PERFORMANCE OF RED CHILI PLANTS (*Capsicum annum* L.) IN RESPONSE TO ORGANIC FERTILIZER MIXTURE OF PALM OIL FRONDS, EMPTY FRUIT BUNCHES, AND COW MANURE

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Abstract. One approach to increasing chili production is through fertilisation. The use of organic fertilizers is a viable alternative. This study aims to evaluate the response of red chili plants (*Capsicum annum* L.) to the application of an organic fertilizer made from a mixture of palm oil fronds, empty fruit bunches, and cow manure. The research was conducted from April to July 2024 in Lubuk Sini Village, Taba Penanjung District, Central Bengkulu Regency. The method employed was an experimental one, using a Completely Randomised Design (CRD) Non-Factorial with one factor and four replications. The treatment factor was the dose of the organic fertilizer mixture of palm oil fronds, empty fruit bunches, and cow manure, comprising five levels: D0 = Without Organic Fertilizer (NPK 200 kg ha^{-1}), D1 = 15 t h^{-1}, D2 = 20 t h^{-1}, D3 = 25 t h^{-1}, and D4 = 30 t h^{-1}. Data were analysed using analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level. The results showed that the D4 = 30 t h^{-1} dosage had a significant effect on the height and fruit weight of red chili plants.

Key word: Red chili, Organic fertilizer, Palm oil fronds, and emty fruit bunches

Introduction

Red chili (*Capsicum annum* L.) is a horticultural commodity widely consumed in Indonesia. The demand for chili continues to grow in line with population growth and the expansion of industries that use chili as a raw material. The high demand for red chili makes it a commodity with substantial economic value. High prices and rising demand motivate farmers to improve production continually. In Bengkulu Province, the production of curly red chili increased from 215,200 quintals in 2022 to 216,184 quintals in 2023 [1].

Efforts to increase red chili production are ongoing, including using inorganic fertilizers, which have resulted in significant negative environmental impacts. Seriously utilize of chemical fertilizers has driven to soil and water contamination and diminished soil quality due to the exhaustion of micronutrients. Chemical fertilizers also disturb the balance of ecosystems, causing the accumulation of toxic chemicals and damaging beneficial soil organisms. As public awareness of the importance of environmentally friendly farming practices grows, organic fertilizers are becoming a more sustainable and safer alternative.

Organic fertilizers, derived from natural materials, can improve soil fertility gradually, enhance soil structure, and increase the soil's capacity to retain water. They contribute to the sustainability of agricultural production by improving soil conditions and promoting biodiversity within the soil. Additionally, organic fertilizers reduce farmers' dependence on expensive farming inputs that are not always available. Organic fertilizers also increase soil productivity in the long term, positively impacting yields and farmers' incomes. Organic fertilizers can be produced by farmers themselves using agricultural, livestock, or household waste, reducing production costs. One such source of organic material is palm oil plantation waste, such as palm fronds and empty fruit bunches.

In Bengkulu Province, palm oil fronds are a by-product of oil palm plantations and are readily available, notably around government, private, and community-owned plantations. Palm fronds are discarded after each harvest and can be collected at no cost. Using a shredder or chopper, the fronds can be processed into small pieces suitable for use as organic fertilizer (Sunarti dan Hasibuan, 2018). The increase in processing capacity has resulted in an increasing abundance of empty oil palm fruit bunches and by-products from palm oil processing plants. These organic wastes have great potential as raw materials for alternative organic fertilizers. A previous study [3] found that a mixture of palm fronds and empty fruit bunches in a 1:1 ratio, applied at a dose of 25 tons/ha, increased the number of branches, fruits, and fruit weight in red chili plants. Additionally, other research [4] reported that the use of bokashi (fermented cow manure) and empty oil palm bunches (EOPB) could replace chemical (inorganic) fertilizers in oil palm plants.

This study combined palm fronds and empty fruit bunches with cow manure to produce organic fertilizer with improved nutrient content. This mixture is expected to enhance the growth and yield of red chili plants, thereby reducing production costs, stabilizing chili prices, and increasing farmers' incomes.

