exchange capacity. This is supported by the opinion of Maulana *et al.*³ that the planting medium is very important for root growth and development in the absorption of various nutrients for the survival of seedlings. During oil palm seedling propagation, the planting medium must have ideal chemical and physical properties in accordance with the needs of the plant. An ideal planting medium has stable aggregates, a loamy texture, good water retention capacity and an optimal number of pores. Therefore, to maximize the quality of the planting medium, organic matter needs to be added.

One alternative organic material that can be used to improve oil palm seedling growth is liquid cow urine fertilizer. Biourine has the advantage of improving the physical, chemical and biological properties of the soil, a technique for increasing soil fertility. The use of cow urine as liquid organic fertilizer must go through a fermentation process involving microorganisms to become cow biourine that is ready to be applied to the growing medium. According to Gusriyono *et al.*⁴ some of the advantages of using cow biourine are that it can improve soil structure, increase water retention and prevent the soil from hardening quickly, thereby helping to provide nutrients for plants to enhance their growth and development. Meanwhile, according to Syamsia *et al.*⁵ cow biourine contains nutrients, namely 2.7% nitrogen, 0.89% phosphorus, 1.27% potassium, 5.8% calcium, 7.2% sodium and stabilizes the pH at 7.2-8.2. Additionally, according to Anwar *et al.*⁶ fermented cow urine has several characteristics, including a more complete nutrient composition compared to unfermented cow urine. Fermented cow urine or cow biourine can be used as a nutrient source for plants.

The results of the research by Pahlawati *et al.*⁷ show that the application of cow biourine can increase the availability of Ammonium Nitrogen (N-NH₄⁺) up to a concentration of 2% cow biourine in ultisol soil. Meanwhile, the results of research by Nurhayat *et al.*⁸ show that the application of biourine fertilizer has a significant effect on the observed variables of soil organic carbon, total phosphorus, available phosphorus, plant dry weight, phosphorus uptake and number of pods in Entisol soil.

This study analyzes seedling growth and provides innovative and sustainable solutions for challenges of oil palm cultivation by optimizing the use of local resources in the form of biourine to improve the growth and adaptability of oil palm seedlings on marginal land. Meanwhile, the relevance of this study, both theoretically and in terms of application, focuses on optimizing the use of suboptimal land and the use of alternative organic fertilizers.

MATERIALS AND METHODS

Materials and time of research: This experimental research was conducted in Sukomulyo Village, Tugumulyo District, Musi Rawas Regency, at an altitude of 82.50 m above sea level (masl). The research was conducted from May 2025 to October 2025. This research uses adaptive oil palm varieties on marginal soil, the results of a selection of adaptive oil palm varieties aged 4 months at the pre-nursery stage, which are then used as further test material at the main nursery stage, thereby obtaining the best adaptive oil palm varieties on various marginal soils as follows: (A1) Adaptive Themba

Table 1: Research plan for randomized block design for the main nursery stage in the field

Number	Block 1	Block 2	Block 3
1	A3B2	A1B0	A4B0
2	A3B1	A2B0	A5B2
3	A2B1	A3B2	A1B1
4	A5B0	A1B2	A1B2
5	A4B0	A4B2	A2B2
6	A2B0	A5B2	A2B0
7	A5B2	A5B0	A2B1
8	A1B0	A4B1	A4B2
9	A3B0	A2B1	A4B1
10	A1B1	A2B2	A3B1
11	A2B2	A5B1	A1B0
12	A4B2	A1B1	A3B2
13	A5B1	A4B0	A5B0
14	A4B1	A3B1	A5B1
15	A1B2	A3B0	A3B0

