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Application of Cow Manure Bokashi Fertilizer to Nutrients of Top Soil Oxisol Planting Media with the Growth and Yield of Red Spinach (*Amaranthus tricolor* L.)

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ABSTRACT— Red spinach is a favorite vegetable of the Indonesian people because it has a fairly high nutritional content. However, its productivity has decreased due to the reduction of soil nutrients and the use of chemical fertilizers (inorganic) by farmers, in addition to the type of soil that is generally used for planting in Sorong Regency, West Papua, namely the type of oxysol soil that has progressed. Weathering with high content is undoubtedly due to high rainfall. For this reason, this study was conducted to determine the growth response and yield as well as the best dose of bokashi fertilizer to optimize the growth and yield of red spinach (Amaranthus tricolor L.) in Oxisol soil in Sorong Regency. This study used a single factor with a randomized block design consisting of 4 levels of treatment. Each treatment was repeated 3 times to obtain 12 experimental trials. The dosage of bokashi fertilizer treatment is as follows: P0= bokashi fertilizer 20 g/polybag; P1= bokashi fertilizer 40 g/polybag; P2= bokashi fertilizer 60 g/polybag; and P = 80 g/polybag of bokashi fertilizer. The results showed that the application of bokashi fertilizer on Oxisol topsoil planting media significantly affected the growth and yield of red spinach and the nutrient content of Oxisol growing media also increased after harvest. Treatment of 80 gr bokashi fertilizer (P3) gave optimal results and the best production with a plant height of 51.5 cm, a number of leaves 13.3 strands, and a wet weight of 19.4 gr.

KEYWORDS: bokashi fertilizer, oxisol, red spinach.

1. INTRODUCTION

Red spinach is one of the most popular types of vegetables in Indonesia. According to [1], the increasing public interest in vegetables, especially red spinach, is due to the high nutritional content. Judging from its nutritional content, red spinach is a type of vegetable that has many benefits for health and body growth, especially for children because it contains iron, vitamins, and minerals.

In Indonesia, red spinach production in 2014 reached 134,159.1 tons on a land area of 39,619 ha, in 2015 red spinach production on 42,138 ha of land was 150,084.5 tons, in 2016 a land area of 43,456 ha reached 160,247.1 tons, in 2017 with a land area of 40,608 ha and a production of 148,288.5 tons, and in 2018 a land area of 39,619 ha with a production of 162,263.4 tons [2]. From these data, it can be seen that there is an increase in the area of land every year followed by an increase which has increased, but if the addition only increases because the area of land increases. This means that there is no optimization of land area with low production due to the low nutrient content in the soil and the use of inorganic fertilizers. Spinach plants can be planted in wet or cold land with the addition of fertilizers to add nutrients to the soil. Based on its use, there are two kinds of fertilizers, namely organic fertilizers and inorganic fertilizers. Both of these fertilizers have their advantages and disadvantages in developing plants. Organic fertilizers have the advantage of being able

to improve the biological, physical, and chemical properties of the soil, while the advantages of inorganic fertilizers are that they are easy to decompose and can be directly absorbed by plants so that growth becomes more fertile. However, on the other hand, inorganic fertilizers have weaknesses, namely, they are expensive and add to physical, biological, and chemical damage to the soil. Bokashi (organic material rich in biological resources) is an organic fertilizer produced from the fermentation of organic materials such as compost and manure by utilizing decomposing microorganisms such as fermenting microbes or fungi. The result is solid fertilizer in a decomposed condition so that it contains more macro-nutrients (N, P, K, Mg, S, and Ca) and micronutrients (Zn, B, Fe, Cu, Mn, Mo, and Cl). easily absorbed by plant roots.

In a previous study conducted by [3], the application of bokashi fertilizer on mustard greens with a dose of 80gr/polybag of bokashi fertilizer showed the results had a significant effect on plant height, a number of leaves, and net weight of mustard plants. This shows that the application of bokashi can increase the concentration of nutrients in the soil, especially N, P, and K as well as other nutrients, and can improve air and groundwater systems, including Oxisol soils, which are old types of soils with high clay accumulation and high clay content. low in nutrients contains high levels of iron oxides and AL oxides. The lack of nutrients in Oxisol soil can be improved by the application of organic fertilizers such as bokashi solid fertilizer. For this reason, this study was conducted to determine the growth response and yield as well as the best dose of bokashi fertilizer to optimize the growth and yield of red spinach (Amaranthus tricolor L.) on Oxisol soil in Sorong Regency.