MATERIALS AND METHODS

Research Location

The research was conducted from April to July 2024 in Lubuk Sini Village, Taba Penanjung District, Central Bengkulu Regency, Bengkulu Province.

Research material

The tools used for this study were polybags, buckets, hoes, digital scales, rulers, stationery, machetes/knives, meters, and documentation tools. The materials used for this study were Chili seeds, Organic fertilizers Mixed from oil palm fronds, empty bunches and cow dung, water, NPK fertilizer, and planting media in topsoil.

Research Design

The study employed a Completely Randomized Design (CRD) with a single treatment factor, namely the dose of organic fertilizer made from palm fronds, empty fruit bunches, and cow manure. The treatment levels were:

D0 = Without Organic Fertilizer (NPK 200 kg ha^{-1})
D1 = 15 t h^{-1}
D2 = 20 t h^{-1}
D3 = 25 t h^{-1}
D4 = 30 t h^{-1}

Each treatment was replicated four times, with each experimental unit consisting of five sample plants. If the ANOVA results showed significant effects, Duncan's Multiple Range Test (DMRT) was conducted at a 5% significance level to assess the differences between treatments.

Research Implementation

Organic Fertilizer Preparation

The organic fertilizer was made by chopping palm oil fronds using a shredder into pieces measuring 2-3 cm. Empty fruit bunches were similarly chopped into small pieces. The chopped palm oil fronds and empty fruit bunches were mixed with cow manure in a 1:1:1 ratio. Bran was added, and the mixture was stirred evenly. A fermentation solution was prepared by adding five caps of EM-4 (Effective Microorganisms) to 20 liters of clean water, followed by two tablespoons of sugar. The solution was stirred thoroughly and evenly poured over the fertilizer mixture. The mixture was then placed in a composting area, covered with tarpaulin, and left for 5-7 days. The compost was stirred every four days. The compost was considered ready if it had the following characteristics: a fragrant smell, a dark brown-black color, a fine texture, and a slightly moist but not wet consistency [5].

Preparation of Planting Medium

The topsoil was loosened, sifted, and cleared of plant residues and debris. Each polybag required 10 kg of soil. The prepared soil was mixed with the organic fertilizer from palm fronds, empty fruit bunches, and cow manure according to the tested treatment. The mixture was placed in polybags and left for one week before the red chili seedlings were transplanted. For treatment D0, the planting medium was not given organic fertilizer but was provided with inorganic fertilizer (NPK) at a dose of 200 kg ha^{-1}.

Seed preparation

The red chili seeds used are superior keris chili seeds purchased from agricultural stores. The seeds are soaked in warm water at 50°C overnight to accelerate seed growth, then sown in the nursery. The seeding medium uses topsoil that has been sifted and cleaned of dirt. The seeds are watered regularly with a fine sprayer for good seed development. The seeds will germinate in 7 days. After 30 days, the seedlings are ready to be planted.

Planting red chilies

Seeds that are old enough are moved to prepared polybags by inserting the seeds into the media with a depth of approximately 10 cm. In each polybag, two red chili seeds are planted.

Maintenance

Maintenance includes watering, weeding, replanting, and pest and disease control. Watering is done according to the weather conditions in the field using a watering can. Weeding is done once a week by manually removing weeds that grow in polybags or around red chili plants. Replanting is done if plants die or grow poorly two weeks after planting. Pest and disease control is carried out depending on field conditions. If pests and diseases stimulate the plants, pesticide spraying is carried out for pest control using chlorpyrifos and diseases using synergy 300 EC fungicide. Organic pesticides are applied in the form of a solution soaked in garlic skin to repel fruit flies and fleas. Spraying is done depending on the condition of the red chilies attacked by pests and diseases.

Observed Variables

Plant Height (cm)

Using a measuring tape, plant height was measured from the base of the stem to the highest growing point. Measurements were taken at intervals starting from 2 Weeks After Planting (WAP) and continued until 12 WAP.

Number of Tertiary Branches

The number of tertiary branches of each plant is recorded. Tertiary branches are the branches where flowers are formed. Observations are made after flowering to ensure that no other tertiary branches grow.

Flowering Time (Days)

Flowering time was recorded from planting until 80% of the plant population had produced flowers.

