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Effects of Organic Fertilizer Application and Spatial Arrangement on the Growth of *Zingiber officinale* var. amarum in Oil Palm Polyculture Systems

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Abstract. Polyculture systems in oil palm (*Elaeis guineensis* Jacq.) plantations represent an integrated agricultural approach with the potential to improve land-use efficiency and the productivity of intercrops. This study aimed to analyze the effects of integrated nutrient management and plant spacing on the vegetative growth of emprit ginger (*Zingiber officinale* var. amarum) in an oil palm-based polyculture system. The study was conducted at the oil palm research plantation, Faculty of Agriculture, Sriwijaya University, Indralaya District, Ogan Ilir Regency, South Sumatra, at a position of 3 ° 13'13.1 "S 104 ° 38'28.6" E - 3 ° 13'33.8 "S 104 ° 38'08.9" E. The study used a split-plot design with three replications was employed. The main plot factor consisted of organic fertilizer types, namely P1 (chicken manure at 10 ton ha^{-1}) and P2 (compost EOPFB/TKKS at 15 ton ha^{-1}). The subplot factor consisted of plant spacing variations: SA1 (30 cm × 60 cm), SA2 (40 cm × 60 cm), and SA3 (50 cm × 60 cm). The results showed that organic fertilizer type and plant spacing significantly affected most vegetative growth parameters of emprit ginger. The application of chicken manure tended to produce optimal growth compared to compost EOPFB/TKKS. A spatial arrangement of 40 cm × 60 cm was identified as the optimal spacing arrangement for promoting growth and biomass accumulation in emprit ginger. Furthermore, the interaction between chicken manure based organic fertilizer and the 40 cm × 60 cm spacing exhibited the most favorable treatment combination, resulting in increased rhizome production and greater plant biomass accumulation.

1 Introduction

Palm oil plantations are one of Indonesia's key agricultural sectors. However, the continuous use of monoculture farming systems has led to declining soil quality and low land-use efficiency. One way to increase land productivity while maintaining the sustainability of agroecosystems is through the adoption of polyculture systems. The polyculture system allows for the use of the space between oil palm trees to grow economically valuable intercrops, such as ginger. One of the most commonly cultivated ginger varieties is ginger emprit (*Zingiber officinale* var. amarum).

Ginger emprit is a biopharmaceutical plant with high economic value that is widely used as a raw material for herbal medicines, health drinks, and spices. Ginger emprit is relatively tolerant of shaded conditions, making it a promising candidate for cultivation in oil palm plantations. This adaptability is linked to ginger's physiological characteristics, which allow it to grow even under low light conditions by utilizing light more efficiently for photosynthesis [1]. However, the polyculture of ginger in oil palm plantations faces several challenges, particularly competition between crops for nutrients, water, growing space, and light. In addition, the extensive root system of oil palms can also intensify competition for water and nutrients in the soil.

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These conditions can affect canopy growth, root development, and ginger rhizome formation if not balanced with proper cultivation management. Therefore, appropriate cultivation strategies are needed, such as adjusting planting distances, applying organic fertilizer, and managing the growing environment to reduce the level of competition between plants

One approach that can be taken is the use of organic fertilizers such as empty fruit bunches (EOPFB/TKKS) and chicken manure. Empty fruit bunches EOPFB/TKKS is a solid waste product from oil palm plantations that is rich in organic matter and has the potential to improve the physical, chemical, and biological properties of the soil [2]. Meanwhile, chicken manure contains macronutrients such as nitrogen, phosphorus, and potassium, which play a key role in supporting plant growth [3]. Previous studies have also reported that the application of chicken manure can enhance plant growth by increasing plant height, the number of leaves, and root development due to increased nutrient availability and improved growing medium conditions [4]. The application of these two organic materials is expected to increase the availability of nutrients and improve soil fertility in oil palm based on polyculture systems.

In addition to nutrient management, proper spacing is also a key factor in the cultivation of emprit ginger. Proper spacing can improve light absorption efficiency, reduce competition among plants, and optimize the use of water and nutrients. In addition, the shading conditions in oil palm plantations result in lower light intensity reaching the plants, making proper spacing crucial for maximizing light distribution and supporting the plants' photosynthesis [5]. Previous studies have shown that proper planting spacing can improve light distribution and reduce excess moisture around plants, which can trigger disease outbreaks. Therefore, three spacing levels were selected to represent different spatial arrangement and to evaluate the response of emprit ginger to varying degrees of plant competition and light availability under oil palm canopy conditions.

