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The Effect of Empty Oil Palm Fruit Bunch Compost on the Growth and Production of Romaine Lettuce (*Lactuca sativa* L.)

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Abstract

Background: Excessive use of inorganic fertilizers can degrade soil quality and the environment, highlighting the need for alternative fertilization strategies. Organic fertilizers, such as compost derived from empty oil palm fruit bunches (Empty Fruit Bunches/EFB), a solid by-product of the palm oil processing industry, offer potential benefits for sustainable vegetable cultivation. EFB compost is considered a promising organic fertilizer due to its nutrient content and ability to improve soil properties.
Aims: This study aimed to determine the effect of empty oil palm fruit bunch (EFB) compost application on the growth and production of romaine lettuce (*Lactuca sativa* var. *longifolia*).
Methods: The study was conducted from August to October 2023 at the Faculty of Agriculture's experimental garden at Muhammadiyah University of Jakarta. The experiment employed a Completely Randomized Block Design (CRBD) with five treatments: NPK fertilizer at 0.75 g per polybag as the control, and EFB compost at 50, 100, 150, and 200 g per polybag. Growth and yield parameters were observed to evaluate the response of romaine lettuce to the different fertilization treatments.
Result & Conclusion: The results showed that EFB compost at all tested doses produced effects comparable to those of the NPK treatment across all observed parameters. Among the treatments, the application of EFB compost at a dose of 100 g per polybag was identified as the most effective in supporting the growth and production of romaine lettuce plants.

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1. Introduction

Vegetables are a crucial commodity in supporting national food security and contribute significantly to national development as a horticultural commodity (Kaloh, 2021). According to the Central Bureau of Statistics (2022), vegetable production in Indonesia reached 14.80 million tons. Vegetables are crucial for public health as they are a source of vitamins, minerals, protein, plant nutrients, and fiber. The nutritional content of vegetables plays a crucial role in minimizing the risk of various diseases. Therefore, efforts to cultivate vegetables continue, including romaine lettuce.

Romaine lettuce (*Lactuca sativa* var. longifolia) is a vegetable with high nutritional value and economic potential, as well as strong prospects for development. Some important substances contained in vegetables that are very useful for the body are protein, carbohydrates, water, minerals, and fiber. This vegetable contains various nutrients that play an important role in the body's metabolism (Utama *et.al.,* 2018). The nutritional content of romaine lettuce (*Lactuca sativa* L. var.

longifolia), according to the United States Department of Agriculture (2019), per 100 g of romaine lettuce contains 17 kcal, 0.3 g fat, 3.3 g carbohydrates, 2.1 g dietary fiber, 1.2 g sugar, and 1.2 g protein.

Fertilization is an important part of plant cultivation. Most farmers in Indonesia still rely on inorganic fertilizers such as urea, potassium chloride (KCl), and triple superphosphate (TSP) for crop cultivation because they deliver faster results. If this continues, the soil can become hard. Roots will struggle to develop, penetrate, or even breathe, which can stunt the plant's growth. This problem can be addressed by using organic fertilizers, such as compost.

Compost is an organic fertilizer derived from plant waste and is very useful for improving soil nutrients. Compost can improve soil productivity physically (enhancing soil structure), chemically (increasing nutrient content), and biologically (stimulating beneficial microbes) (Roidah, 2013). One plant waste that can be used as compost is Empty Fruit Bunch (EFB). EFB has considerable potential for use as compost. EFB's nutritional content includes: 35% carbon (C), 2.34% nitrogen (N), a carbon to nitrogen ratio (C/N) of 15, 0.31% phosphorus (P), 5.53% potassium (K), 1.46% calcium (Ca), 0.96% magnesium (Mg), and 52% water. EFB can be applied to various plants as an organic fertilizer, either alone or in combination with chemical fertilizers (Widiastuti & Panji, 2007).

