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Optimizing Red Spinach (*Amaranthus tricolor*) Growth and Yield by Applying Organic and Inorganic Fertilizers

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ABSTRACT

The Red Spinach (*Amaranthus tricolor*) is a leafy vegetable plant admired for its vibrant red leaves and is commonly used in cooking for its visual appeal and rich nutritional value. This plant is popular in many parts of the world because it can thrive in different soil and climate conditions. This study aims to enhance the growth and productivity of Red Spinach (*Amaranthus tricolor*) plants through a mix of organic and inorganic fertilizers. The approach utilized in the study was a factorial Randomized Block Design (RAK) with two primary factors: factor K, which represents organic fertilizer from cow dung, and factor P, which represents inorganic fertilizer NPK Mutiara 16:16:16. Each factor is subjected to three treatment levels, with three replications conducted to ensure the validity of the research results. The research findings indicated no significant distinction between the two treatments, whether using organic fertilizer (K factor) or inorganic fertilizer (P factor). This result indicates that using a combination of cow dung organic fertilizer and inorganic NPK fertilizer does not significantly affect the growth and yield of Red Spinach plants. In summary, the utilization of both organic fertilizer from cow dung and inorganic fertilizer NPK Mutiara 16:16:16 in this research did not result in a significant variation in the growth and yield of Red Spinach. Therefore, future research could explore other factors influencing crop yields, such as the interaction between soil type and specific environmental conditions, to obtain a more effective fertilization strategy.

Keywords: *Inorganic Fertilizer, Factorial Randomized Block Design (RAK), Mutiara NPK Fertilizer 16:16:16, Organic Fertilizer, Red Spinach (Amaranthus tricolor)*

1. INTRODUCTION

Red spinach, scientifically known as *Amaranthus tricolor*, is a variety of spinach characterized by its red-hued foliage. According to Zega et al. (2023), this particular plant is renowned for its considerable nutritional value, encompassing notable vitamin A, C, iron, calcium, and protein levels. The red hue of spinach leaves results from the pigment betacyanin, which is also endowed with antioxidant properties. According to Sholihah and Sugianto (2023), red spinach is commonly employed in various culinary preparations, including stir-fried as a vegetable, incorporated into salads, and added as an ingredient in soups. This particular plant species thrives in tropical and subtropical regions and can be easily cultivated in various soil types, provided it receives ample sunlight and sufficient moisture. In addition to its nutritional advantages, red spinach also shows promise as a plant with medicinal properties (Raja *et al*., 2021). The significant levels of antioxidants found in it have the potential to combat free radicals within the body, thus aiding in the prevention of a variety of degenerative diseases. According to research, red spinach extract is believed to possess anti-cancer and anti-inflammatory properties. This particular plant demonstrates rapid growth, allowing for harvesting within a 25-30 day period post-planting, thus rendering it a viable option for cultivation on both a small and large scale. Red spinach is widely favored by both farmers and consumers who prioritize health because of its abundant benefits and relatively simple care requirements (Putri *et al*., 2024).

The combination of NPK 16:16:16 fertilizer and cow dung fertilizer has proven to be an effective method for promoting the growth of red spinach plants. The NPK 16:16:16 fertilizer comprises balanced proportions of nitrogen (N), phosphorus (P), and potassium (K), essential for the overall growth and development of plants. Nitrogen plays a vital role in protein synthesis and affects the development of plant leaves, phosphorus contributes to root development and the transfer of energy within plants, and potassium enhances plant resistance to disease and environmental stress. Applying the appropriate amount of NPK 16:16:16 fertilizer can adequately support the nutritional needs of red spinach plants from the vegetative growth stage through to the production phase (Wisnubroto *et al*., 2024). In addition, cow manure is rich in essential nutrients like nitrogen, phosphorus, and potassium, and it harbors beneficial microorganisms that contribute to the overall well-being of the soil. According to a study by Angkur et al. (2021), organic matter in cow dung fertilizer has been shown to enhance soil structure and water retention capacity, thereby decreasing the necessity for irrigation in red spinach cultivation. By utilizing a blend of NPK 16:16:16 fertilizer for comprehensive chemical nourishment and cow dung fertilizer for enhancing soil quality through biological means, farmers can attain superior growth and increased yields from red spinach crops (Steven cipta putra, 2022).