A1B0: Themba variety oil palm seedlings adapted in sub-ultisol soil at a depth of 0-50 cm without the application of cow urine, A1B1: Themba variety oil palm seedlings adapted in sub-ultisol soil at a depth of 0-50 cm with the application of 20% cow biourine concentration, A1B2: Themba variety oil palm seedlings adapted in sub-ultisol soil at a depth of 0-50 cm with the application of 40% cow biourine concentration, A2B0: Icalix variety oil palm seedlings adapted in sub-ultisol soil at a depth of 51-100 cm without the application of cow urine, A2B1: Icalix variety oil palm seedlings in adapted sub-ultisol soil at a depth of 51-100 cm with the application of 20% cow biourine concentration, A2B2: Icalix variety oil palm seedlings adapted in sub-ultisol soil at a depth of 51-100 cm with the application of 40% cow biourine concentration, A3B0: Spring variety oil palm seedlings adapted in sub-ultisol soil at a depth of 101-150 cm without the application of cow urine, A3B1: Spring variety oil palm seedlings adapted in sub-ultisol soil at a depth of 101-150 cm with the application of 20% cow biourine concentration. A3B2 = spring variety oil palm seedlings adapted in sub-ultisol soil at a depth of 101-150 cm with the application of 40% cow biourine concentration, A4B0: Spring variety oil palm seedlings adapted to histosol soil without the application of cow urine, A4B1: Spring variety oil palm seedlings adapted to histosol soil with 20% concentration of cow biourine application, A4B2: Spring variety oil palm seedlings adapted to histosol soil with 40% concentration of cow biourine application, A5B0: Rhemba variety oil palm seedlings adapted to entisol soil without the application of cow urine, A5B1: Themba variety oil palm seedlings adapted to entisol soil with 20% concentration of cow biourine application. A5B2: Themba variety oil palm seedlings adapted to entisol soil with 40% concentration of cow biourine application, Block 1: Repeated treatment testing 1, Block 2 : Repeated treatment testing 2 and Block 3: Repeated treatment testing 3

varieties on sub-ultisol soil at a depth of 0-50 cm, (A2) Adaptive Icalix varieties on sub-ultisol soil at a depth of 51-100 cm, (A3) Adaptive Spring varieties on sub-ultisol soil at a depth of 101-150 cm, (A4) Adaptive Spring to Marginal Histosol Soil and (A5) Adaptive Themba to Marginal Entisol Soil. The marginal soil characteristics used in this study are less fertile soils in dryland soils for second-layer ultisols and wetland soils in histosols and entisols and Cattle Biourine.

Research methods: This study used a Completely Randomized Block Design (CRBD) factorial with two treatment factors. The treatments consisted of combinations of oil palm seedlings adapted to marginal soils with cow biourine, resulting in 15 treatment combinations. This study was conducted in the field for 6 months. Meanwhile, the cow biourine used in this study was fermented for 14 days. Cow biourine was applied to oil palm seedlings at 1-month intervals for a total of 5 times. The research design layout is shown in Table 1.

Observed parameters: The parameters observed in this study included agronomic and physiological aspects of the plants: (1) Plant height by measuring from the base of the stem to the longest leaf blade, (2) Number of leaf blades by counting all fully opened leaf blades, (3) The number of stomata was determined by taking the underside of leaves that had been treated with cuticle and attaching insulation,

then observing them using a 40x magnification microscope in the Bengkulu University laboratory, (4) Leaf chlorophyll was measured by measuring the center of a perfect leaf using a chlorophyll meter (SPAD meter) in the morning, (5) Bold diameter by measuring the palm trunk using calipers, (6) Wet plant weight by measuring all parts of the plant using digital scales, (7) Root volume by cutting the cleaned palm tree roots, then placing them in a 200 mL measuring cup containing 100 mL of water to obtain the volume increase, (8) Root length by measuring from the base of the root to the tip of the root and (9) Plant root weight by measuring all parts of the root using digital scales.

Data analysis: The research data on adaptive oil palm nursery technology on marginal soil with the application of cow biourine was analyzed using Analysis of Variance (ANOVA) to determine the effect of each treatment, tested using diversity analysis. If the F-test results showed a very significant and significant effect, then a 5 and 1% level of Significant Difference Test (SD). If the F-count value is smaller than the F table value of 5%, then the treatment is declared to have no significant effect. If the F-count value is greater than the F table value of 5% but smaller than the F table value of 1%, then the treatment is declared to have a significant effect. If the F-count value exceeds the F table value at the 1% level, the treatment is declared to have a very significant effect.

RESULTS AND DISCUSSION

The results of the analysis of the diversity of adaptive oil palm seedling growth studies on marginal soil in relation to cow biourine are shown in Table 2.

The results of the analysis of variance in Table 2 show that the adaptive oil palm seedling treatment (A) had a very significant effect on leaf chlorophyll, wet weight of litter, root volume and root weight and a significant effect on the number of leaves and stem diameter. The cow biourine treatment (B) had a significant effect on the number of leaves and root weight. Meanwhile, the interaction between the adaptive oil palm seedling treatment and the application of cow biourine (I) had a very significant effect on wet weight of the canopy and root weight, as well as a significant effect on root volume.