Research conducted by Amri *et al.* (2018) and Abdillah (2021) on processing EFB waste into compost used only EFB waste as the raw material, without other ingredients. EFB compost acts as a soil conditioner by increasing soil microbial activity, improving soil fertility and structure, and thereby enhancing root development and expansion. EFB compost is a suitable organic fertilizer for vegetable cultivation. EFB compost is produced from empty oil palm fruit bunches, which contain essential nutrients such as N, P, K, Mg, and Ca that are readily absorbed by plants (Samsul & Rosmawati, 2017). The use of EFB in composting can serve as an alternative method for processing oil palm plantation waste while adding value to it. In addition, EFB compost is expected to function as an alternative fertilizer for plant cultivation. Therefore, this study aimed to evaluate the effect of EFB compost on the growth and yield of romaine lettuce.

2. Method

2.1 Research Method

The research was conducted from February to April 2024 at the Experimental Field of the Faculty of Agriculture, Muhammadiyah University of Jakarta. The research location is at an altitude of approximately 25 m above sea level (m.a.s.l) with Latosol soil. The materials used were labels, romaine lettuce seeds, EFB compost, NPK fertilizer, 30 cm x 30 cm polybags, and organic pesticides. This research was conducted using a Randomized Complete Block Design (CRBD). The treatments given were EFB compost doses (P), consisting of 0.75 g NPK/polybag (P0), 50 g EFB/polybag (P1), 100 g EFB/polybag (P2), 150 g EFB/polybag (P3), and 200 g EFB/polybag (P4). Each treatment was replicated 5 times, resulting in 25 experimental units. Each experimental unit consisted of three sample plants, resulting in a total of 75 plants. The weight of the soil is 5kg/ polybag.

2.2 Plant Cultivation

Seeds are sown in seed trays filled with organic growing media. Once the seed medium is ready, 2-3 romaine lettuce seeds are sown per hole and watered. After sowing and watering, the seed tray is placed in a shaded area, protected from direct sunlight. The planting medium is prepared one week before transplanting. The planting medium is soil with EFB compost added. A 5 kg planting medium, consisting of a mixture of soil and EFB, is placed in 30 cm x 30 cm polybags, depending on the treatment. The EFB compost is applied during planting medium preparation, mixed with the growing medium at the prescribed dosage for each treatment. It is then allowed to settle for one week (Herlina *et al.*, 2015). NPK fertilizer is applied at a dose of 0.75 g/plant, and is applied to the P0 treatment only once, 2 weeks after planting (Fuad, 2010). Plant watering is done regularly in the morning or evening (depending on conditions), with attention paid to the soilbed's humidity. Pest control is done manually, by directly removing pests that attack the plants, or by spraying botanical natural pesticides. Weed control is carried out by removing weeds around the romaine lettuce plants. Romaine lettuce is harvested when the plants are 6 weeks old after planting. Harvesting is done by removing the plants from the growing medium.

3. Results and Discussion

3.1 Crop Height

The analysis of variance showed that the application of EFB compost had a very significant effect on romaine lettuce plant height at 2 weeks after planting (WAP), a significant effect at 3–4 WAP, and no significant effect at 5–6 WAP. Further analysis using Duncan's Multiple Range Test (DMRT) at the 5% significance level for plant height is presented in Table 1.

Tabel 1. Effect Of Providing EFB Compost on The Height of Romaine Lettuce Plants Aged 2-6 Weeks After Planting

Treatment	Crop Height (cm)				
	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP
NPK 0.75 g/*polybag* (Control)	10.11 b	16.59 b	22.03 bc	26.72 a	32.29 a
EFB Compost 50 g/*polybag*	9.42 a	15.55 a	21.13abc	26.01 a	31.46 a
EFB Compost 100 g/*polybag*	10.25 b	16.55 b	22.26 c	27.10 a	33.28 a
EFB Compost 150 g/*polybag*	9.45 a	15.93ab	10.46 a	25.39 a	31.09 a
EFB Compost 200 g/*polybag*	9.21 a	15.61 a	20.43 a	25.43 a	30.93 a

Note : Numbers followed by the same letter in the same column are not significantly different based on the DMRT follow-up test at the 5% level.