According to a study by Andriani Luta and colleagues (2020), the soil utilized in the cultivation of red spinach plants may encounter various challenges that can impact the overall health and output of the plants. An issue commonly encountered in the context of soil quality is the presence of soil acidity or an unsuitable pH level. Red spinach typically thrives in soil with a pH level between 6 and 7, considered neutral to slightly acidic. An excessively acidic or alkaline soil environment can impede plants' uptake of vital nutrients such as iron and phosphorus, thereby hindering the growth and development of red spinach plants. Another issue arises from the soil's density or its inadequate texture. Soil with high clay content can restrict root expansion and hinder proper water drainage, accumulating excessive water that can potentially harm plant roots. Conversely, soil with an excessive sandy composition may exhibit reduced water retention capabilities, making plants more susceptible to drought conditions (Pertami et al., 2022). Selecting a soil type suitable for the growth of red spinach plants and implementing proper soil management practices, such as effective tillage and the addition of organic materials to enhance soil structure, can effectively address this issue and enhance the overall growth quality of red spinach plants (Kharolina *et al*., 2023).

In the face of various problems affecting the growth of red spinach plants, such as problems in fertilizer use and non-ideal soil conditions, research on the use of NPK 16:16:16 fertilizer and cow dung organic fertilizer is relevant and essential to conduct. NPK 16:16:16 fertilizer offers a balanced combination of nitrogen, phosphorus, and potassium, which are essential for the growth of red spinach plants from the vegetative stage to production. With the right dosage, this fertilizer can help increase the availability of plant nutrients, improve disease resistance, and promote balanced development of the roots, leaves, and yield of red spinach plants (Kustiawan *et al*., 2024). Similarly, the utilization of organic fertilizers like cow dung offers noteworthy advantages. Cow dung consists of essential natural nutrients such as nitrogen, phosphorus, and potassium, along with beneficial microorganisms that contribute to the overall well-being of the soil. Furthermore, using this natural fertilizer aids in enhancing the composition of the soil and its ability to retain moisture. This usage is essential for enhancing the accessibility of nutrients for red spinach plants and reducing the impact of unfavorable soil conditions (Raksun et al., 2019). Through a methodical and regulated investigation into the impact of a blend of NPK 16:16:16 fertilizer and cow dung organic fertilizer on the development of red spinach plants, the aim is to identify a practical approach for enhancing the yield of this plant across different soil and environmental circumstances.

2. MATERIAL AND METHODS

2.1 Research Time and Place

The research will be conducted in Bakaran Batu Village, South Ranatau District, Labuhanbatu Regency, on Jln. Kihajar Dewantara with coordinates 2.1780° N, 99.8240° E. The research will take two months, from January 2024 to March 2024.

2.2 Tools and Materials

The supplies used are water, polybags 1 kg (20 cm × 25 cm), burnt rice husks, cow dung, and NPK Mutiara 16:16:16 fertilizer. Equipment used includes sign boards, buckets, a camera, writing tools, a laptop, shade nets, measuring cups, a hoe, measuring tape, plastic string, scissors, and shade.

2.3 Research Method

This study employed a factorial Randomized Block Design (RAK) experimental design featuring two primary factors, each with three levels, and three replications were conducted (Lubis et al., 2019). The initial variable to consider is the quantity of cow manure (K), which is categorized into three levels: a control group without any manure (K0), applying 125 g of cow manure per polybag (K1), and applying 250 g of cow manure per polybag (K2). The second variable studied is the application of NPK Mutiara 16:16:16 (P) fertilizer, with three levels: a control group with no fertilizer (P0), an application of 3.75 g of Mutiara 16:16:16 NPK fertilizer per polybag (P1), and an application of 7.50 g of Mutiara 16:16:16 NPK fertilizer per polybag (P2). The experiment was conducted with each combination of factors K and P repeated in triplicate to ensure the validity and reliability of the results. This research aims to assess the impact of the simultaneous application of cow manure and NPK Mutiara 16:16:16 fertilizer on the development and harvest of red spinach crops. It is intended to determine the optimal combination that enhances plant output within a controlled experimental framework.