Results of the 5 and 1% significant difference test for adaptive oil palm varieties on marginal soil (A): Based on the SD test at the 1% level, with $p\text{-value} < 0.01$ in Table 3. it is known that treatment A5 is significantly different from several treatments in terms of leaf chlorophyll, wet weight of brushwood, root volume and root weight. Meanwhile, based on the 5% SD test, with $p\text{-value} < 0.05$, treatment A5 was significantly different from treatments A1, A2 and A3 but not significantly different from treatment A4 in terms of leaf number and stem diameter.

Results of the 5% significant difference test for cow biourine application (B): Based on the 5% Significant Difference Test, with $p\text{-value} < 0.05$ in Table 4 it was found that treatment B1 was significantly different from treatment B0 but not significantly different from treatment B2 in terms of the number of leaves and root weight parameters.

Results of the 5 and 1% honest significant difference test for the interaction between adaptive oil palm varieties on marginal soil (a) with cattle biourine application (B): Based on the 1% level SD test, with $p\text{-value} < 0.01$ in Table 5 it is known that the A5B2 interaction treatment is significantly different in all treatments for the parameters of wet weight of the trunk and root weight. Meanwhile, the 5% level SD test shows that, with $p\text{-value} < 0.05$ the A5B2 treatment is significantly different in all treatments for the root volume parameter.

Number of stomata (mm^2): The results of the data in Fig. 1 below show that the treatment of adaptive oil palm seedlings with cow biourine treatment A1B2 has the highest number of stomata at 24 mm^2 and A5B2 has the lowest number of stomata at 13 mm^2 .

The main-nursery phase of the study, consisting of 45 experimental units, can be seen in Fig. 2.