2. MATERIAL AND METHODS

This research was carried out in Majener Village, Salawati District, Sorong Regency, and soil sample analysis was carried out at the Chemistry and Soil Fertility Laboratory, Department of Soil Science, Faculty of Agriculture, Hasanuddin University. The research was carried out from September 2020 to February 2021.

The tools used in this research are a watering pot, scales, tape measure/ruler, plastic bag, soil drill, scissors, camera, stationery, and a set of laboratory equipment. The materials used in this study were red spinach seeds, solid bokashi fertilizer.

This study used a single factor with a randomized block design consisting of 4 levels of treatment. Each treatment was replicated 3 times to obtain 12 experimental units. The treatment dose of bokashi fertilizer is as follows: P0 = bokashi fertilizer 20 g/polybag; P1 = bokashi fertilizer 40 g/polybag; P2 = bokashi fertilizer 60 g/polybag; and P3 = 80 gr/polybag bokashi fertilizer. The mathematical model in this study is a one factorial Randomized Block Design (RBD) [4].

Research Implementation includes 1) Preparation of planting media: Preparation of planting media was carried out by taking Oxisol topsoil samples by cleaning the soil surface from the existing litter, then sifted and put into polybags measuring 17.5 x 40 cm. 2) Analysis of initial soil samples (before planting): Oxisol soil samples, which are planting media, were taken for initial soil analysis, ± 1kg, 3) Seed preparation: The red spinach seeds used were red spinach varieties BA 124. The seeds were soaked in water to select quality seeds. The seeds that float are discarded and what is taken for seedlings is the submerged seeds. 4)Planting: Planting is done when the seedlings are 7 days old and have a height of 3 cm to 6 cm with planting time in the afternoon. This is so that plants can adapt to the environment so they do not experience stress due to direct sunlight. 5) Fertilization: Fertilization was carried out when red spinach was 2 and 3 weeks after planting (WAP). Fertilization is done by sowing bokashi fertilizer into polybags. 6) Weeding: The purpose of weeding is to clean nuisance plants (weeds). Weeding is done every 2 weeks. Weeding is done by pulling weeds. 7) Watering: After the seeds are planted, watering is carried out every day, namely in the morning and evening.

The tool used is a watering pot measuring 5 liters. 8) Pest and disease control: Pest and disease control can be adjusted according to the level of attack in the field. 9)Harvesting: harvesting is done when the plant is 4 weeks old. 10) Analysis until the final ground: analysis until the final soil by taking soil in polybags of plants whose red spinach plants have been harvested first. Soil samples were taken for the four treatments with 1kg.

Observation Variable: Observations were made on the growth variables of red spinach plants. The observed variables include 1) Plant height: observation of plant height was measured from the base of the stem to the highest part of the plant. Measurements were made when the plants were 1 to 4 weeks after planting; 2) a number of leaves: the number of leaves was calculated by counting the number of fully opened leaves of red spinach plants aged 1 to 4 weeks after planting; and 3) weight of plant wet furnace: wet stover weight was weighed at the time of harvest with a plant age of 4 weeks.

Data analysis: The results of the next study were analyzed using an analysis of variance (ANOVA). If there is a real influence from the treatment, then it is continued with Honest Significant Difference (HSD) at a 5% confidence level.

3. RESULT AND DISCUSSION

From the results of the analysis of soil samples in the laboratory and the status of soil fertility based on the criteria for assessing soil properties, [5] can see the fertility results in table 1 below:

Table 1. Data Analysis of Soil Samples Before Planting and After Harvest

Soil Properties	Soil Properties Analysis Results				
	Soil Sample Before Planting	Soil Samples After Harvesting For Each Treatment			
		P0 (bokashi fertilizer 20 gr/polybag)	P1 (bokashi fertilizer 40 gr/polybag)	P2 (bokashi fertilizer 60 gr/polybag)	P3 (bokashi fertilizer 80 gr/polybag)
Soil Texture	Silty clay	Silty clay	Silty clay	Silty clay	Silty clay
pH	6,10 (slightlys-acidic)	6,32 (slightlys-acidic)	6,42 (slightlys-acidic)	6,45 (slightlys-acidic)	6,51 (slightlys-acidic)
C-organic (%)	1,66 (low)	1,97 (low)	2,45 (medium)	2,56 (medium)	2,62 (medium)
N (%)	0,12 (low)	0,14 (low)	0,17 (low)	0,18 (low)	0,21 (medium)
P_2O_5 Olsen-(ppm)	15 (low)	19,13 (low)	20,24 (low)	20,99 (low)	22,34 (low)
K (cmol kg^{-1})	0,15 (low)	0,30 (medium)	0,33 (medium)	0,35 (medium)	0,40 (medium)
Ca (cmol kg^{-1})	2,77 (low)	5,10 (medium)	5,28 (medium)	5,30 (medium)	5,43 (medium)
Mg (cmol kg^{-1})	1,72 (medium)	1,64 (medium)	1,97 (medium)	2,38 (height)	2,90 (height)
Na (cmol kg^{-1})	0,24 (low)	0,42 (medium)	0,52 (medium)	0,63 (medium)	0,78 (medium)