Harvest Time (Days)

Harvest time was recorded from planting to the first harvest when fruits reached physiological maturity. Criteria for physiological maturity included the fruit's maximum weight, intact and firm structure, and a dark, glossy red color with slight black streaks (indicating 90% ripeness).

Number of Fruits per Plant

The number of fruits per plant was recorded during harvest. The fruits were counted for each sample plant over six harvests, with intervals of 4 days between harvests.

Fruit Weight per Plant (g)

Observations were made by adding up the weight of the fruit from the sample plants from the 1st to the 6th harvest.

Supporting Data

Supporting data were obtained by analyzing the physical and chemical characteristics of the palm fronds organic fertilizer mixture, empty fruit bunches, and cow manure. Physical characteristics, including color, aroma, and texture, were

observed visually after fermentation. Chemical characteristics were analyzed by testing the fertilizer's nutrient content, including organic carbon (C), nitrogen (N), phosphorus (P), kalium (K), and pH.

Results and Discussion

Results

An analysis of variance (ANOVA) was conducted based on observations of all parameters. The data from the study are presented in Table 1. The table shows that the fertilizer dosage significantly affected plant height at 12 WAP and fruit weight per plant. Fertilizer dosage also significantly affected the number of tertiary branches, flowering, and harvest times. Data that showed significant or highly significant differences were followed up with Duncan's Multiple Range Test (DMRT).

Table 1. Summary of variance analysis (ANOVA) for the response of chili plants (*Capsicum annum* L.) to the organic fertilizer mixture of palm fronds, empty fruit bunches, and cow manure for all observed variables.

Variable	F-value
	Fertilizer Dosage (D)
Plant Growth	
1. Plant Height (cm)	
2.4. Height at 2 WAP	0,06 t
2.5. Height at 4 WAP	1,91 t
2.6. Height at 6 WAP	2,04 t
2.7. Height at 8 WAP	1,11 t
2.8. Height at 10 WAP	0,82 t
2.9. Height at 12 WAP	6,17 **
1. Number of Tertiary Branches	3,32 *
2. Flowering Time (Days)	4,06*
Chili Plant Yield	
3. Harvest Time (Days)	3,27 *
4. Number of Fruits per Plant	4,49 *
5. Fruit Weight per Plant (g)	21,37 **
F-tabel 5 %	3,06
F-tabel 1 %	4,89

Note: *Explanation: * = significant, ** = highly significant, ns = not significant

Plant Height

The variance analysis for plant height at 12 WAP showed a highly significant result, and further testing with DMRT was conducted. The DMRT results for plant height at 12 WAP are presented in Table 2.

Table 2. DMRT test results at a 5% level, showing the effect of fertilizer dosage on the height of red chili plants at 12 WAP.

Dosage	Average Height (cm)
D0	35,90 d
D1	39,40 c
D2	43,35 b
D3	44,80 b
D4	47,05 a

Note: Values followed by the same letter in the same column are not significantly different at the 5% level

The organic fertilizer mixture of palm fronds, empty fruit bunches, and cow manure at 30 t h-1 (D4) resulted in the best plant height, followed by 25 t h-1 (D3). Overall, treatments with the organic fertilizer mixture across all dosages (D1, D2, D3, and D4) produced better results than the standard inorganic fertilizer treatment (NPK 200 kg ha^{-1}).

Number of Tertiary Branches

The variance analysis for the number of tertiary branches showed a significant result. The DMRT results for the number of tertiary branches are presented in Table 3.

Table 3. DMRT test results at a 5% level, showing the effect of fertilizer dosage on the number of tertiary branches in red chili plants.

Dosage	Average Number of Tertiary Branches
D0	25,50 c
D1	29,00 b
D2	29,25 b
D3	29,50 b
D4	32,50 a

Note: Values followed by the same letter in the same column are not significantly different at the 5% level.

The highest number of tertiary branches was observed in the D4 treatment (30 t h^{-1}), significantly different from the D0, D1, D2, and D3 treatments. However, all treatments with the organic fertilizer mixture still produced better results than the D0 treatment (standard inorganic fertilizer).