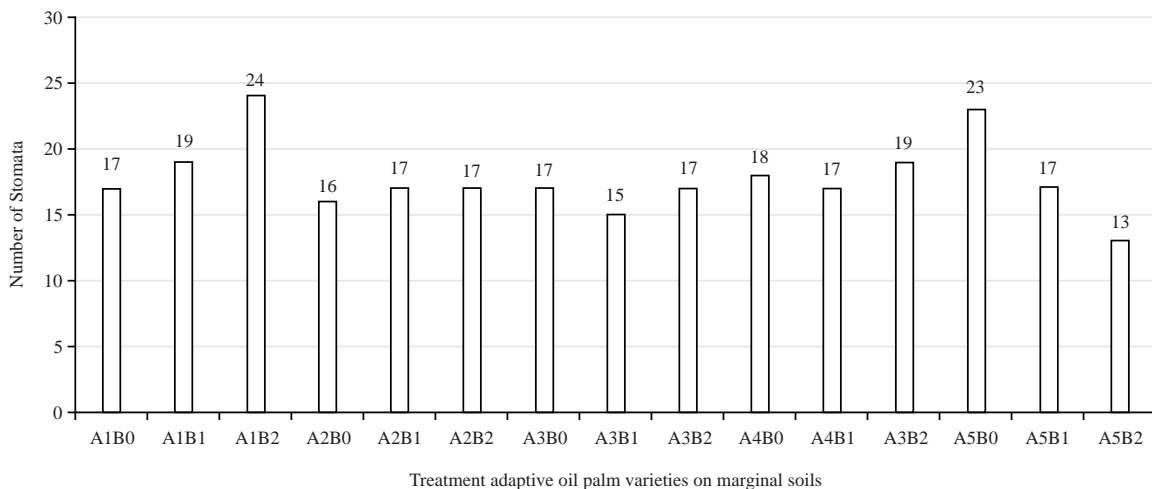


Fig. 1: Diagram of stomata growth rate in main nursery

A1B0: Themba variety oil palm seedlings adapted in sub-ultisol soil at a depth of 0-50 cm without the application of cow urine, A1B1: Themba variety oil palm seedlings adapted in sub-ultisol soil at a depth of 0-50 cm with the application of 20% cow biourine concentration, A1B2: Themba variety oil palm seedlings adapted in sub-ultisol soil at a depth of 0-50 cm with the application of 40% cow biourine concentration, A2B0: Icalix variety oil palm seedlings adapted in sub-ultisol soil at a depth of 51-100 cm without the application of cow urine, A2B1: Icalix variety oil palm seedlings in adapted sub-ultisol soil at a depth of 51-100 cm with the application of 20% cow biourine concentration, A2B2: Icalix variety oil palm seedlings adapted in sub-ultisol soil at a depth of 51-100 cm with the application of 40% cow biourine concentration, A3B0: Spring variety oil palm seedlings adapted in sub-ultisol soil at a depth of 101-150 cm without the application of cow urine, A3B1: Spring variety oil palm seedlings adapted in sub-ultisol soil at a depth of 101-150 cm with the application of 20% cow biourine concentration, A3B2: Spring variety oil palm seedlings adapted in sub-ultisol soil at a depth of 101-150 cm with the application of 40% cow biourine concentration, A4B0: Spring variety oil palm seedlings adapted to histosol soil without the application of cow urine, A4B1: Spring variety oil palm seedlings adapted to histosol soil with 20% concentration of cow biourine application, A4B2: Spring variety oil palm seedlings adapted to histosol soil with 40% concentration of cow biourine application, A5B0: Themba variety oil palm seedlings adapted to entisol soil without the application of cow urine, A5B1: Themba variety oil palm seedlings adapted to entisol soil with 20% concentration of cow biourine application, A5B2: Themba variety oil palm seedlings adapted to entisol soil with 40% concentration of cow biourine application



Fig. 2: Six-month-old oil palm seedlings at the main-nursery stage

Table 2: Results of the analysis of the diversity of adaptive oil palm seedling growth studies in relation to cattle biourine

No	Parameters observed	F-Count			CoV (%)	F-Table		
		A	B	I		A	B	I
1	Plant height	0.55 ^{ns}	1.32 ^{ns}	1.42 ^{ns}	6.32	2.71	2.34	2.29
2	Number of leaves	3.31*	3.18*	0.95 ^{ns}	6.46	2.71	2.34	2.29
3	Leaf chlorophyll	4.39**	1.56 ^{ns}	0.87 ^{ns}	6.76	4.07	2.34	2.29
4	Stem diameter	3.98*	1.26 ^{ns}	1.96 ^{ns}	10.14	2.71	2.34	2.29
5	Wet weight of the stalks	16.36**	0.86 ^{ns}	9.03**	15.90	4.07	2.34	3.23
6	Root volume	4.59**	1.86 ^{ns}	2.79*	29.70	4.07	2.34	2.29
7	Root length	2.27 ^{ns}	0.06 ^{ns}	1.54 ^{ns}	21.52	2.71	2.34	2.29
8	Root weight	10.96**	2.77*	5.17*	21.47	4.07	2.34	3.23

A: Adaptive oil palm seedling treatment, B: Cattle biourine treatment, I: Interaction of adaptive oil palm seedlings with cattle biourine, **:Very significant effect, *: Significant effect, ns: No significant effect and CoV: Coefficient of diversity

Table 3: Summary of the significant difference test for adaptive oil palm varieties on marginal soil (A)

Adaptive oil palm varieties factor (A)	Leaf chlorophyll (SPAD unit)	Wet weight of the stalks (g)	Root volume (mL)	Root weight (g)	Number of leaves (strands)	Stem diameter (cm)	Score
A1	68.03 ^{AB}	142.29 ^C	51.11 ^{AB}	28.53 ^{AB}	10.39 ^a	36.39 ^{ab}	12
A2	66.75 ^A	105.55 ^B	47.22 ^A	24.11 ^A	9.89 ^a	34.33 ^a	7
A3	65.65 ^A	80.62 ^A	35.00 ^A	21.62 ^A	10.39 ^a	33.33 ^a	6
A4	71.89 ^B	116.86 ^B	50.00 ^A	29.98 ^B	10.45 ^b	37.72 ^b	11
A5	63.33 ^A	136.98 ^C	64.45 ^B	39.30 ^C	11.00 ^b	39.33 ^b	13

Numbers followed by the same letter in the same column are not significantly different at the 5 and 1% test levels

Table 4: Summary of the significant difference test for the application of cow biourine (B)

Cow biourine factor (B)	Number of leaves (strands)	Root weight (g)	Score
B0	10.07 ^a	25.87 ^a	2
B1	10.63 ^b	29.14 ^{ab}	4
B2	10.57 ^{ab}	31.12 ^b	4

Numbers followed by the same letter in the same column are not significantly different at the 5% test levels

Table 5: Summary of the significant difference test for the ab interaction factor

