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Maximizing Red Chili Yield through NPK Fertilizer and Agricultural Waste Biochar Utilization

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Abstract

This study aims to determine the effect of NPK combined with biochar from various agricultural wastes in increasing the growth and yield of red chili plants. The research method used was a Randomized Complete Block Design (RCBD) with a factorial pattern, involving two factors and three replications. The first factor is the NPK fertilizer dosage, comprising four levels: 0, 300, 600, and 900 kg ha^{-1}. The second factor is the biochar treatment, consisting of four types: biochar from mangosteen skin, biochar from rambutan, biochar from coffee skin, and biochar from rice husk. The application of NPK fertilizer has a significant to very significant effect on all observed variables, except for intangible effects on variables such as stem diameter, root fresh weight, plant fresh weight, and root dry weight. The biochar treatment has no significant effect on all observed variables, except for fruit weight and fruit count, which show a significant effect. The interaction between NPK fertilizer and biochar has no significant effect on all observed variables, except for plant height, number of leaves, number of fruits, and fruit weight, which exhibit a significant to very significant effect. The highest fruit weight of 205.70 g was obtained from the interaction between a dosage of 900 kg ha^{-1} with biochar from coffee skin, showing an increase of 114.72% compared to the lowest treatment fruit weight obtained from the interaction between no NPK dosage and biochar from rambutan, which was 95.80 g.

Keywords: *NPK fertilizer, agricultural waste, biochar, red chili*

1. Introduction

In Indonesia, chili plants (Capsicum annum L.) are commonly cultivated by farmers across various regions. The consistent demand for red chili throughout the year requires continuous cultivation. Unfortunately, farmers often overlook environmental factors affecting red chili production, resulting in decreased yields. In 2016, the estimated total chili consumption reached 2.90 kg per capita, which increased to 2.95 kg in 2017, 3.00 kg in 2018, and 3.05 kg in 2019. The growing demand emphasizes the importance of aligning chili production with consumption to avoid sharp price spikes [1].

Hybrid chili peppers (F1) offer numerous advantages, including high production rates, adaptability to various conditions, uniform growth, and the ability to meet consumer quality standards [2]. According to [3], red chili cultivation is suitable for both lowlands and highlands, including rice fields or moors at altitudes up to 1400 m above sea level. The use of polybag planting media, as suggested by [4], proves practical for limited cultivation areas. When employed with proper techniques, it can yield satisfactory harvests for all types of chili plants.

Cultivating red chili using polybag media and incorporating NPK and Biochar fertilizers into the soil enhances soil structure. This makes the soil more friable, facilitating better root system development and optimizing nutrient absorption. The NPK Mutiara 16:16:16 fertilizer [5] is a compound fertilizer containing 16% each of N, P, and K [6]. The use of NPK fertilizer presents a viable option to increase chili plant productivity [7]. Biochar, a solid material derived from the pyrolysis process of organic materials, serves as a soil improver. Numerous global studies indicate that biochar enhances soil's physical, chemical, and biological properties [8, 9, 10]. It acts as a stable carbon source for organic carbon conservation in the soil [11]. Laird emphasizes two crucial aspects of biochar use: its nutrient-related tendencies and its high persistence [12].

Rice husk biochar contains C-organic (20.93%), N (0.71%), P (0.06%), and K (0.14%). The application of rice husk biochar to the soil yields optimal results for plant growth [13]. Coffee skin biochar, as indicated by various sources, contains carbohydrates, protein, fat, and minerals. A study by [14, 15] indicates the effectiveness of coffee skin biochar in enhancing plant growth. Rambutan skin, with 35% lignin and 24% cellulose [16], is also considered for its potential contribution. This study aims to explore the combined impact of biochar derived from various agricultural wastes and NPK fertilizers on enhancing the growth and yield of red chili plants.