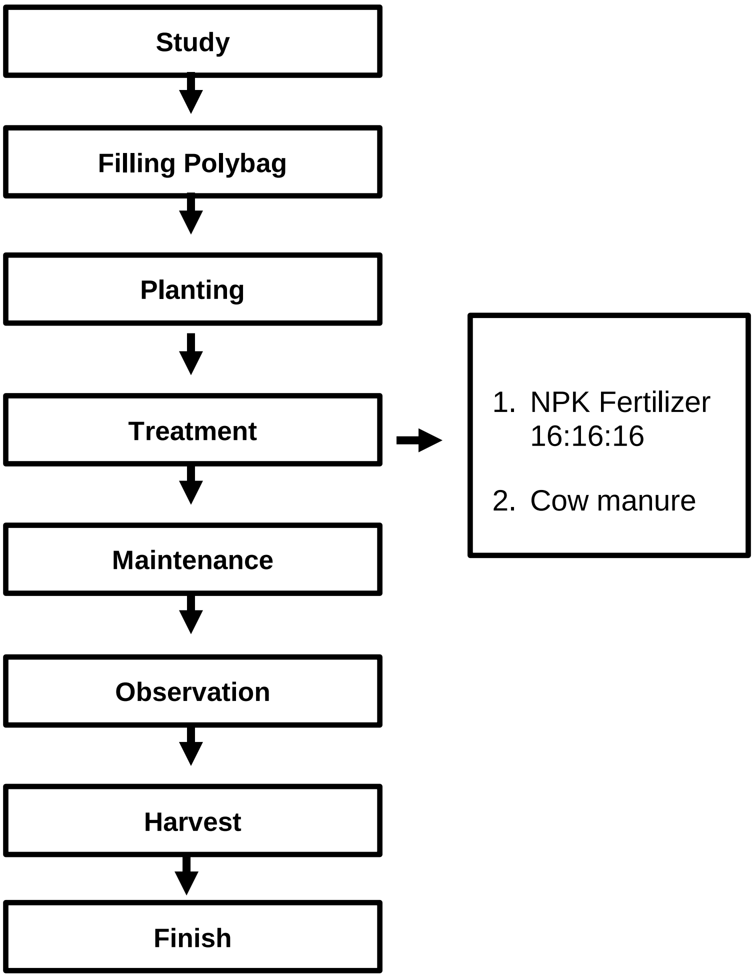

Figure 1. Research flow diagram

2.4 Research Parameter

This study utilizes three primary parameters to assess the growth and yield of red spinach plants: plant height, the number of leaves per plant, and the fresh weight of the plant. Plant height was measured to assess the level of support provided by each fertilizer treatment for the vertical growth of red spinach. The assessment of vegetative development in plants, which serves as an indicator of their overall health and productivity, is conducted through the counting of leaves per plant. The measurement of fresh-weight crops is conducted to evaluate the overall yield of the crop, serving as an indicator of both photosynthetic efficiency and biomass accumulation. The research is intended to thoroughly understand the impact of a mixture of cow manure and NPK Mutiara 16:16:16 fertilizer on the development and productivity of red spinach plants, utilizing these standards.

2.5 Data Analysis

If there is a significant effect in this study, it will be analyzed using Analysis Of Variance (ANOVA) (Xie 2023) (Parasmita et al. 2022).

3. RESULT AND DISCUSSION

3.1 Plant Height

Table 1 displays the data on the average plant height based on field. The results of termite mortality observations can be seen in Table 1.