Although the individual effects of organic fertilizers and planting spacing have been widely reported, studies evaluating the combined application of Empty fruit bunches (EOPFB/TTKS) and chicken manure together with different planting densities for emprit ginger under oil palm polyculture systems remain limited. Therefore, this study was conducted to evaluate the effects of combined organic fertilization and spatial arrangement on the early growth of *Zingiber officinale* var. amarum in an oil palm polyculture system.

2 Materials and Methods

2.1.1 Research site

The study was conducted at the Research Field of the Faculty of Agriculture, Sriwijaya University (3°14'02"S 104°38'12" E) from October 2025 to January 2026. The research site is a tropical lowland.

2.1.2. Research Procedures and Data Collection

The study was conducted on a 20-year-old Dura oil palm plantation with a planting spacing of 8 m × 8 m and an inter-row spacing of 7.62 m. The experimental plot was prepared by creating raised beds measuring 4 m × 2 m, with a spacing of 60 cm between treatments. The planting material used in the study was emprit ginger rhizomes *(Zingiber officinale var. amarum)* Halina variety. The ginger rhizomes were obtained from the "Berkah Alam Biofarmaka Seed Breeders' Farmers' Group" in Nagrak Subdistrict, Sukabumi Regency, West Java. The planting material consisted of healthy emprit ginger rhizome seed pieces with an average weight of 20 g and a diameter of approximately 2–3 cm. Each seed piece contained 2 viable buds. Before planting, the rhizome seed pieces were air-dried for 24 h and treated with a fungicide Antrazeb 85 WP.

Fertilizer application consists of organic and inorganic fertilizers. Organic fertilizers are applied 1 week before planting, specifically 10 tons^{-1} ha of chicken manure and 15 tons^{-1} ha of empty oil palm fruit bunches (EOPFB/TKKS). Fertilizer doses are adjusted according to the treatment per plot. Inorganic fertilizer, specifically NPK fertilizer, is used as the second basal application at a dose of 7.5 g^{-1} plant and is applied when the ginger is 4 weeks old. Planting is carried out using planting distances according to the treatment, namely: 30 cm x 60 cm, 40 cm x 60 cm, and 50 cm x 60 cm.

The variables observed weekly were: plant height (cm), measured from the base of the main stem to the highest point on the leaf using a ruler; number of shoots; number of leaves; and SPAD values, measured using a Konica Minolta SPAD-502 Plus. Next, the variables observed destructively when the plants were 5 months old after planting were the morphological characteristics of the plants, starting from the leaves, stems, rhizomes, and roots (shoot number, rhizome number, rhizome diameter (mm) was measured using a Vernier caliper, stem length (cm), and root length (cm)). Stomatal count (units) was performed by selecting a leaf for observation and applying nail polish to the underside of the leaf within an area of approximately 2 cm × 2 cm. The nail polish was allowed to dry, after which a transparent adhesive was applied to the treated leaf surface, pressing firmly to ensure the nail polish adhered completely. After that, the film was immediately peeled off the leaf and attached to a microscope slide, then observed under a microscope using 4x, 10x, and 40x objective lenses. The slide was then photographed, and the number of stomata in the field of view was counted and recorded. The stomatal density (SD) was calculated as the number per unit leaf area and determined based on the formulas below [6].

$$\text{Stomatal Density} = \frac{\text{Number of Stomata}}{\text{Unit Leaf Area}}$$

The plant biomass parameters observed were the fresh weight and dry weight of plant organs, consisting of leaves, stems, and rhizomes. Measurements were taken by first weighing the wet weight the plants were then dried in an oven at 60°C for 48 hours and subsequently weighed using an analytical balance. The environmental parameter measured was light intensity.