2. Materials and Methods

This research was conducted in East Denpasar, spanning from April to July 2023. The research design used was a Random Block Design (RBD) with a factorial pattern, involving two main factors: the concentration of NPK fertilizer and biochar, each with three treatments. The first factor was the concentration of NPK fertilizer (N), with the following treatments: N0 (0 kg ha^{-1}), N1 (300 kg ha^{-1}), N2 (600 kg ha^{-1}1), N3 (900 kg ha^{-1}). The second factor related to the application of Biochar (derived from mangosteen skin, rambutan skin, coffee skin, and rice husk), with the treatments as follows: B1 (Mangosteen skin biochar), B2 (Rambutan skin biochar), B3 (Coffee skin biochar), B4 (Rice husk biochar). As a result, there were 16 treatment combinations, 3 replications, and 48 research polybags created.

The tools utilized in this study included polybags measuring 30x30 cm, meters, scales, knives, filters, buckets, labels, markers, cameras, stationery, iron barrels, kerosene, and other necessary equipment. The materials involved in this research comprised F1 red chili seeds, soil, NPK fertilizer, and biochar derived from mangosteen skin waste, rambutan skin, coffee skin, and rice husks. The results of soil analysis conducted before the research, along with the laboratory analysis of several types of biochar, are presented in Table 1.

Table 1. Results of soil analysis and various types of biochar before research

Types of Analysis	pH	EC (mmhos/cm)	C Organic (%)	N Total (%)	P Available (ppm)	K Available (ppm)	Water Content (%)	Texture
1. Soil	7.4	0.58	3.23	0.22	99.30	194.50	3.71	Sandy loam
2. Coffee skin	7.3	28.40	24.73	0.34	121.66	579.20	5.77	-
3. Mangosteen skin	8.3	10.80	12.72	0.18	507.06	708.51	8.80	-
4. Rambutan skin	7.1	2.83	34.21	0.18	391.73	748.67	9.76	-
5. Rice husky	5.1	17.24	18.45	1.07	1.83	1.48	11.35	-

Source: Soil Science Laboratory, Faculty of Agriculture, Udayana University, Denpasar 2023.

Several variables were observed during the study, including plant height, number of leaves, number of branches, stem diameter, fresh weight of roots, fresh weight of plants, dry weight of plants, dry weight of roots, number of fruits, and weight of fruits.

The research data were analyzed using a statistical analysis of variance following the research design. For single treatments demonstrating a significant effect, further analysis was conducted using the LSD test at the 5% level. In cases of significant effects on interactions, the analysis proceeded with the Duncan 5% test.

3. Results and Discussion

The results of the statistical analysis of all observed variables are presented in the appendix. Table 2 illustrates the significance of the effects of NPK and biochar fertilizer dosing, as well as their interaction (NxB) on the observed variables.

Table 2. Significant application of NPK (N) and biochar (B) fertilizers and their interaction with all observed variables.

No	Variable	Treatment		
		NPK (N)	Biochar (B)	Interaction (NxB)
1	Plant Height (cm)	**	ns	*
2	Number of Leaves (strands)	*	ns	**
3	Number of Branches (fruit)	**	ns	ns
4	Steam diameter (mm)	ns	ns	ns
5	Fresh Root Weight (g)	ns	ns	ns
6	Fresh Plant Weight (g)	ns	ns	ns
7	Dry Plant Weight (g)	*	ns	ns
8	Dry Root Weight (g)	ns	ns	ns
9	Number of Fruits (fruits)	*	*	**
10	Fruit Weight (g)	**	*	*

Note: ns = non significant (P≥0.05), * = significant (P<0.05), ** = Very significant (P<0.01)

Table 2 indicates that the NPK fertilizer dosage significantly affects ($P < 0.05$) variables such as the number of leaves, dry weight of plants, and number of fruits. Furthermore, it has a highly significant effect ($P < 0.01$) on plant height, number of branches, and fruit weight. However, there is no significant effect ($P > 0.05$) on other variables. In contrast, biochar treatment does not significantly impact ($P > 0.05$) any observed variables except for fruit count, where it shows a significant effect ($P < 0.05$). The interaction between NPK treatment and biochar (NxB) has a significant effect ($P < 0.05$) on plant height and fruit weight, and a highly significant effect ($P < 0.01$) on the number of leaves and number of fruits. However, there is no significant effect ($P \geqslant 0.05$) on other variables.