CEC (cmol kg^{-1})	15,98 (low)	18,79 (medium)	19,56 (medium)	20,43 (medium)	22,01 (medium)
Base Saturation (%)	27 (low)	34 (low)	36 (low)	42 (medium)	45 (medium)

Source: Primary Data After Processing, 2021.

Based on the data in table 1, the nutrient status of Oxisol planting media before planting was still in the low category with a loamy texture and slightly acidic pH. This is because Oxisol soil is soil that has undergone advanced weathering or what is called old soil with deep solum and has a high clay content but is not active so that its cation exchange capacity (CEC) is low, iron and aluminum oxide content is high, including acid soils and low availability of macro and micronutrients. This is by [6] that Oxisol is a mineral soil that is rich in the oxidation of iron and aluminum, has undergone advanced weathering, and is found in the area around the equator (intertropical region) and has special properties, namely very low nutrient reserves and natural fertility. very low. [7] added that oxisol soils are soils with advanced weathering and have oxic horizon boundaries, very high clay fraction, low cation exchange capacity, where the lower surface horizon contains a lot of iron and aluminum oxides so that the soil is less fertile but with proper fertilization and tillage can become productive soil. Due to the problem of Oxisol soil properties, the addition of bokashi fertilizer was given. From table 1 it can be seen that the soil properties after harvesting in each treatment increased, the more doses of bokashi fertilizer, the higher the soil nutrient status, even though the existing nutrients had been absorbed by the red spinach plant in the process of growth and development. This is due to the ability of Bokashi fertilizer to provide sufficient and available nutrients to plants, and can also improve soil properties. This is following [8] which states that the application of compost, especially bio boost can improve soil structure by increasing the content of soil organic matter. Added again by [9] that giving bokashi is one way to improve the physical, chemical, and biological properties of the soil to increase the quality and quantity of plant production. The application of organic inputs can stimulate the microorganism activities in the soil, which play their roles in decomposition process and mineralization of organic matters of the soil, so that they can increase essential nutrients availability in the soil. The importance of soil fertility analysis to assess the status of nutrients in the soil so that it helps in recommending the determination of plant types and recommendations for appropriate fertilization.

Table 2. Effect of Application of Cow Manure Bokashi Fertilizer on Plant Height of Red Spinach at the age of 2,3, and 4 Weeks After Planting (WAP).

Fertilization Treatment	**Plant Height (cm)**		
	2 WAP	**3 WAP**	**4 WAP**
P0= 20 gr bokashi/polybag	17,6 a	27,7 a	42,7a
P1= 40 gr bokashi/polybag	19,0 a	35,1 a	45,9a
P2= 60 gr bokashi/polybag	19,9 a	37,2 b	49,3b
P3= 80 gr bokashi/polybag	23,2 b	38,5 b	50,5b
HSD 0,05	3,7	8,2	3,3

Note: The numbers followed by the same letter in the same column show that they are not significantly different based on the 5% HSD test.

Based on the further HSD test in the table above, it shows that the dose of bokashi fertilizer for P0, P1, and P2 treatments was significantly different from P3 treatment at the age of 2 WAP, and at 3 and 4 WAP, the PO and P1 treatments were significantly different from P2 and P2. P3, this is a real difference, giving bokashi dirt on Oxisol soil affects each treatment. Bokashi manure fertilizer has a significant effect on plant height. This is because the content of bokashi fertilizer contains microorganisms that can increase soil fertility to stimulate

the plant growth process. This is in line with [11] that bokashi fertilizer, which is a fermented organic matter combined with microbial stock, have been reported as a potential agricultural practice to enhance the farming land and crop production and it's containing microorganisms which are integral to the soil, capable of providing nutrients from plants through the recycling process as well as soil structural elements suitable for plant growth. The results of the HSD test with a level of 0.05 showed that the administration of bokashi fertilizer with P3 treatment responded better to red spinach plants with an average plant height of 50.5 cm at the age of 4 WAP.