2.1.3. Research Design and Statistical Analysis

This study was conducted using a split-plot design with main plots and subplots, and three replications. The main plots for organic fertilizer types (P) were: P1 = Chicken Manure = 10 tons/ha (8 kg/plot), P2 = Empty fruit bunches Fertilizer (EOPFB/TKKS) = 15 tons/ha (12 kg/plot), Subplots (Sub Plot) for planting distance (J) were as follows: SA1 = 30 cm x 60 cm, SA2 = 40 cm x 60 cm, SA3 = 50 cm x 60 cm. All collected data were analyzed using analysis of variance (ANOVA), and the significance levels between treatments were tested using the least significant difference (LSD) at P < 0.05. Several parameters were investigated using simple regression to determine the relationships. All analyses were performed using R Studio (v2023.06.0+421) for Windows 10. All data obtained were visualized in tables and figures.

3 Result and Discussion

The application of chicken manure organic fertilizer promoted faster ginger plant height growth compared to EOPFB/TKKS organic fertilizer. Plant spacing had a positive effect on ginger plant height. A planting spacing of 40 cm × 60 cm is the optimal spacing for supporting plant height growth. The application of organic fertilizer had a significant effect on plant height growth starting at 5 MST, while planting spacing had a significant effect starting at 1 MST (Figure 1).

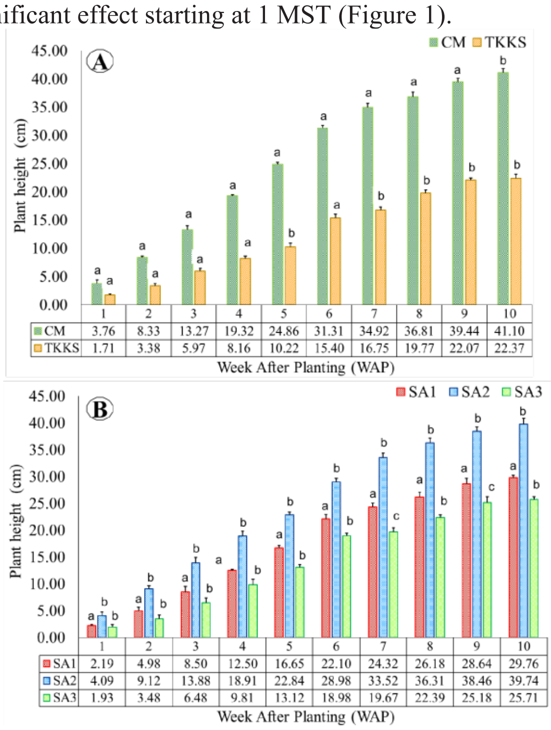

Fig.1. The effect of fertilizer and spatial arrangement on plant height. Means followed by the same letters within columns are not significantly different, whereas means followed by different letters within columns are significantly different based on the LSD test at p ≤ 0.05.

Organic chicken manure fertilizer has a higher nutrient content and makes nutrients more readily available to plants, particularly nitrogen, which plays a key role in the formation of vegetative tissues such as stem elongation. In addition, the relatively low C/N ratio of chicken manure accelerates the mineralization process, allowing nutrients to be readily absorbed by plants during the early growth phase [7]. Conversely, EOPFB/TKKS organic fertilizer has a high lignocellulose content, so its decomposition process proceeds more slowly and nutrient release becomes less optimal for supporting the early vegetative growth of ginger plants. In a ginger-oil palm polyculture system, the shaded environmental conditions result in lower light availability, so the plants require optimal nutritional support to ensure that photosynthesis and vegetative growth continue to proceed well. Therefore, the application of chicken manure is more effective in enhancing the height growth of ginger plants under oil palm canopies.

A planting spacing of 40 cm × 60 cm is the best spacing for promoting plant height growth because it creates a balance between plant population and available growing space. Optimal planting spacing allows plants to access light, water, nutrients, and root space more efficiently, thereby reducing competition among plants. These conditions support increased photosynthetic activity and the accumulation of photosynthates used for plant vegetative growth. Conversely, overly dense planting distances can increase competition among plants for growth factors, particularly in oil palm polyculture systems that already have relatively high shading levels.

Vegetative growth, particularly of the leaves, was faster following the application of chicken manure organic fertilizer compared to EOPFB/TKKS. The application of chicken manure organic fertilizer (CM) resulted in a higher number of leaves compared to EOPFB/TKKS organic fertilizer. The application of organic fertilizer and planting spacing had a significant effect starting from 2 MST. Planting spacing influenced the number of leaves on the ginger plants. A planting distance of 40 cm × 60 cm is the optimal distance for supporting leaf formation (Figure 2).