3.1.1. Plant Height

Based on the results of the statistical analysis presented in Table 2, the NPK fertilizer dosage (N) demonstrates a highly significant effect ($P < 0.01$) on plant height per plant, while biochar treatment (B) shows no significant effect ($P \geqslant 0.05$) on plant height per plant. Conversely, the interaction (NxB) exhibits a significant effect ($P < 0.05$) on plant height per plant.

Referring to Table 3, the highest plant height per plant, at 132.67 cm, is observed in the interaction between the dosage of 600 kg ha^{-1} of NPK fertilizer and 10 t ha^{-1} of rambutan skin biochar (N2B2). This height is significantly different and represents a 40.64% increase compared to the lowest plant height, which is 94.33 cm per plant, obtained in the interaction between no NPK fertilizer dosage and 10 t ha^{-1} of rambutan skin biochar (N0B2).

Table 3. Average height of red chili plants per plant in the interaction treatment of npk fertilizer dose and biochar application (NxB)

Treatment	B1	B2	B3	B4
N0	110.00 cde	94.33 e	115.00 bcde	124.33 abc
N1	127.00 abc	122.67 abc	117.67 bcd	117.67 bcd
N2	131.00 ab	132.67 a	131.00 ab	118.67 abcd
N3	127.00 abc	116.00 bcd	130.33 ab	114.67 bcde

Note: Numbers followed by the same lowercase letter are not significantly different according to the Duncan test at a 5% significance level.

3.1.2. Number of Leaves

Based on the results of the statistical analysis presented in Table 2, the NPK (N) fertilizer dose treatment exhibits a significant effect ($P < 0.05$) on the number of leaves per plant. In contrast, biochar treatment (B) shows a non-significant effect ($P \geqslant 0.05$) on the number of leaves per plant. However, the interaction (NxB) demonstrates a highly significant effect ($P < 0.01$) on the number of leaves per plant.

Referring to Table 4, the highest number of leaves per plant, at 671.00 strands, is observed in the interaction between dosage of 600 kg ha-1 of NPK fertilizer and 10 t ha^{-1} of mangosteen skin biochar

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(N2B1). This number is significantly different, representing an 82.33% increase compared to the lowest number of leaves per plant, which is 368.00 strands, obtained in the interaction between no NPK fertilizer dosage and 10 t ha^{-1} of rambutan skin biochar (N0B2).

3.1.3. Number of Branches

Based on the results of the statistical analysis presented in Table 2, the NPK (N) fertilizer dose treatment demonstrates a highly significant effect ($P < 0.01$) on the number of branches per plant. However, biochar treatment (B) and the interaction (NxB) show no significant effect ($P \geqslant 0.05$) on the number of branches per plant.

Referring to Table 4, the treatment with a dose of 600 kg ha^{-1} of NPK fertilizer (N2) yields the highest number of branches per plant, with 23.50 pieces. This result is significantly different from the lowest number of branches observed in the treatment without NPK fertilizer (N0), which is 19.17 pieces per plant. Additionally, in the treatment with 10 t ha^{-1} of mangosteen skin biochar (B1), the highest yield of branches is 22.67 per plant, significantly different from the treatment with 10 t ha^{-1} of rambutan skin biochar (B2), which gives the lowest yield of 21.50 pieces per plant.

Table 4. Variable averages of the number of branches. trunk diameter. fresh weight of roots in NPK and biochar fertilizer treatment.

Treatment	Number of Branches (buah)	Stem Diameter (cm)	Fresh Root Weight (g)
NPK Dosage			
N0 (0 kg ha^{-1})	19.17 b	2.05 a	13.22 a
N1 (300 kg ha^{-1})	22.67 a	2.13 a	13.60 a
N2 (600 kg ha^{-1})	23.50 a	2.14 a	14.37 a
N3 (900 kg ha^{-1})	22.83 a	2.12 a	12.06 a
LSD 5%	2.34	0.12	2.34
Types of Biochar			
B1 (Mangosteen skin)	22.67 a	2.12 a	12.36 a
B2 (Rambutan skin)	21.50 a	2.11 a	13.08 a
B3 (Coffee skin)	22.17 a	2.14 a	14.03 a
B4 (Rice husk)	21.83 a	2.07 a	13.78 a
LSD 5%	2.34	0.12	2.34

Note: The average value followed by the same letter in the same treatment and column means there is no significant difference in the 5% LSD test.