Adaptive variety factor with cow biourine (AB)	Wet weight of the stalks (g)	Root weight (g)	Root volume (mL)	Score
A1B0	168.67 ^D	37.77 ^C	60.00 ^c	10
A1B1	147.57 ^D	26.50 ^B	53.33 ^{bc}	9
A1B2	110.63 ^{BC}	21.33 ^B	40.00 ^b	7
A2B0	82.77 ^{AB}	12.80 ^A	41.67 ^b	5
A2B1	128.67 ^C	32.07 ^C	60.00 ^c	9
A2B2	105.20 ^B	27.47 ^{BC}	40.00 ^b	7
A3B0	73.17 ^A	14.90 ^{AB}	25.00 ^a	4
A3B1	103.20 ^B	25.57 ^B	35.00 ^a	5
A3B2	65.50 ^A	24.40 ^B	45.00 ^b	5
A4B0	105.80 ^B	31.20 ^C	50.00 ^b	7
A4B1	103.10 ^B	22.97 ^B	40.00 ^b	6
A4B2	141.67 ^C	35.77 ^C	60.00 ^c	9
A5B0	132.63 ^C	32.70 ^C	46.67 ^b	8
A5B1	94.87 ^B	38.57 ^{CD}	56.67 ^c	9
A5B2	183.43 ^E	46.63 ^D	90.00 ^d	13

Numbers followed by the same letter in the same column are not significantly different at the 5 and 1% test levels

DISCUSSION

The results of the diversity analysis show that the treatment of adaptive oil palm seedlings on marginal soil (A) had a very significant effect on the parameters of leaf chlorophyll, wet weight of branches, root volume, root weight and a significant effect on the parameters of number of leaves and stem diameter. This is due to the interaction between oil palm seedling varieties and growing media. Furthermore, genetic factors are more dominant in supporting plant growth; these factors are absolute and have existed since the formation of the embryo in the seed. Testing combinations of varieties and growing media to determine the extent of plant resistance and adaptation to less than ideal soil conditions results in a variety of traits in each plant that are more adaptive to less supportive growing media conditions, such as limited nutrients, moisture and soil aeration.

The availability of quality oil palm seedlings requires the support of a good growing medium that is able to provide water and nutrients to support plant growth and development. The use of poor growing media affects the use of superior varieties, which also influences plant growth and development. Each variety has different genetic advantages, resulting in different characteristics. According to Melati *et al.*⁹ a good growing medium must have a composition that can provide nutrients and support optimal seedling growth. The design of the growing medium can include various materials such as soil, cow manure, or other materials that can provide organic matter to the soil. Adaptive varieties test marginal environmental conditions for the ability to respond morphologically and physiologically compared to non-adaptive varieties. This is supported by Renzi *et al.*¹⁰ through testing obtained evolutionary adaptation patterns.

Based on the results of the SD test at 5%, with p-value<0.05 and 1% levels, with p-value<0.01 and the A5 tabulation data (adaptive themba variety on entisol growing media), the best response was observed for the parameters of leaf chlorophyll, wet weight of seedlings, root volume, root weight, number of leaves and stem diameter. This suggests that themba oil palm seedlings are more tolerant to entisol soil, resulting in better growth compared to other growing media conditions. Similarly, various other varieties with different genetic characteristics show tolerance to different growing media. Oil palms can grow in various types of soil, such as histosol andisol, entisol, inceptisol and ultisol^{11,12}.

The results of the diversity analysis show that the application of cow biourine (B) has a significant effect on the parameters of leaf number and root weight. The carbon content in biourine plays a role in helping oil palm seedling growth. Organic carbon in the form of organic compounds such as amino acids, peptides and carbohydrates helps provide additional nutrients in the soil for oil palm seedlings. In addition, organic carbon acts as a soil conditioner, thereby increasing soil fertility, as the available organic matter is decomposed by soil microorganisms, producing compounds that are more easily absorbed by plant roots.

Based on the results of the SD test at a level of 5%, with p-value<0.05 on the concentration of 20% cow biourine (B1), the best response was observed in terms of the number of leaves and root weight. This is because the concentration of 20% cow biourine (10 mL of cow biourine +40 mL of water) administered twice a month was able to optimally influence the growth characteristics of oil palm seedlings. The results of cow biourine analysis at the Bengkulu University Soil Science Laboratory showed the following content values: Organic C: 1.36%; N: 0.98%; P: 0.79%; and K: 1.47%. The nitrogen, phosphorus and potassium contained in cow biourine each have their own roles.