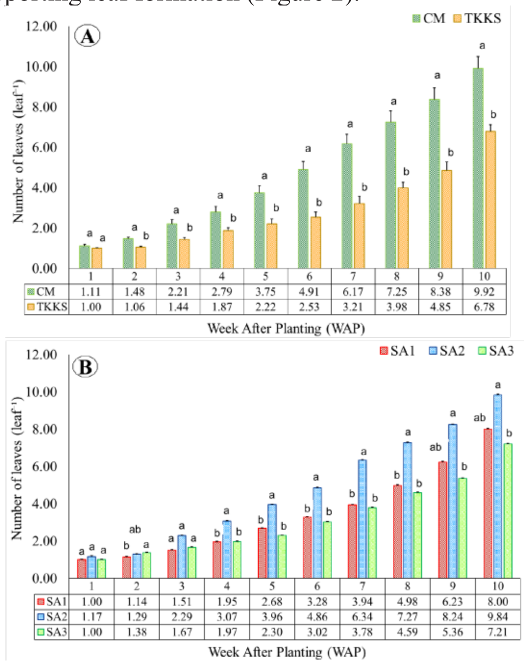

Fig.2. The effect of fertilizer and Spatial arrangement on number of leaves. Means followed by the same letters within columns are not significantly different, whereas

means followed by different letters within columns are significantly different based on the LSD test at $p \leq 0.05$.

Leaf number is an important indicator of plant vegetative growth because it is directly related to the plant's photosynthesis process. The higher increase in leaf number observed in the chicken manure treatment indicates that this nutrient source is capable of supporting leaf formation. The higher availability of nitrogen in chicken manure fertilizer plays a role in chlorophyll formation and the development of leaf meristematic tissue, thereby accelerating the leaf formation process [8]. Additionally, sufficient nutrient availability can enhance plant metabolic activity and accelerate the formation of new leaves.

Plant spacing also plays a crucial role in ginger leaf formation. A 40 cm × 60 cm spacing yields more leaves due to a more balanced growing space between plants. This condition allows for more even light distribution across the plant canopy, making the photosynthesis process more efficient [9]. In oil palm polyculture systems, planting distance is a critical factor because ginger grows under shaded conditions with low light intensity.

The number of ginger shoots tended to increase gradually during the observation period. However, the application of organic fertilizer and planting density had no significant effect on ginger shoot formation. The number of ginger shoots resulting from the application of chicken manure tended to be higher than that resulting from the application of EOPFB/TKKS fertilizer (Figure 3).

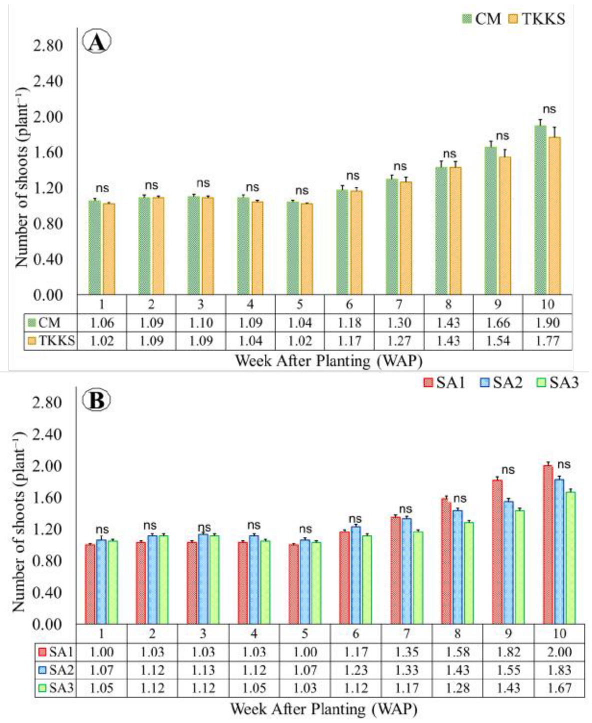

Fig.3. The effect of fertilizer and spatial arrangement on number of shoots. Means followed by "ns" within columns are not significantly different based on the LSD test at $p \leq 0.05$; ns = non-significant.