3.1.4. Steam Diameter

Based on the statistical analysis results in Table 2, it can be concluded that the NPK fertilizer dose (N), biochar treatment (B), and their interaction (NxB) do not have a significant effect ($P \geqslant 0.05$) on the stem diameter variable per plant.

Regarding Table 4, it is observed that the treatment with a dose of 600 kg ha^{-1} of NPK fertilizer (N2) yields the highest stem diameter per plant, measuring 2.14 mm. This result is significantly different from the lowest stem diameter obtained from the treatment without NPK fertilizer (N0), which is 2.05 mm per plant. Furthermore, in the treatment with 10 t ha^{-1} of coffee skin biochar (B3), the highest yield of stem diameter per plant is 2.14 mm, significantly different from the treatment with 10 t ha^{-1} of rice husk biochar (B4), which gives the lowest yield of 2.07 mm per plant.

3.1.5. Fresh Root Weight

Based on the results of the statistical analysis in Table 2, it is evident that the NPK fertilizer dose treatment (N), biochar treatment (B), and their interaction (NxB) do not have a significant effect ($P \geqslant 0.05$) on the variable fresh weight of roots per plant.

Referring to Table 4, the treatment with a dose of 600 kg ha^{-1} of NPK fertilizer (N2) yields the highest fresh weight of roots per plant, measuring 14.37 g. This result is significantly different from the lowest fresh weight of roots obtained from the NPK fertilizer dose treatment of 900 kg ha^{-1} (N3), which is 12.06 g per plant. Additionally, in the treatment with 10 t ha^{-1} of coffee skin biochar (B3), the highest yield of fresh root weight per plant is 14.03 g, significantly different from the treatment with 10 t ha^{-1} of mangosteen skin biochar (B1), which gives the lowest yield of 12.36 g per plant

3.1.6. Fresh Plant Weight

Based on the results of the statistical analysis in Table 2, it is evident that the NPK fertilizer dose treatment (N), biochar treatment (B), and their interaction (NxB) do not have a significant effect ($P \geqslant 0.05$) on the variable fresh weight of plants per plant.

Referring to Table 5, the treatment with a dose of 900 kg ha^{-1} of NPK fertilizer (N3) yields the highest fresh weight of plants per plant, measuring 142.47 g. This result is significantly different from the lowest fresh weight of plants obtained from the treatment without NPK fertilizer dose (N0), which is 110.09 g per plant. Additionally, in the treatment with 10 t ha^{-1} of rambutan skin biochar (B2), the highest yield of fresh weight of plants per plant is 138.78 g, significantly different from the treatment with 10 t ha^{-1} of mangosteen skin biochar (B1), which gives the lowest yield of 123.38 g per plant.

3.1.7. Dry Plant Weight

Based on the results of the statistical analysis in Table 2, the NPK (N) fertilizer dose treatment has a significant effect ($P < 0.05$) on the dry weight of plants per plant, while biochar treatment (B) and the interaction (NxB) do not have a significant effect ($P \geqslant 0.05$) on the variable dry weight of plants per plant.

Referring to Table 5, the treatment with a dose of 300 kg ha^{-1} of NPK fertilizer (N1) yields the highest dry weight of plants per plant, measuring 12.37 g. This result is significantly different from the lowest dry weight of plants obtained from the treatment without NPK fertilizer dose (N0), which is 9.91 g per plant. Additionally, in the treatment with 10 t ha^{-1} of rambutan skin biochar (B2), the highest yield of dry weight of plants per plant is 11.66 g, significantly different from the treatment with 10 t ha^{-1} of mangosteen skin biochar (B1), which gives the lowest yield of 11.18 g per plant.

Table 5. Average variables of fresh weight of roots. the dry weight of plants. the dry weight of roots in NPK and Biochar fertilizer treatment.