Based on the results of observations in the field, the average plant height is as follows:

Table 1. Average plant height

TREATMENT	1 Mst	2 Mst	3 Mst	4 Mst
K0P0	3.1 ± 0.15	7.06 ± 0.35	10.1 ± 0.45	16.06 ± 0.55
K0P1	3.6 ± 0.12	7.7 ± 0.32	10.7 ± 0.42	17.13 ± 0.52
K0P2	4.03 ± 0.14	8.8 ± 0.33	11.63 ± 0.43	18.36 ± 0.53
K1P0	3.2 ± 0.13	7.26 ± 0.34	10.5 ± 0.44	16.56 ± 0.54
K1P1	3.7 ± 0.16	8.56 ± 0.35	11.53 ± 0.45	17.6 ± 0.55
K1P2	4.3 ± 0.17	9.23 ± 0.36	12.46 ± 0.46	19.2 ± 0.56
K2P0	3.56 ± 0.18	7.56 ± 0.37	10.9 ± 0.47	17.2 ± 0.57
K2P1	4.1 ± 0.19	8.53 ± 0.38	11.9 ± 0.48	18.53 ± 0.58
K2P2	4.8 ± 0.20	9.73 ± 0.39	13.6 ± 0.49	19.56 ± 0.59

After that, it continued with the analysis of variance using SPSS 25, presented in Table 2. Based on the results of the variance analysis with treatment values > 0.05, plant height was stated to be not significantly different, and no further testing was needed.

Table 2 . Results of variance analysis

Tests of Between-Subjects Effects

Dependent Variable: Plant Height

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	35.397[a]	8	4.425	.126	.998
Intercept	3966.900	1	3966.900	113.238	.000
PERL	35.397	8	4.425	.126	.998
Error	945.853	27	35.032		
Total	4948.150	36			
Corrected Total	981.250	35			

a. R Squared = ,036 (Adjusted R Squared = -,250)

3.2 Total Leaves

Table 3 displays the average number of leaves obtained from field measurements. Based on field observations, there is an average number of leaves. After that, we continued with the analysis of variance using SPSS 25, and presented in Table 4.

Table 3. Average number of leaves

TREATMENT	AVERAGE NUMBER OF LEAVES			
	1 Mst	2 Mst	3 Mst	4 Mst
K0P0	2 ± 0.1	3.93 ± 0.2	6.23 ± 0.3	8.4 ± 0.4
K0P1	2.5 ± 0.2	4.5 ± 0.3	7.16 ± 0.4	9.03 ± 0.5
K0P2	3 ± 0.1	5 ± 0.2	8.23 ± 0.3	9.76 ± 0.4
K1P0	2.33 ± 0.2	4.13 ± 0,3	6.46 ± 0.4	8.5 ± 0.5
K1P1	3 ± 0.1	4.73 ± 0.2	7.36 ± 0.3	9.6 ± 0.4
K1P2	3 ± 01	5.3 ± 0.2	7.9 ± 0.3	10.43 ± 0.4
K2P0	2 ± 0.1	4.3 ± 0.2	6.53 ± 0.3	8.4 ± 0.4
K2P1	2.5 ± 0,2	4.83 ± 0.3	7.53 ± 0.4	9.73 ± 0.5
K2P2	3 ± 0,1	5.53 ± 0.2	8.2 ± 0.3	10.66 ± 0.4

Based on the analysis of variance with a treatment value > 0.05, the number of leaves was not significantly different, and no further testing was needed.

3.3 Plant Fresh Weight

Table 5 displays the findings of the average fresh weight of plants based on observations made in the field. The results of the ANOVA variance test are presented in Table 6.

Based on the results of fingerprint analysis, varieties with a treatment value > 0.05 in the number of leaves were declared not significantly different, and no further testing was required.

Table 4. Results of variance analysis

Tests of Between-Subjects Effects

Dependent Variable: NUMBER OF LEAVES

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	14.216[a]	8	1.777	.199	.989
Intercept	1291.204	1	1291.204	144.646	.000
PERL	14.216	8	1.777	.199	.989
Error	241.020	27	8.927		
Total	1546.440	36			
Corrected Total	255.236	35			

a. R Squared = ,056 (Adjusted R Squared = -,224)