The lack of a significant effect of organic fertilizer application on the number of shoots is likely due to the fact that shoot formation in ginger plants is more influenced by genetic factors and the physiological capacity of the rhizome than by nutrient availability during the early growth phase. Additionally, the shoot formation process in ginger occurs more slowly because the plant first focuses on the growth of vegetative organs such as stems and leaves [10].

Planting density had no significant effect on the number of ginger shoots. This indicates that the level of competition among plants during the early growth phase is not yet significant in influencing the shoot formation process. Under oil palm polyculture conditions, the relatively shaded growing environment causes shoot growth to proceed more slowly.

The SPAD values of ginger plants in a polyculture system with oil palm increased gradually starting at 1 MST and reached optimal levels at 3 MST. The SPAD values of ginger leaves began to decline starting at 4 MST, which is related to the leaves' advancing age. The application of chicken manure (CM) organic fertilizer tended to produce higher SPAD values compared to EOPFB/TKKS organic fertilizer. Furthermore, planting distance showed a relatively uniform response in SPAD values (Figure 4).

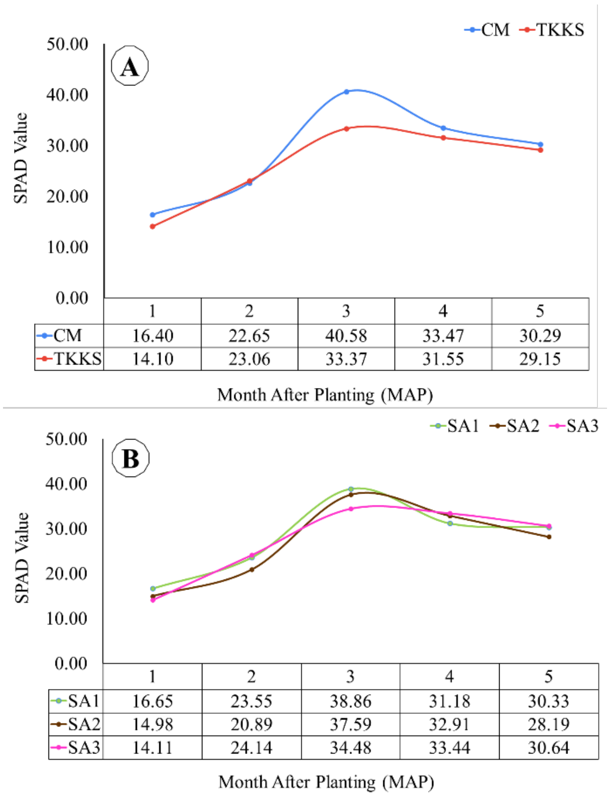

Fig.4. The effect of fertilizer and spatial arrangement on SPAD value

An increase in SPAD values generally correlates with rising leaf chlorophyll content as the plant progresses through the vegetative phase. This suggests that plants are able to adapt to the growing environment under oil palm shade by improving photosynthetic efficiency. The optimal SPAD value at 3 MST indicates that during this phase, the plant's physiological activities are at their peak, particularly in chlorophyll formation and nitrogen uptake. After the optimal phase, SPAD values tend to decline, which is likely related to leaf senescence and the shift in photosynthate allocation toward the formation and development of ginger rhizomes.

The application of organic fertilizer and planting density had no significant effect on stomatal number and stomatal density. However, the application of chicken manure organic fertilizer had a positive effect on stomatal number and stomatal density. Stomatal number and stomatal density were higher due to chicken manure organic fertilizer. Planting density had little effect on stomatal number and stomatal density (Table 1).

Table 1. The effect of fertilizer and Spatial arrangement on stomatal number and density

Treatment	Number of stomata	Stomatal density (stomata mm^{-2})
Fertilizer		
CM	12.11 a	23.33 a
TKKS	9.11 a	17.55 a
LSD	3.79	4.3
Spatial Arrangement		
SA1	10.83 a	20.87 a
SA2	10.50 a	20.23 a
SA3	10.50 a	20.23 a
LSD	1.73	2.3
Interaction of F and SA		
CM:SA1	12.00 ab	23.12 ab
CM: SA2	12.33 a	23.76 a
CM: SA3	12.01 ab	23.12 ab
TKKS: SA1	9.66 bc	18.62 bc
TKKS: SA2	8.66 c	16.69 c
TKKS:SA3	9.00 c	17.34 c
LSD	2.45	2.3

Means followed by the same letters within columns are not significantly different, whereas means followed by different letters within columns are significantly different based on the LSD test at $p \leq 0.05$. *LSD* = least significant difference.