Treatment	Fresh Plant Weight (g)	Dry Plant Weight (g)	Dry Weight of Roots (g)
Dose NPK			
N0 (0 kg ha^{-1})	110.09 a	9.91 b	1.12 a
N1 (300 kg ha^{-1})	137.53 a	12.37 a	1.14 a
N2 (600 kg ha^{-1})	131.28 a	12.03 a	1.24 a
N3 (900 kg ha^{-1})	142.47 a	11.28 a	1.13 a
LSD 5%	34.61	1.62	0.18
Types of Biochar			
B1 (Mangosteen skin)	123.38 a	11.18 a	1.03 b
B2 (Rambutan skin)	138.78 a	11.66 a	1.18 a
B3 (Coffee skin)	134.27 a	11.54 a	1.16 a
B4 (Rice husk)	124.93 a	11.20 a	1.26 a
LSD 5%	34.61	1.62	0.18

Note: The average value followed by the same letter in the same treatment and column means there is no significant difference in the 5% LSD test.

3.1.8. Dry Root Weight

Based on the results of statistical analysis in Table 2, it is evident that NPK fertilizer dose treatment (N), biochar treatment (B), and their interaction (NxB) do not have a significant effect ($P \geqslant 0.05$) on the variable dry weight of roots per plant.

Referring to Table 5, the treatment with a dose of 600 kg ha^{-1} of NPK fertilizer (N2) yields the highest dry weight of roots per plant, measuring 1.24 g. This result is significantly different from the lowest dry weight of roots obtained from the treatment without NPK fertilizer dose (N0), which is 1.12 g per plant. Additionally, in the treatment with 10 t ha^{-1} of rice husk biochar (B4), the highest yield of dry root weight per plant is 1.26 g, significantly different from the treatment with 10 t ha^{-1} of mangosteen skin biochar (B1), which gives the lowest yield of 1.03 g per plant.

3.1.9. Number of Fruits

Based on the results of statistical analysis in Table 2, the dose treatment of NPK fertilizer (N) with biochar treatment (B) has a significant effect ($P < 0.05$) on the number of fruits per plant, while the interaction (NxB) has a highly significant effect ($P < 0.01$) on the number of fruits per plant.

Based on Table 6, the highest number of fruits per plant, at 74.00 pieces, is obtained in the interaction between the dose of NPK fertilizer 300 kg ha^{-1} with rice husk biochar 10 t ha^{-1} (N1B4). This is significantly different or increased by 44.16% compared to the lowest number of fruits per plant, which is 51.33 pieces, obtained in the interaction between the dose of NPK fertilizer 300 kg ha^{-1} with biochar from mangosteen skin 10 t ha-1 (N1B1).

Table 6. The average number of red chili fruits per plant in the treatment involves the interaction of NPK fertilizer doses and biochar application (NxB).

Treatment	B1	B2	B3	B4
N0	53.67 cde	53.33 cde	58.33cdc	70.67 ab
N1	51.33 e	60.67 bcde	53.33 cde	74.00 a
N2	66.67 abc	64.00 abcde	69.33 ab	70.33 ab
N3	65.00 abcde	54.67 cde	63.67 abcde	52.00 de

Note: Numbers followed by the same lowercase letter are not significantly different according to the Duncan test at a 5% significance level.

3.1.10. Fruit Weight

Based on the results of statistical analysis in Table 2, the NPK (N) fertilizer dose treatment has a highly significant effect ($P < 0.01$) on fruit weight per plant, while biochar treatment (B) and interaction (NxB) have a significant effect ($P < 0.05$) on fruit weight per plant.

Based on Table 7, the highest fruit weight per plant, at 205.70 g, is obtained in the interaction between the dose of NPK fertilizer 900 kg ha^{-1} with coffee skin biochar 10 t ha^{-1} (N3B3). This is significantly different or increased by 114.72% compared to the lowest fruit weight per plant, obtained without interaction of NPK fertilizer dose with biochar from mangosteen skin 10 t ha^{-1} (N0B1) amounting to 95.80 g per plant.

Table 7. The average weight of red chili fruit per plant in the interaction treatment of NPK fertilizer dose and biochar (NxB) application.

Treatment	B1	B2	B3	B4
N0	95.80 e	122.93 cde	131.20 cde	128.60 cde
N1	144.83 bcde	148.40 bcde	137.03 bcde	129.63 cde
N2	182.37 ab	160.50 bcde	191.27 ab	162.63 bc
N3	131.97 bcde	162.00 bcd	205.70 a	149.00 bcde

Note: Numbers followed by the same lowercase letter are not significantly different according to the Duncan test at a 5% significance level.