Can be see on 2 WAP. the 100 g/polybag EFB compost treatment resulted in the highest plant height (10.25 cm). which was not significantly different from the 0.75 g/polybag NPK treatment (control) but was significantly different from the other treatments. At 3 WAP. the 0.75 g/polybag NPK treatment (control) produced the highest plant height (16.59 cm). which was not significantly different from the 100 g/polybag and 150 g/polybag EFB compost treatments. but was significantly different from the 50 g/polybag and 200 g/polybag EFB compost treatments. The effect on 4 WAP. the 100 g/polybag EFB compost treatment resulted in the highest plant height (22.26 cm) and was not significantly different from the 0.75 g/polybag NPK treatment (control) and the 50 g/polybag EFB compost treatment. but was significantly different from the 150 g/polybag and 200 g/polybag EFB compost treatments. At 5 and 6 WAP. the 100 g/polybag EFB compost treatment produced the highest plant heights of 27.10 cm and 33.28 cm. respectively. and was not significantly different from the other treatments.

3.2 Number of Leaf

The analysis of variance showed that the application of EFB fertilizer had a very significant effect on the number of leaves of romaine lettuce at 5–6 weeks after planting (WAP), while no significant effect was observed at 2–4 WAP. Table 2 presents the DMRT results at the 5% significance level, showing mean leaf numbers for treatments at 5–6 WAP.

Table 2. The effect of giving EFB Compost on the number of leaves of romaine lettuce plants aged 2-6 WAP

Treatment	Total Leaf				
	2 WAP	3 WAP	4 WAP	5 WAP	6 WAPT
NPK 0.75 g/polybag (control)	5.67 a	10.27 a	13.80 a	18.13 b	25.33 b
EFB Compost 50 g/polybag	5.87 a	9.87 a	13.33 a	17.27 a	25.13 b
EFB Compost 100 g/polybag	5.47 a	10.40 a	14.07 a	19.20 c	25.47 b
EFB Compost 150 g/polybag	5.33 a	9.53 a	13.40 a	19.27 c	23.80 ab
EFB Compost 200 g/polybag	5.40 a	10.07 a	13.73 a	18.53 bc	21.80 a

Note: Numbers followed by the same letter in the same column show no significant difference based on the DMRT test at the 5% level.

Based on the table, for 2 WAP, the 50 g/polybag EFB compost treatment produced the highest number of leaves (5.87) and was not significantly different from the other treatments. At 3 and 4 WAP, the 100 g/polybag EFB compost treatment resulted in the highest number of leaves, with values of 10.40 and 14.07 leaves, respectively, and was not significantly different from the other treatments. Moving forward to 5 WAP, the 150 g/polybag EFB compost treatment produced the highest number of leaves (19.27 leaves) and was not significantly different from the 100 g/polybag and 200 g/polybag EFB compost treatments, but was significantly different from the 0.75 g/polybag NPK treatment (control) and the 50 g/polybag EFB compost treatment. At 6 WAP, the 100 g/polybag EFB compost treatment produced the highest number of leaves (25.47 leaves) and was significantly different from the 200 g/polybag EFB compost treatment, but was not significantly different from the other treatments (Table 2).