The application of organic chicken manure tends to increase the number and density of stomata. This is thought to be related to the higher nitrogen content, which supports leaf tissue development and stomatal cell differentiation. Additionally, organic matter can improve growing medium conditions and enhance nutrient uptake by plants [11].

Meanwhile, planting density had no significant effect on the number and density of stomata because differences in planting density were not sufficient to create significant changes in the microclimate, particularly in light intensity and humidity. According to [12], stomatal development is influenced by environmental factors such as light and water conditions; thus, relatively uniform environmental conditions resulted in no significant differences in stomatal numbers across treatments.

The application of organic chicken manure fertilizer affects the number and density of stomata. Based on microscopic observations, the leaf growth of plants treated with chicken manure organic fertilizer showed a higher number of stomata and a denser stomatal arrangement compared to the other treatments (Figure 5). This is likely because chicken manure organic fertilizer improves growing medium conditions and enhances plant physiological activity, thereby optimizing stomatal formation.

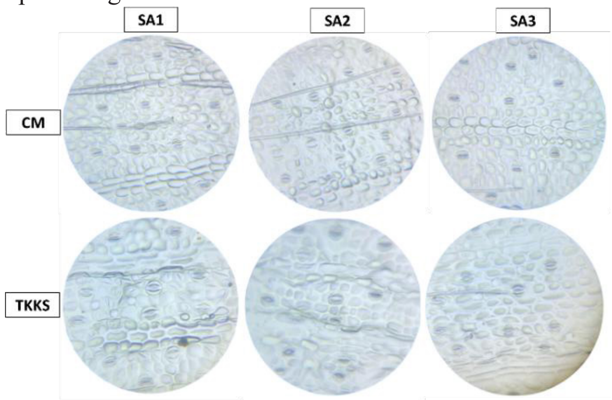

Fig. 5. Visual representation of stomatal number

There were morphological differences in ginger plants at 5 months after planting due to the application of organic fertilizer and planting spacing. The application of chicken manure organic fertilizer and a planting spacing of 40 cm × 60 cm (CM:SA2) showed the best growth compared to other treatments, characterized by better plant height, a greater number of leaves, and a longer and more developed root system (Figure 6). During the early growth phase (<5 months after planting), ginger plants generally allocate more of their photosynthetic products to vegetative growth, particularly the stems and leaves. Five months after planting, rhizome development begins to occur more actively as a food reserve storage organ, so that optimal canopy and root growth is thought to support the formation and enlargement of ginger rhizomes.

Fig. 6. Morphological apearance of ginger plants at 5 months after planting (MAP).

Optimal ginger plant growth is linked to the ability of chicken manure organic fertilizer to increase nutrient availability and improve the physical properties of the growing medium, thereby supporting root growth and more efficient nutrient uptake, which in turn supports plant growth. Furthermore, plant density and spacing influence the efficiency of nutrient utilization, which affects the plant's vegetative growth.

Ginger rhizome formation generally occurs after vegetative growth has reached its optimal stage; thus, the development of healthy leaves and a robust root system plays a crucial role in increasing photosynthetic product accumulation to support rhizome enlargement.

Fertilizer application had a significant effect on the number of ginger shoots, with chicken manure yielding a higher number of shoots compared to EOPFB/TKKS organic fertilizer. However, fertilizer treatment did not significantly affect the number of rhizomes, tuber diameter, stem length, or root length. Planting distance management only significantly affected the number of rhizomes; a 40 cm × 60 cm spacing produced more rhizomes. The interaction between fertilizer application and planting distance showed a significant effect on the number of rhizomes and tuber diameter. The combination of chicken manure organic fertilizer application and a 40 cm × 60 cm planting distance (CM:SA2) produced a greater number of rhizomes (Table 2).