The Nitrogen, Phosphorus and Potassium content in cow biourine each has their own role. Nitrogen compounds play a role in helping to form chlorophyll, enhancing the photosynthesis process and helping to accelerate seedling growth. According to Safitri *et al.*¹³ the concentration of chlorophyll in leaves has a direct influence on photosynthetic efficiency. An increase in chlorophyll levels will contribute to the optimisation of photosynthetic reactions. The Phosphorus compound content plays a role during the growth period of oil palm seedlings by helping to form a strong root system, especially primary and secondary roots and assisting in the formation of meristem tissue. Potassium compounds in cow biourine play a role in maintaining water balance, nutrients and enzyme activity in plants. Potassium is also able to increase the resistance of seedlings to environmental stress such as drought and pathogen attacks, especially in marginal soils.

In addition, cow biourine also contains hormone compounds such as auxin and gibberellin, which can also help increase plant growth. This is supported by the opinion of Aryadika *et al.*¹⁴ the potassium content in cow urine plays an important role in the process of carbohydrate formation and transport to other parts of the plant. In addition, potassium also activates enzymes that are essential for photosynthesis reactions. Cow biourine contains natural substances in the form of hormones that promote plant growth, thereby increasing root growth in seeds or seedlings¹⁵. The organic content in cow biourine plays a role in improving the physical, chemical and biological characteristics of the soil¹⁶. This is supported by Putri *et al.*¹⁷, who states that cow urine applied to the soil as a growing medium will turn into soil fertilizer. Microorganisms in the soil and water convert the nitrogen (N) components in urine into Ammonium (NH_4^+) and then into Nitrate (NO_3^-).

The results of the diversity analysis show that the interaction of adaptive oil palm seedlings on marginal media with the application of cow biourine (I) has a very significant effect on the parameters of wet weight of the trunk, root weight and a significant effect on the parameter of root volume. This is because the interaction between various marginal soils and various palm oil varieties with cow biourine works synergistically to optimize plant metabolism and physiology. Marginal soils have limitations in providing nutrients and water, so external inputs are needed. In this case, cow biourine plays a role in increasing soil fertility and nutrients, even though the percentage is very small. In addition, the use of superior varieties that are resistant to marginal soil conditions will be more responsive to soil improvement through cow biourine, such as resistance to

environmental stress (drought and soil acidity). Superior varieties produced from crossbreeding in the form of tenera varieties have better seedling growth compared to local varieties that are less adaptive. According to Ena *et al.*¹⁸ nutrient absorption is closely related to photosynthesis, a biological process that produces photosynthates. Improved availability and efficiency of nutrient absorption in cow biourine will optimize the metabolic process, resulting in an increase in the overall quality and quantity of crops. Cow biourine organic fertilizer is one of the environmentally friendly and sustainable alternatives in crop cultivation technology¹⁹.

On marginal soils with low organic carbon, total nitrogen and available phosphorus, the use of adaptive oil palm seedlings essentially limits growth due to low nutrient content. A solution that can be implemented is to apply cow biourine to marginal soil growing media to increase organic C, mineral N and available P in Entisols, Histosols and Podzols. This increase in nutrient availability allows superior varieties to express their yield potential more optimally, as reflected in increased growth in oil palm seedling parameters. This is supported by the research results of Rahma *et al.*²⁰ which found that the application of cow biourine with incubation periods of two and four weeks had an effect on ammonium and nitrate content, as well as available P content in the soil. Furthermore, according to the results of research by Sofiana and Syaban²¹ the combination of cow biourine fertilizer and superior varieties has a significant effect on plant growth.

Based on diversity analysis, the 5% with $p\text{-value} < 0.05$ and 1% with $p\text{-value} < 0.01$ SD tests showed that the adaptive interaction treatment of the Themba variety in Entisol planting media with a 40% concentration of cow biourine (20 mL of cow biourine+30 mL of water) (A5B2) gave a positive response to the growth of wet weight, root weight and root volume. This is because cow biourine with the right concentration is thought to be able to provide nutrients and growth regulators that support root and leaf growth, especially when using superior varieties on marginal soils. In addition, the combination of stress-resistant varieties and the right dose of biourine can increase the resistance of oil palm seedlings to unfavorable environmental conditions. The use of cow urine as a biological fertilizer has the potential to reduce dependence on inorganic fertilizers. The continuous use of inorganic fertilizers can adversely affect soil quality from a biological, chemical and physical perspective. Cattle urine, rich in organic matter, contributes significantly to improving the physical, biological and chemical conditions of the soil^{22,23}. Organic fertilizers are known to improve soil fertility by

enhancing the soil's ability to retain water and improving the chemical and biological aspects of the soil²³. This is supported by the opinion of Novianto *et al.*²⁴ that to determine the fertility status of the chemical and physical properties of soil, it is necessary to conduct soil fertility index analysis tests.