Table 3. Effect of Application of Cow Manure Bokashi Fertilizer on Number of Leaves of Red Spinach at the age of 2,3, and 4 Weeks After Planting (WAP).

Fertilization Treatment	Number of Leaves (strands)		
	2 WAP	3 WAP	4 WAP
P0= 20 gr bokashi/polybag	4,0 a	5,3 a	8,0 a
P1= 40 gr bokashi/polybag	6,7 b	6,7 b	10,0 a
P2= 60 gr bokashi/polybag	6,3 b	8,0 b	12,0 b
P3= 80 gr bokashi/polybag	7,7 b	9,3 c	13,3 b
HSD 0,05	2,2	1,3	3,6

Note: The numbers followed by the same letter in the same column show that they are not significantly different based on the 5% HSD test.

Based on the results of the HSD further test in table 3, it shows that the application of bokashi fertilizer on the number of leaves of red spinach plants was significantly different between P0 and P1, P2, and P3 at week 2 after planting. At 3 MST P1 and P2 were not significantly different, but significantly different from P0 and P3, then at week 4 where P0 and P1 were not significantly different, as were P2 and P3. The results of data analysis using ANOVA showed that the application of bokashi fertilizer to the highest number of red spinach leaves was in treatment P3 while the lowest average was in treatment P0. This is because the availability of nutrients increases with the level of treatment given. After all, cow dung bokashi fertilizer contains complete nutrients, especially nitrogen. We can see this in the analysis of the median nutrient status of Oxisol in table 1, the soil analysis before planting showed that the N 0.12% and K 0.15% content were still relatively low but during the application of bokashi fertilizer, cow dung in the planting media. The increase in nutrients after harvest was increased. The growth of the number of leaves is related to the role of nitrogen as a component of chlorophyll, this is by [12] who states that increasing levels of nitrogen in the soil are associated with the formation of chlorophyll in the leaves, thereby increasing the photosynthesis process which stimulates the increase in the number of plant leaves. The K nutrient is 4.47% which affects the process of leaf formation, where plants need potassium nutrients in the formation of carbohydrates to produce a large number of leaves. [13] who states that leaves that have high chlorophyll contents are more efficient in capturing sunlight energy for photosynthesis. Greener leaves have higher chlorophyll content, and wider leaf surfaces contain more chlorophyll. The investment of photosynthetic results in vegetative organs that greatly determines productivity at the next level of development, namely generative and crop yields.

Table 4. Effect of Application of Cow Manure Bokashi Fertilizer on Wet Weight (gr) of Red Spinach at the age of 2,3, and 4 Weeks After Planting (WAP).

Fertilization Treatment	Wet Weight (gr)
P0= 20 gr bokashi/polybag	8,8 a
P1= 40 gr bokashi/polybag	17,7 b
P2= 60 gr bokashi/polybag	18,0 b

P3= 80 gr bokashi/polybag	19,4 b
HSD 0,05	3,9

Note: The numbers followed by the same letter in the same column show that they are not significantly different based on the 5% HSD test.

Results Based on the HSD in Table 4, it shows that the dose of bokashi fertilizer on the wet weight of spinach plants with P0 treatment was significant with P1, P2, and P3 treatments. The highest plant weight of dry matter was obtained in the P3 treatment, this indicates that the higher the level of bokashi fertilizer, the higher the production. The high production of fresh plant weight in bokashi fertilizer treatment was due to the availability of nutrients, namely N, P, and K in the soil from bokashi fertilizer which was then used for red spinach plant growth until harvest. This is following [14] that the nutrient content of N, P, and K greatly affects the level of soil fertility. [15] added that the nutrient N (nitrogen) contained in the soil functions for the formation and growth of vegetative plant parts, such as leaves, stems, and roots, besides that the N element does not work to increase overall plant growth. There is an increase in biomass because plants absorb more air and nutrients, nutrients stimulate the development of organs in the roots so that plants can absorb plants such as nutrients and air more, then the photosynthetic activity will increase and affect the increase in plant weight.

4. CONCLUSION

Based on the results of this study it can be concluded that:

1) Application of bokashi fertilizer on Oxisol top soil planting media had a significant effect on the growth and yield of red spinach.
2) There was an increase in nutrients in Oxisol top soil planting media after planting.
3) Treatment of 80 gr (P3) bokashi fertilizer gave optimal results and the best production with a plant height of 51.5 cm, number of leaves 13, 3 strands, and a wet weight of 19, 4 gr.

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