The application of organic chicken manure fertilizer increased the number of ginger shoots more than EOPFB/TKKS organic fertilizer. This is thought to be because chicken manure contains macronutrients, particularly nitrogen, which are more readily available and thus support the vegetative growth of plants [13]. Additionally, the organic matter content in chicken manure enhances the activity of soil microorganisms involved in nutrient mineralization, making nutrients more readily available for plant uptake. Meanwhile, EOPFB/TKKS fertilizer has a coarser texture and high fiber content, resulting in a slower decomposition rate, which causes nutrient release to occur more gradually.

The application of organic chicken manure fertilizer influences the increase in ginger plant biomass, which includes rhizomes, stems, and leaves. Furthermore, a planting spacing of 40 cm × 60 cm resulted in higher fresh and dry biomass weights of rhizomes, stems, and leaves compared to other treatments (Table 3).

The increase in ginger plant biomass under the chicken manure organic fertilizer treatment indicates that an adequate supply of nutrients can enhance plant physiological activity, particularly in terms of tissue formation and dry matter accumulation. The improved nutrient availability from chicken manure allows the translocation of photosynthetic products to storage organs such as rhizomes to occur more optimally [14], thereby increasing plant biomass in the stems, leaves, and rhizomes.

Additionally, a planting spacing of 40 cm × 60 cm is the optimal spacing for ginger plant growth. Planting distance relates to growing space, thereby increasing the efficiency of light and nutrient utilization. An optimal planting distance also influences root system development and rhizome formation because plants have better growing space. These conditions support the formation of greater fresh and dry biomass high because the plants can grow more optimally without facing competition.

Light intensity under oil palm shade (A) is lower than in open areas (B). Under oil palm shade, daytime light intensity ranges from 10,000 to 35,000 lux, whereas in open areas it reaches 130,000 to 230,000 lux. Light intensity is highest during the day, both under shade and in open areas. This indicates that shade reduces the distribution of direct sunlight, thereby creating a microenvironment with lower light intensity compared to open areas (Figure 7).

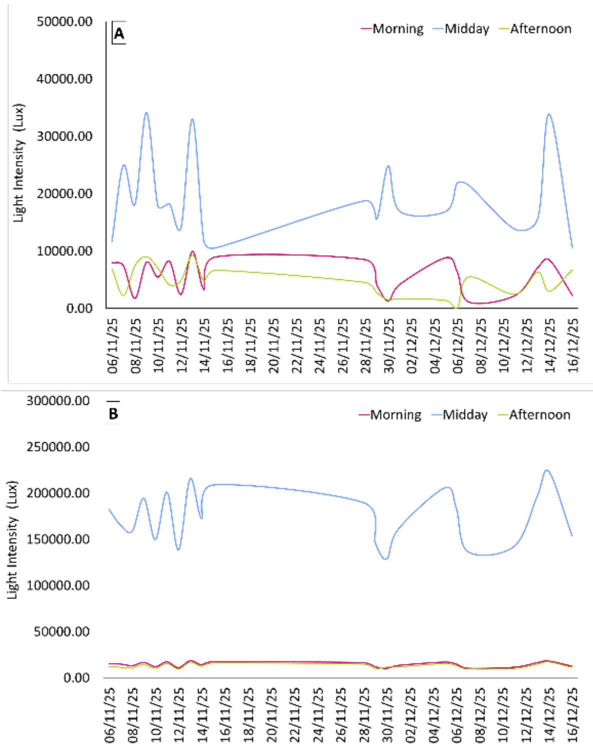

Fig. 7. Light Intensity Under Shaded Conditions in an Oil Palm Polyculture System (A) and Outside Shaded Conditions (B)

Light intensity is a key factor in supporting ginger growth in polyculture systems because the plant requires light for photosynthesis. Ginger is a moderately shade-tolerant plant, so its growth can still proceed optimally under low to moderate light intensities, particularly for supporting vegetative growth and leaf development. This is evident from the vegetative growth and leaf development of emprit ginger, which remain optimal in oil palm polyculture systems. According to [15], ginger plants exhibit better growth under shaded conditions compared to full sunlight due to a more humid environment and the ability to reduce heat stress. Additionally, plants growing under shaded conditions generally adapt by increasing photosynthetic efficiency and chlorophyll content to maximize light absorption.