Flowering Time

The variance analysis for flowering time in red chili plants showed a significant result. The average flowering time was 39.97 days. The DMRT results at the 5% level are presented in Table 4.

Table 4. DMRT test results at a 5% level, showing the effect of fertilizer dosage on the flowering time of red chili plants (days).

Dosage	Average Flowering Time (days)
D0	37,20 d
D1	39,05 c
D2	40,10 c
D3	40,50 b
D4	43,00 a

Note: Values followed by the same letter in the same column are not significantly different at the 5% level.

The D4 treatment (30 t h^{-1}) significantly delayed flowering compared to the D0, D1, D2, and D3 treatments.

Harvest Time (Days)

The variance analysis for harvest time showed a significant result. The DMRT results at the 5% level are presented in Table 5.

Table 5. DMRT test results at a 5% level, showing the effect of fertilizer dosage on the harvest time of red chili plants (days).

Dosage	Average Harvest Time (days)
D0	80,90 b
D1	80,40 c
D2	80,60 b
D3	80,75 b
D4	81,45 a

Note: Values followed by the same letter in the same column are not significantly different at the 5% level.

The D4 treatment (30 t h^{-1}) had the longest harvest time, significantly different from other treatments.

Number of Fruits per Plant

Table 6. DMRT test results at a 5% level, showing the effect of fertilizer dosage on the number of fruits per plant in red chili plants.

Dosage	Average Number of Fruits
D0	19,50 b
D1	17,31 c
D2	19,38 b
D3	20,38 a
D4	20.44 a

Note: Values followed by the same letter in the same column are not significantly different at the 5% level.

The variance analysis for the number of fruits per plant showed a significant result. The DMRT results at the 5% level are presented in Table 6. The D3 and D4 treatments showed the best results, significantly different from D0, D1, and D2.

Fruit Weight per Plant (g)

The variance analysis for fruit weight per plant from the first to the sixth harvest showed a highly significant result. The DMRT results at the 5% level are presented in Table 7. The D4 treatment (30 t h^{-1}) resulted in the highest fruit weight, significantly different from other treatments.

Table 7. DMRT test results at a 5% level, showing the effect of fertilizer dosage on the fruit weight of red chili plants (g).

Dosage	Average Fruit Weight (g)
D0	54,54 d
D1	55,08 b
D2	55,32 b
D3	54,95 c
D4	57,76 a

Note: Values followed by the same letter in the same column are not significantly different at the 5% level.

Supporting Data

The quality of the organic fertilizer was assessed based on its physical and chemical characteristics. These observations were made on the organic fertilizer mixture of palm fronds, empty fruit bunches, and cow manure from day four after production to day 30. These characteristics included texture, aroma, color, and temperature, as presented in Table 8

Table 8. Physical characteristics of the organic fertilizer mixture of palm fronds, empty fruit bunches, and cow manure.

Characteristic	Day 4	Day 8	Day 21	Day 30
Texture	Coarse, clumpy	Coarse, clumpy	Smooth	Smooth
Color	Light brown	Dark brown	Dark brown	Dark brown-black
Aroma	Musty	Decayed wood smell	Decayed wood smell	Odourless
Temperature (°C)	-	-	26°C	22°C

Observation data on physical characteristics show that when organic fertilizer is four days old, it has a rough and lumpy texture, is light brown, and has a musty aroma. At eight days old, organic fertilizer has a rough texture and does not lump, is dark brown, and has a rotten wood aroma. At 14 days old, organic fertilizer is still rough. At 21 days old, organic fertilizer already has a smooth texture, is dark brown, has a rotten wood aroma, and has a temperature of 26^{o}c. At 30 days old, organic fertilizer has a soft texture, is blackish brown, has no aroma, and has a temperature of 22^{o}c, which means that organic fertilizer from oil palm fronds, empty oil palm bunches, and cow dung is ready to use.

Observation of the Chemical Characteristics of organic fertilizers mixed with oil palm fronds, empty oil palm bunches, and cow dung, chemical tests were carried out. The results of chemical tests on

fertilizer content are presented in Table 9. Organic fertilizers from oil palm fronds, empty oil palm bunches, and cow dung have N-Total 2.10%, P 0.97%, K 0.43%, C-Organic 33.74%, and pH 6.79.