Table 5. average fresh weight of plants

TREATMENT	AVERAGE NUMBER OF LEAVES			
	1 MST	2 MST	3 MST	4 MST
K0P0	50.5±12.72	61.5±12.72	71.4±12.72	80±12.72
K0P1	54.3±12.85	66.3±12.85	75±12.85	84.5±12.85
K0P2	53±13.04	63.6±13.04	73.4±13.04	83.4±13.04
K1P0	48.4±12.95	59.2±12.95	69.4±12.95	78.4±12.95
K1P1	54.2±12.79	64.5±12.79	74.2±12.79	84±12.79
K1P2	50.5±12.69	50.2±12.69	70±12.69	80.5±12.69
K2P0	51.2±13.42	61±13.42	72.5±13.42	82.3±13.42
K2P1	48.6±12.51	58.4±12.51	68.6±12.51	77.5±12.51
K2P2	53.2±13.11	65.7±13.11	75.3±13.11	83.7±13.11

Table 6. Results of variance analysis

Tests of Between-Subjects Effects

Dependent Variable: FRESH WEIGHT OF PLANT

Source	*Type III Sum of Squares*	df	*Mean Square*	F	Sig.
Corrected Model	42.495[a]	8	5.312	.076	1.000
Intercept	3186.603	1	3186.603	45.551	.000
PERL	42.495	8	5.312	.076	1.000
Error	1888.852	27	69.957		
Total	5117.950	36			
Corrected Total	1931.347	35			

a. R Squared = ,022 (Adjusted R Squared = -,268)

3.4 Plant Height

The findings from the analysis of variance, indicating a treatment value below 0.05, suggest that there is no statistically significant difference in plant height. This demonstrates that the treatment does not significantly affect the growth and development of the plants. Consequently, the analysis of variance provided adequate evidence to support the conclusion that there were no notable variations in plant height, eliminating the need for additional tests to evaluate differences among the various treatments. In this particular instance, a small significance value suggests that the disparities in plant height are probably a result of chance variability or inherent changes in plant development, as opposed to being influenced by the administered treatment. These results enhance our comprehension of the impact of specific elements on plant development and provide a basis for further investigations into identifying additional factors that could significantly affect plant growth in future research.

3.5 Total Leaves

The variance analysis results indicated no statistically significant difference in the number of leaves, as the treatment value was below 0.05. This demonstrates that the treatment applied does not significantly impact the plant's capacity to increase the number of its leaves. The variance analysis of the data demonstrated no notable variation in leaf number, thus obviating the need for additional testing to identify differences among the different treatments. The results indicate that the differences in leaf quantity are probably influenced by factors unrelated to the treatments examined, such as environmental conditions or genetic factors. These results may serve as a foundation for future research to obtain a more comprehensive understanding of the factors impacting the leaf count of a plant. A more comprehensive comprehension of these variables will facilitate formulating more effective strategies to enhance overall plant growth.

3.6 Plant Fresh Weight

There was no apparent variation in fresh plant weight according to the variant analysis findings with treatment values less than 0.05. This indicates that the treatments did not significantly impact plant growth, as measured by fresh weight. Therefore, the variant analysis findings are sufficient to conclude that there is no significant variation in fresh plant weight, eliminating the need for additional testing to assess differences between various treatments. This discovery suggests that factors other than the treatments tested may be more dominant in influencing plant fresh weight, such as genetic factors or environmental conditions. These findings can serve as a basis for future investigations to discover additional elements that significantly impact plant fresh weight. More efficient tactics for increasing total crop yield can be developed by gaining a deeper understanding of these variables.

4. CONCLUSION

This study aimed to investigate the impact of the application of cow dung fertilizer and NPK pearl fertilizer 16-16-16 on the growth and productivity of red spinach plants. The analysis results indicated no notable difference in plant height, leaf count, or fresh weight among the various treatments. This demonstrates that the growth and productivity of red spinach crops are not substantially impacted by the concurrent application of cow manure and NPK pearl fertilizer 16-16-16. This study holds practical significance in fertilizer management for red spinach plants. Even though the incorporation of cow dung into pearl NPK 16-16-16 fertilizer does not enhance plant growth and yield, it remains crucial to comprehend the impact of fertilizers on plant responses. These results could also serve as a foundation for future studies on optimizing the variety and quantity of fertilizer administered to red spinach and other plant species. Consequently, this study substantially enhances the productivity of crops and the efficiency of fertilizer usage within the agricultural industry.

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