3.2. Discussion

The results reveal a significant effect ($P < 0.05$) of the interaction between NPK fertilizer and biochar (NxB) on fruit weight per plant. The highest fruit weight per plant, reaching 205.70 g, is achieved with the interaction between a dose of 900 kg ha-1 of NPK fertilizer and 10 t ha^{-1} of coffee skin biochar (N3B3). This value is significantly different, showing an increase of 114.72% compared to the lowest fruit weight per plant obtained without the interaction of NPK fertilizer dose with 10 t ha^{-1} of biochar from mangosteen skin (N0B1), amounting to 95.80 g per plant (Figure 1).

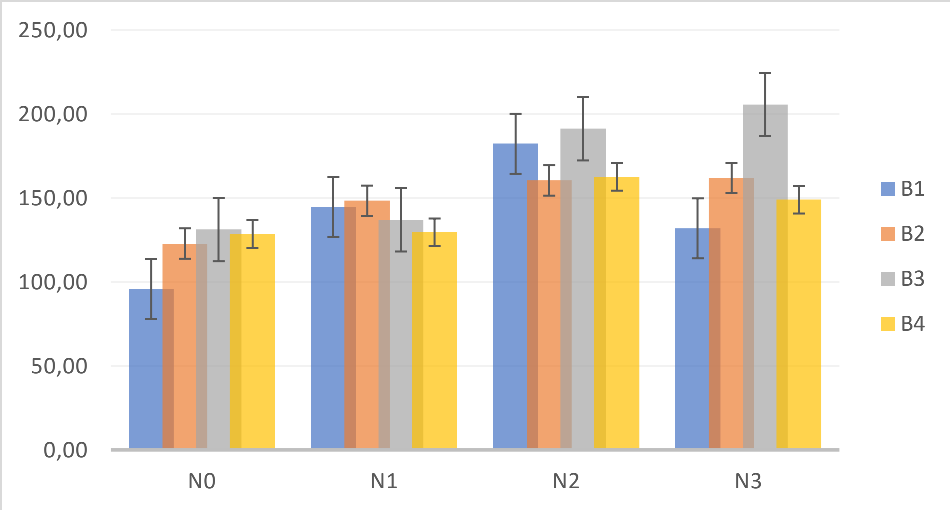

Figure 1. The effect of the interaction between NPK fertilizer and various types of biochar on fruit weight per plant

Consequently, the application of this N3B3 interaction demonstrates its potential to enhance the growth and yield of red chili plants. This finding contrasts with the study conducted by [17], which suggested that increasing the NPK fertilizer dose from 600 kg ha^{-1} to 900 kg ha^{-1} could enhance phosphorus (P) absorption, subsequently improving the growth and yield of red chili. Different treatments elicit distinct responses in terms of growth and outcomes, as supported by [18], emphasizing that nutrients stimulate overall plant development, contributing to growth and production.

The study further reveals that the application of biochar had a significant effect ($P < 0.05$) on the variables of the number of fruits and fruit weight while having no tangible effect ($P \geqslant 0.05$) on other variables such as plant height, number of leaves, number of branches, trunk diameter, fresh weight of roots, fresh weight of plants, dry weight of plants, and dry weight of roots. Hence, the application of coffee skin biochar at 10 t ha^{-1} demonstrated the potential to enhance yields in red chili plants, aligning with the findings of [19], emphasizing the influence of biochar on parameters related to the number of fruits and fruit weight.

Biochar, as a soil improver, possesses the ability to retain nutrients and water in the soil, supporting the provision of essential elements for plant growth. It exerts a real influence on fruit weight and the number of fruits due to its composition of beneficial compounds such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg). Consistent with the study by [20], biochar dosing treatments have a significant to very noticeable effect on onion growth and yield. Additionally, biochar contributes to soil moisture retention and fertility, and its effects can last for extended periods in the soil, aiding in reducing CO_2 emissions.