3.3 Leaf Length

The results of the analysis of variance indicated that the application of EFB fertilizer had a very significant effect on romaine lettuce leaf length at 2 and 6 weeks after planting (WAP), whereas no significant effect was observed at 3–5 WAP. The results of further analysis using Duncan's Multiple Range Test (DMRT) at the 5% significance level for leaf length are presented in Table 3

Table 3. The effect of giving EFB Compost on the leaf length of romaine lettuce plants aged 2-6 weeks after planting

Treatment	Leaf Length (cm)				
	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP
NPK 0.75 g/polybag (control)	4.99 ab	7.17 a	10.30 a	12.83 a	14.71 a
EFB Compost 50 g/polybag	4.81 a	7.06 a	10.05 a	12.13 a	14.56 a
EFB Compost 100 g/polybag	5.13 b	7.22 a	10.18 a	12.50 a	15.45 b
EFB Compost 150 g/polybag	4.96 ab	7.05 a	10.17 a	11.95 a	14.37 a
EFB Compost 200 g/polybag	5.02 ab	7.04 a	10.00 a	12.22 a	14.26 a

Note: Numbers followed by the same letter in the same column show no significant difference based on the DMRT test at the 5% level.

During the second week after planting (2 WAP), the application of 100 g/polybag EFB compost resulted in the longest leaf length (5.13 cm), which was significantly different from the 50 g/polybag EFB compost treatment but not significantly different from the other treatments. which was significantly different from the 50 g/polybag EFB compost treatment but not significantly different from the other treatments. Subsequently, at 3 WAP, the 100 g/polybag EFB compost treatment also produced the longest leaf length (7.22 cm), although this value did not differ significantly from the other treatments. in contrast, at 4 and 5 WAP, the 0.75 g/polybag NPK treatment resulted in the longest leaf lengths, measuring 10.18 cm and 12.50 cm, respectively; however, these values were not significantly different from those of the other treatments. Finally, at 6 WAP, the 100 g/polybag EFB compost treatment produced the longest leaf length (15.45 cm) and was significantly different from all other treatments (Table 3).

3.4 Leaf Width

The analysis of variance showed that the application of EFB fertilizer significantly affected the observed variable, romaine lettuce leaf width, at 2 weeks after planting (WAP) and had a very significant effect at 3 WAP. However, at 4–6 WAP, the application of EFB fertilizer did not have a significant effect on romaine lettuce leaf width. The results of further analysis using Duncan's Multiple Range Test (DMRT) at the 5% significance level for leaf width are presented in Table 4.

Tabel 4. The effect of giving EFB Compost on the leaf width of romaine lettuce plants aged 2-6 weeks after planting

Treatment	Leaf Width (cm)				
	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP
NPK 0.75 g/polybag	2.41 a	3.17 abc	5.20 a	7.29 a	9.45 a
EFB Compost 50 g/polybag	2.47 b	3.26 bc	5.25 a	7.17 a	9.30 a
EFB Compost 100 g/polybag	2.77 d	3.43 c	5.41 a	7.37 a	9.55 a
EFB Compost 150 g/polybag	2.51 c	3.13 ab	4.96 a	6.96 a	9.18 a
EFB Compost 200 g/polybag	2.40 a	2.99 a	5.16 a	7.10 a	9.09 a

Based on the table, at 2 WAP, the 100 g/polybag EFB compost treatment produced the widest leaf width (2.77 cm), which was significantly greater than that of the other treatments. At 3 WAP, the 100 g/polybag EFB compost treatment resulted in the widest leaf width (3.43 cm) and was not significantly different from the 0.75 g/polybag NPK treatment (control) and the 50 g/polybag EFB compost treatment, but was significantly different from the 150 g/polybag and 200 g/polybag EFB compost treatments. And then on 4–6 WAP, the 100 g/polybag EFB compost treatment produced the widest leaf widths, namely 5.41 cm, 7.37 cm, and 9.55 cm, respectively, and was not significantly different from the other treatments.

3.5 Root Length, Weight, Plant Gross Weight, and Consumption Weight

The results of the analysis of variance showed that the application of EFB compost to romaine lettuce had a significant effect on root length. The results of further analysis using Duncan's Multiple Range Test (DMRT) at the 5% significance level for root length are presented in Table 5.