Table.2 Growth and Morphological of Ginger Plants

Treatment	Shoot number	Rhizome number	Rhizome diameter (mm)	Stem length (cm)	Root length (cm)
Fertilizer					
CM	2.36 a	3.21 a	15.40 a	22.00 a	17.32 a
TKKS	1.59 b	2.37 a	12.58 a	17.72 a	13.50 a
LSD	0.55	1.07	3.12	4.98	9.59
Spatial Arrangement					
SA1	2.00 a	2.67 b	13.98 a	18.62 a	15.82 a
SA2	2.33 a	3.36 a	14.19 a	21.12 a	16.23 a
SA3	1.60 a	2.33 b	13.79 a	19.83 a	14.17 a
LSD	0.91	0.68	1.29	4.78	4.66
Interaction of F and SA					
CM:SA1	2.20 ab	2.90 b	16.23 a	21.00 ab	18.49 ab
CM: SA2	3.22 a	4.28 a	14.97 ab	23.91 a	19.85 a
CM: SA3	1.66 b	2.44 b	14.98 ab	21.09 ab	13.63 ab
TKKS: SA1	1.78 b	2.44 b	11.73 c	16.25 b	13.15 b
TKKS: SA2	1.44 b	2.44 b	13.41 bc	18.33 ab	12.62 b
TKKS:SA3	1.55 b	2.23 b	12.59 c	18.58 ab	14.72 ab
LSD	1.29	0.96	1.82	6.76	6.59

Note: Means followed by the same letters within columns are not significantly different, whereas means followed by different letters within columns are significantly different based on the LSD test at $p \leq 0.05$. *LSD* = least significant difference.

Table.3 Biomass Characteristics of Ginger Plants

Treatmen	Fresh rhizome weight (g)	Dry rhizome weight (g)	Fresh stem weight (g)	Dry stem weight (g)	Leave fresh weight	Leave dry weight
Fertilizer						
CM	4.75 a	0.39 a	2.10 a	0.19 a	2.77 a	0.32 a
TTKS	3.28 b	0.30 a	1.67 a	0.18 a	1.76 a	0.35 a
LSD	1.04	0.25	0.51	0.12	1.76	0.18
Spatial Arrangement						
SA1	4.16 a	0.38 a	1.89 ab	0.19 a	1.80 b	0.34 ab
SA2	4.20 a	0.36 a	2.36 a	0.20 a	2.99 a	0.40 a
SA3	3.70 a	0.29 a	1.39 b	0.16 a	2.01 ab	0.26 b
LSD	0.68	0.08	0.65	0.06	1.03	0.12
Interaction of F and SA						
CM:SA1	4.97 a	0.43 a	2.10 ab	0.23 a	1.87 b	0.36 ab
CM: SA2	4.88 a	0.44 a	2.96 a	0.21 a	3.93 a	0.40 a
CM: SA3	4.42 ab	0.30 b	1.23 b	0.14 a	2.52 ab	0.19 b
TTKS: SA1	3.35 c	0.33 ab	1.69 b	0.16 a	1.73 b	0.31 ab
TTKS: SA2	3.51 bc	0.28 b	1.76 b	0.20 a	2.04 b	0.40 a
TTKS:SA3	2.99 c	0.28 b	1.56 b	0.18 a	1.51 b	0.33 ab
LSD	0.96	0.12	0.93	0.097	1.46	0.17

Note: Means followed by the same letters within columns are not significantly different, whereas means followed by different letters within columns are significantly different based on the LSD test at $p \leq 0.05$. *LSD* = least significant difference.

3 Conclusion

The application of organic chicken manure fertilizer was able to increase the growth and biomass of ginger plants compared to empty fruit bunches (EOPFB/TKKS) organic fertilizer, particularly in terms of plant height, number of leaves, number of shoots, fresh rhizome weight, and stem and leaf biomass. A planting spacing of 40 cm × 60 cm resulted in enhanced growth and biomass accumulation during the vegetative growth stage because it reduced competition among plants for light, water, nutrients, and growing space. The interaction between chicken manure organic fertilizer and the 40 cm × 60 cm planting spacing indicates the favorable treatment for increasing ginger rhizome yield and plant biomass combination during the vegetative growth stage. The combination of chicken manure organic fertilizer application and the 40 cm × 60 cm spacing represents the optimal cultivation system integration within a polyculture system of ginger and oil palm.

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