According to [21], the application of biochar has various positive impacts, including increasing soil pH, enhancing soil aggregate structure, improving soil moisture content, promoting soil's ability to supply essential nutrients such as calcium (Ca), magnesium (Mg), phosphorus (P), and potassium (K), stimulating soil microbial respiration, enhancing soil microbial biomass, increasing cation exchange capacity, and ultimately enhancing plant yield. Furthermore, biochar is acknowledged to augment the number of fruits and overall production outcomes in plants [22]. Previous research [23, 24] supports the notion that biochar application can elevate soil pH and cation exchange capacity in sandy clay soils in West Nusa Tenggara. Studies [25, 26] have affirmed that the addition of biochar enhances soil fertility and restores degraded soil quality. Therefore, the application of biochar, specifically from coffee skins and rice husks, has the potential to amplify production outcomes in red chili plants.

The study further demonstrated that the interaction between NPK fertilizer and agricultural waste biochar (NxB) had a significant effect ($P < 0.05$) on the variable plant height. The plant height results revealed the highest value of 132.67 cm in the interaction between the NPK fertilizer dose of 600 kg ha^{-1} and rambutan skin biochar 10 t ha^{-1} (N2B2), indicating a significant increase of 40.64%

compared to the lowest plant height obtained in the interaction without an NPK fertilizer dose but with biochar from rambutan skin 10 t ha^{-1} (N0B2), measuring 94.33 cm.

The results of soil analysis and the examination of various types of biochar (Table 1) reveal that the nitrogen content in both the soil and different biochar types is uniformly low. Conversely, the carbon, phosphorus, and potassium content in the soil and biochar is notably high. As a result, the utilization of NPK Mutiara fertilizer proves to be highly beneficial for supplementing nitrogen nutrients in the soil and biochar, thereby establishing a balanced nutrient profile essential for optimal growth and fruit weight yield in red chili plants. As highlighted by [7], nitrogen content plays a crucial role in stimulating plant growth, particularly in the development of stems and leaves. Additionally, nitrogen contributes to the formation of chlorophyll-rich green leaves, a vital component in the process of photosynthesis.

The interaction between NPK fertilizer and agricultural waste biochar (NxB) has demonstrated the potential to enhance growth and yield in red chili plants. Consequently, the combined application of NPK fertilizer and agricultural waste biochar exhibits a tangible influence on variables such as plant height, number of leaves, number of fruits, and fruit weight. By [27], the application of NPK Mutiara fertilizer expedites the decomposition of biochar by increasing soil microbial activity, transforming it into a source of organic matter, and resulting in a reduction in soil bulk density. Furthermore, [19] also emphasized that the use of biochar and additional NPK basic fertilizer can support the growth of cayenne pepper plants and various other types of vegetables. Moreover, [28] conducted research indicating that the interaction between the dose of NPK fertilizer and the dose of biochar significantly influences plant height, with the optimal combination being the application of NPK fertilizer at a dose of 400 kg ha^{-1} and a biochar dose of 20 ton ha^{-1}.

The utilization of biochar in agricultural practices is not a novel concept; however, consistent application of biochar on agricultural land has the potential to increase water availability and enhance soil quality. The incorporation of NPK Mutiara fertilizer further accelerates the breakdown of biochar through the activity of soil microorganisms. Inorganic fertilizers such as NPK Mutiara play a crucial role in meeting the nutritional needs of plants due to their high nutrient content, water solubility, and ease of absorption by plants.

4. Conclusion

The application of NPK fertilizer demonstrates a substantial to highly significant impact on all observed variables, except for stem diameter, root fresh weight, plant fresh weight, and root dry weight, where the effect is negligible. Conversely, biochar treatment exhibits no substantial impact on all observed variables, except for fruit weight and fruit count, where a tangible effect is observed. The interaction between NPK fertilizer and biochar does not yield a significant effect on all observed variables, except for plant height, number of leaves, number of fruits, and fruit weight, where the effect ranges from tangible to highly significant. The most notable result is the highest fruit weight of 205.70 g, achieved through the interaction between a 900 kg ha^{-1} NPK dose and biochar derived from coffee skin. This outcome is significantly distinct, representing a 114.72% increase compared to the lowest treatment obtained in the interaction between no NPK dose and biochar from rambutan, resulting in a fruit weight of 95.80 g.

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