Tabel 5. The effect of EFB compost on root length, root weight, gross weight and consumption weight of romaine lettuce plants aged 6 weeks after planting

Treatment	*Root Length (cm)*		*Root Weight (g)*		*Gross Weight (g)*		*Consumption Weight (g)*	
NPK 0.75 g/polybag	*10.31*	*c*	*8.07*	*b*	*98.26*	*bc*	*87.98*	*c*
EFB Compost 50 g/polybag	*9.04*	*ab*	*6.25*	*ab*	*79.33*	*a*	*71.53*	*a*
EFB Compost 100 g/polybag	*10.71*	*c*	*8.72*	*b*	*103.11*	*c*	*91.89*	*c*
EFB Compost 150 g/polybag	*10.05*	*bc*	*7.09*	*ab*	*89.97*	*b*	*80.36*	*b*
EFB Compost 200 g/polybag	*8.67*	*a*	*5.25*	*a*	*75.42*	*a*	*66.85*	*a*

Note: Numbers followed by the same letter in the same column show no significant difference based on the DMRT test at the 5% level.

Table 5 shows that the longest root length was obtained with the 100 g/polybag EFB compost treatment (10.71 cm), which was not significantly different from the 0.75 g/polybag NPK treatment and the 150 g/polybag EFB compost treatment, but was significantly different from the 50 g/polybag and 200 g/polybag EFB compost treatments.

In addition, the highest root fresh weight of romaine lettuce was recorded in the 100 g/polybag EFB compost treatment (8.72 g). This value was significantly different from the 200 g/polybag EFB compost treatment, but not significantly different from the other treatments. Furthermore, the highest total fresh weight for romaine lettuce plants was obtained with the 100 g/polybag EFB compost treatment, at 103.11 g. This treatment was not significantly different from the 0.75 g/polybag NPK treatment, but was significantly different from the remaining treatments. Similarly, the highest consumable fresh weight of romaine lettuce plants was obtained from the 100 g/polybag EFB compost treatment (91.89 g), which was not significantly different from the 0.75 g/polybag NPK treatment, but was significantly different from the other treatments (Table 5).

3.6 Discussion

Based on observation parameters up to 6 weeks after planting (WAP), the 100 g/polybag EFB compost treatment produced favorable results and was not significantly different from the 0.75 g/polybag NPK treatment, the control, except for significant differences in plant height and leaf width of romaine lettuce. These results indicate that the nutrient content of EFB compost is sufficient to meet the nutritional requirements necessary for the growth and development of romaine lettuce. The application of this organic fertilizer is therefore considered capable of improving soil fertility, thereby supporting romaine lettuce growth and yield.

EFB compost has been reported to improve soil physical and chemical properties. In addition, it enhances the availability and solubility of essential nutrients required for plant growth and is relatively resistant to nutrient loss through leaching caused by water infiltration (Azlansyah, 2014). The phosphorus (P) and potassium (K) contents of EFB compost play an important role in plant respiration and photosynthesis, thereby promoting leaf growth. Moreover, potassium functions as an enzyme activator, facilitating the translocation of photosynthates to growing points and stimulating cell growth and development in plant tissues (Hidayat *et al.*, 2010).

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In addition to phosphorus and potassium, nitrogen is essential for accelerating vegetative growth. Nitrogen enhances the conversion of carbohydrates into proteins, which are subsequently transformed into protoplasm, thus supporting leaf growth and development (Tuapattinaya & Tutupoly, 2014). The relatively high nitrogen content of EFB compost increases plant nitrogen uptake as nitrate and ammonium. Furthermore, the application of EFB compost improves soil structure, thereby maximizing nutrient absorption by romaine lettuce plants. According to PT. Perkebunan Nusantara III (2017), the primary function of EFB is as a soil conditioner and a source of nutrients for plants.

Additionally, Sumartoyo (2017) stated that EFB compost is an organic fertilizer capable of increasing soil water-holding capacity, reducing soil aggregation and granulation, improving soil friability, increasing cation exchange capacity (CEC), minimizing nutrient losses due to leaching, enhancing the population and activity of soil microorganisms, and increasing the availability of essential nutrients such as N, P, K, C, Mg, and S.