Table 9. Chemical characteristics of the organic fertilizer mixture of palm fronds, empty fruit bunches, and cow manure.

Lab Code	Sample Code	N-Total (%)	P (%)	K (%)	C-Organic (%)	pH	C/N Ratio
1731	Mixed organic fertilizer	2.10%	0.97%	0.43%	33.74%	6.79	16.07

Discussion

Applying organic fertilizer mixed with oil palm fronds, empty bunches, and cow manure significantly affects the growth and yield of red chili plants. Several growth parameters showed better results, such as plant height, number of tertiary branches, flowering age, harvest age, number of fruits, and fruit weight. A 30 t h^{-1} dose gave the best results on various parameters.

Previous research [3] showed that a mixture of organic fertilizer from oil palm fronds and empty fruit bunches (without cow manure) had a significant effect on the number of branches, number of fruits, and fruit weight, but did not have an impact on plant height, flowering time, or harvest time. In this study, adding cow manure to the organic fertilizer mixture increased plant height growth and red chili yields.

This study recorded the average height of the highest red chili plants at 47.05 cm, while the shortest was 35.90 cm. Organic fertilizer treatment significantly affected the number of tertiary branches essential for forming flowers and fruits. According to [6], the provision of organic fertilizer from cow dung can significantly increase the number of productive branches. Livestock manure can increase soil fertility by increasing plant growth and yield in the form of the number of productive branches. According to [7], the advantages of cow manure or other organic fertilizers are that they can change the soil structure to be better for root development, increase the holding capacity and absorption capacity of the soil for water, improve the life of organisms in the soil and add nutrients to the soil.

Observation of the flowering age of red chili plants in the treatment of organic fertilizer mixed with oil palm fronds, empty oil palm bunches, and cow dung gave a significant difference. The longer flowering age in red chili plants is thought to occur because the plants form many tertiary chilies, where flowers are formed. The number of tertiary branches will undoubtedly produce many flowers, so it takes a longer time (43 days) to reach 80% of the flowering plant population. According to [8], flowers will come out at the plant's age 29-40 days after

planting, and the fruit will ripen within 34-40 after fertilization. The harvest age in this study was 81 days, so according to the statement above, the flowering age of chili plants is 43 days after planting, and the fruit will ripen 38 days later (81 WAP).

The treatment of organic fertilizer mixtures of oil palm fronds, empty oil palm bunches, and cow dung also significantly affects the number of fruits and their weight. This is correlated with the number of tertiary branches, which also has a significant effect. A high number of tertiary branches will produce a lot of fruit and increase the fruit's weight. According to statement [9], increasing the number of plant branches can increase the emergence of flowers, so the number of branches will affect the number of flowers and fruits. Furthermore, according to [10] the number of fruits significantly affects the weight of fruit per plant. The greater the number of fruits, the higher the weight of the fruit per plant. The high number of fruits and fruit weight of chili plants is thought to be due to the nutrients contained in the organic fertilizer mixture of oil palm fronds, empty oil palm bunches, and cow dung being able to meet the needs of red chili plants in vegetative and generative growth.

The results of the nutrient content analysis showed that an organic fertilizer mixture of oil palm fronds, empty oil palm bunches, and cow dung contains total N nutrients of 2.10%, P 0.97%, K 0.43%, organic C 33.74%, C/N ratio of 16.07% and pH 6.79. According to [11], empty oil palm bunches used as compost have advantages, namely having high potassium content, without the addition of starter and chemicals can add nutrients in the soil and improve the soil's physical, chemical, and biological properties. The C/N ratio value (15.67%) is moderate and meets the minimum technical requirements for organic fertilizer [12].

Conclusion

1. The application of the organic fertilizer mixture of palm fronds, empty fruit bunches, and cow manure significantly influenced plant height, tertiary branch number, flowering time, harvest time, fruit number, and fruit weight in red chili plants.

2. The D4 treatment (30 t h^{-1}) provided the best overall results, with the highest plant height and fruit yield.

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