The results of the observed parameter data, several parameters in this study were quantitatively above the indicator description. This indicates a positive interaction between genetics and the plant growth environment. This is supported by other study by Peng *et al.*²⁵ who states that factors originating from within the plant are referred to as genetic factors, while factors originating from outside the plant are known as environmental factors. Plants can respond positively or negatively to changes in environmental conditions. These responses cause interactions between the environment and plant genotypes and these events are often found in trials in various locations²⁶. The relevance of the study on the adaptive characteristics of oil palm varieties on marginal soils is to identify adaptive and high-yielding genotypes and formulate strategies for sustainable oil palm seedling management. Theoretically, a deep understanding of genotype-environment interactions (GxE) in marginal soil conditions enables the selection of superior varieties that are efficient in nutrient utilization and tolerant to abiotic stress. In practical application, this study supports the development of location-specific recommendations for oil palm cultivation on low-fertility soils such as ultisols, entisols, histosols, or soils with imbalanced nutrient content through the addition of organic cow urine. The application of cow biourine aims to serve as an additional fertilizer to enhance plant vigor, thereby producing high-quality seedlings in the field²⁷. The byproducts from cows are used as organic fertilizer to reduce the use of inorganic fertilizers²⁸.

The results of the diagram showing the number of oil palm seedlings stomata during the main nursery period with treatment A1B2 of 24/mm², the highest growth rate of A3B2 plants and the highest leaf growth rate of A3B0 show varied growth in each treatment. This is due to differences in genetic characteristics of varieties, soil conditions and varying application doses. In addition, climatic factors also affect oil palm seedling growth, such as temperature, humidity and rainfall, which influence the effectiveness of cow biourine in maintaining the concentration balance of cow biourine so that it is easily absorbed by plant roots. Stomata are pores located under the leaves that play an important role in water use. According to Nugroho²⁹ stomata are the site of gas exchange of O₂, CO₂ and water vapor from the plant's growing environment to the leaves. Meanwhile, according to Asati *et al.*³⁰ the rate of transpiration in plant organisms can be influenced by the plant's own internal elements, such as the

arrangement and size of the stomata. Stomatal arrangement refers to the density of stomata found in epidermal cells within a certain field of view. A low density of stomata and high epidermal cells in a field of view results in a low distribution of stomata and vice versa. Growth rate analysis covers the entire cycle from carbohydrate distribution by leaves, water and nutrient supply by roots, to the formation of new compounds in plants through various metabolic pathways. According to Gallegos-Cedillo *et al.*³¹ in a study on vegetative development of plants, scientists are able to identify the elements that inhibit the growth rate of these organisms and develop methods to optimize the utilization of the assets possessed by plants.

CONCLUSION

The recommendation for a single treatment results of diversity analysis show that adaptive oil palm seedlings on marginal soil (A) have a very significant and noticeable effect on leaf chlorophyll parameters, wet weight of litter, root volume, root weight, number of leaves and stem diameter.

The recommendation for a single treatment results from the analysis of variance showed that the application of cow biourine (B) had a significant effect on the parameters of number of leaves and root weight.

The recommended for a interaction treatment results from the analysis of variance showed that the interaction between adaptive oil palm seedling treatment and cow biourine application (I) had a very significant effect on wet weight of seedlings and root weight and a significant effect on root volume.

SIGNIFICANCE STATEMENT

The relevance of research on the single-stage characterization of various oil palm varieties on marginal soils plays a role in identifying genotypic expression as demonstrated through quantitative and qualitative characterization measurements of plant phenotypes and the addition of cow biourine fertilizer, in order to formulate sustainable oil palm seedling management strategies. Theoretically, a deep understanding of genotype-environment interactions (GxE) in marginal soil conditions enables the selection of superior varieties that are efficient in nutrient utilization and tolerant to abiotic stress. In practical application, this study supports the development of location-specific recommendations for oil palm cultivation on low-fertility soils such as ultisols, entisols, histosols, or soils with imbalanced nutrient content and low pH.

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