Several previous studies have also demonstrated that EFB compost can support plant growth and development. Subagio *et al.* (2018) reported that EFB compost application improves soil fertility at various plant growth stages by increasing organic carbon content, soil pH, CEC, total phosphorus, and total nitrogen, thereby effectively enhancing eucalyptus (*Melaleuca cajuputi*) growth.

The results of research by Satria *et al.* (2015) showed that the application of EFB compost and NPK fertilizer to agarwood seedlings had the same effect on increasing seedling height, stem diameter, number of leaves, dry weight, and leaf area of agarwood seedlings. The best treatment was the application of EFB compost to 2/3 of the media with NPK 2 g/plant. The results of research by Santi *et al.* (2018) also showed that the application of EFB compost had a good effect on the number of radish plant leaves, the fresh weight of the radish plant tops, the fresh weight of tubers per plant, the length of tubers per plant, and the diameter of tubers per plant. Andira (2022) also reported that the application of oil palm empty bunches (EFB) compost at a dose of 4.5 kg/plot had a good effect on corn plant height, number of leaves, stem diameter, fresh weight of cobs, dry weight of cobs, and the weight of 100 corn kernels. A dose of 3.5 kg/plot yielded the best results for corn cob length, and a dose of 2.5 kg/plot yielded the best results for corn cob diameter.

Research conducted by Habibah *et al.* (2022) showed that applying 225 g of EFB compost per polybag every two days increased seedling height and root fresh weight of oil palm seedlings. Research by Arif (2023) also showed that applying various doses of EFB compost yielded results similar to those of NPK fertilizer (control). These results indicate that the lowest dose of 50 g of EFB compost per plant is sufficient to support plant growth and production.

The results of this study also showed that 100 g of EFB compost per polybag was superior to 150 g and 200 g. This is likely because excessive EFB application can cause toxic effects on plants. Plants have a limited capacity for nutrient absorption. When fertilizer is applied excessively, plants are unable to absorb all the nutrients, and the excess can actually poison the roots and inhibit plant growth. OPEFB contains various nutrients, but in proportions that are not always ideal for all types of plants. Applying high doses of EFB is thought to disrupt soil nutrient balance, making it difficult for plants to obtain other essential nutrients for growth. According to Kusmanto (2010), to achieve optimal fertilization efficiency, fertilizer must be applied in an amount sufficient to meet plant needs, neither too much nor too little. If fertilizer is applied excessively, the soil solution becomes too concentrated, which can cause plant poisoning. Conversely, if fertilizer is applied too little, its effect on plants may not be visible.

The gross plant weight obtained in this study was lower than the potential average plant weight specified in the seed specifications. This discrepancy is presumed to be influenced by environmental factors that did not fully meet romaine lettuce's growth requirements, particularly temperature. According to Taiz *et al.* (2014), temperature affects all biochemical reactions in plants, including photosynthesis and photorespiration. Furthermore, Rai (2014) reported that temperatures outside the optimal range may lead to an imbalance in plant metabolism, with respiration rates exceeding photosynthesis. Under such conditions, a greater proportion of photosynthates is used for respiration, leading to suboptimal plant growth and reduced biomass accumulation.

Nevertheless, both this study's findings and those of several previous studies generally indicate that applying EFB compost as an organic fertilizer can enhance the growth and development of romaine lettuce. This improvement is attributed to the sufficient nutrient content of EFB compost, which is capable of meeting the nutritional requirements necessary for romaine lettuce growth and development.

4. Conclusions

Based on the results of this study, it can be concluded that the 100 g/polybag EFB compost treatment produced significant effects and was not significantly different from the 0.75 g/polybag NPK treatment (control), except for plant height and leaf width of romaine lettuce, which showed significantly different responses.

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