Vol. 12, No. 3 (2023) : 665 - 675
DOI : http://dx.doi.org/10.23960/jtep-l.v12i3.665-675

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Moringa Growth Response in Treatment of Bokashi Composition and Dosage of Moringa Leaf (*Moringa oleifera*) Using Subsoil

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Article History :

Received : 1 February 2023
Received in revised form : 7 March 2023
Accepted : 23 March 2023

Keywords :
Bokashi,
Composition,
Dosage,
Moringa leaves,
Moringa seedling.

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ABSTRACT

Subsoil soil which is at a depth of more than 30 cm below the topsoil is a marginal soil for agricultural cultivation but has great potential for utilization. Improvement of subsoil soil with the use of organic fertilizers alone has been widely carried out. However, the use of moringa leaf bokashi fertilizer is thought to be able to improve the subsoil physically and chemically. The aim of the research was to find out the composition of the best moringa leaf bokashi fertilizer and the right dosage for the growth of moringa. Research using Completely Randomized Design. The first factor was the composition of moringa leaf bokashi, biochar and cow manure (K), namely K1 ratio of moringa leaves: biochar: cow manure (1:1:1); K2: (2:1:1); K3 (3:1:1). The second factor is the dose of moringa leaf bokashi fertilizer. Bo: control 5; B1:10; B2: 20; B3: 30; B4: 40 tons per hectare. The results showed that the K1 composition showed the highest plant height, number of primary roots, and canopy wet weight. A dose of 10 tons per hectare (B1) showed the best growth of Moringa seedlings with the highest dry weight of canopy.

1. INTRODUCTION

Topsoil has the best physical, chemical and biological soil properties and contains a lot of organic matter compared to sub-soil. The continuous use of topsoil and its location on the soil surface causes frequent erosion, so an alternative is needed to replace top soil, namely using subsoil (Firmansyah *et al*., 2020). Subsoil is located in the second layer after topsoil, this soil layer has great potential and is rarely used, but low fertility (Andri *et al*., 2016). Hidayat *et al*. (2020) stated that subsoil is a type of soil that is not good for use as a planting medium if it is not corrected first. This is caused by soil acidity, nutrient availability, and insufficient organic matter content for plants. Acidity in subsoil soil is caused by the high aluminum content in the soil, which disrupts nutrient uptake (Dalimointhe, 2013). Mukhtarruddin *et al*. (2015) stated that subsoil with poor soil characteristics can be improved by using organic fertilizers.

Tambunan *et al*. (2014) stated that the role of organic fertilizers can improve soil structure and reduce erosion and can provide nutrients for plants. Improvement of subsoil is done by adding organic matter to make the soil better. Organic materials derived from plant waste and livestock waste can be used as organic fertilizer. Bokashi is an organic fertilizer produced from the fermentation of organic materials by utilizing the help of decomposing microorganisms and the result is organic fertilizer in decomposed conditions containing more macro and micro nutrients which are ready to be absorbed by plant roots (Tallo & Sio, 2019). Differences in the composition and types of raw materials used to make bokashi will result in different nutrient content (Nurseha *et al*., 2015).

Moringa (*Moringa oleifera*) is a garden plant that is widely grown in Indonesia areas. This plant is a long-lived tree-sized plant reaching a height of 12 m, small egg-shaped leaves, 1-3 cm long and 4 mm to 1 cm wide, blooms all year round with white, cream, or red flowers depending on the species (Isnan & Nurhaeidah, 2017). The benefits of this plant are numerous, namely as medicine and food ingredients. Moringa leaves are used to prevent disease (Misrah *et al*., 2016).

Moringa plants that are propagated using seeds require fertile planting media at the beginning of their growth (Isnan & Nurhaedah, 2017). The use of subsoil that is not fertile can be used as a planting medium after being treated with Moringa leaf bokashi fertilizer. Moringa leaves that cannot be used for food and medicine are used as ingredients to make bokashi (Lubis *et al*., 2019). In making moringa leaf bokashi rice husk should be added as a mixture in order to produce good bokashi. However, processing rice husks into biochar and added as a basic ingredient for making bokhasi can provide nutrients for plants more quickly (Widiastuti & Lantang, 2017).

The use of cow manure into the soil will regulate the temperature of soil moisture in and on the ground (Arifah, 2013). Cow manure helps meet the need for nutrients (Prastyo, 2014). Cow manure can be absorbed more quickly by plants (Yuliana *et al*., 2015). Treatment with a dose of 15 tons per hectare of bokashi cow manure without a mixture of other ingredients accelerates the chili plants to flower (Kusuma *et al*., 2021). Whereas the dose of palm frond bokashi with the addition of Moringa leaves of 20 tons per hectare gave better results on red chili plants (Kinasih *et al*., 2021). Ramadhani *et al.* (2020) reported that giving 20 ton/ha of cow manure and 20,000 L/ha of pineapple liquid waste contributed to phosphate-dissolving microorganisms that were able to improve utisol soil. The application of cow manure and biochar independently has been carried out for soil improvement, but the combination of the cow manure and biochar with the addition of moringa leaf bokashi is expected to improve the quality of fertilizer produced.

The demand for moringa plants is increasing due to their benefits and uses, and it is necessary to improve cultivation techniques. Moringa cultivation techniques include selecting suitable planting media, using good seeds, and providing organic matter (Hilal *et al*., 2018). The role of the planting medium determines the quality of roots; good rooting media will produce good plants (Ningsih, 2014). Hence, the study aimed to determine the effect of moringa leaf bokashi composition and dosage, as well as to identify the best composition for making Moringa leaf bokashi fertilizer and the proper dosage for moringa growth. Moringa leaf waste which is available in large quantities as a result of the expansion of moringa plants allows for the continuity of making moringa leaf bokashi which will be returned to agricultural land in an effort to sustainably cultivate moringa plants.

2. MATERIALS AND METHODS

The research was conducted from January 2021 to April 2021 in Sembayat Village, East Seluma District, Seluma Regency, Bengkulu Province. The materials to be used in this study were Moringa seeds, subsoil, Biochar, EM4, manure, molasses, Moringa leaves, polybags, tissue. The tools that will be used in this study are hoes, machetes, buckets, plastic trays, scissors, pegs, labels, ropes, stationery, measuring instruments, ovens, tarpaulins, cameras, and other supporting tools.

2.1. Research Design

This study used a completely randomized design (CRD) with two factors. The first factor was the composition of the bokashi ingredients, which consisted of 3 levels, while the second factor was the dosage of bokashi, which consisted of 5 levels as shown in Table 1. Each treatment has three replications, and a total of 45 experimental units. Each experimental unit consisted of 5 sample plants, so 225 experimental units were obtained.

Table 1. Treatment of the composition and dosage of moringa leaf bokashi

	Treatment	
Notation	**Bokashi composition (Manure biochar: moringa leaves)**	**Dosage of bokashi (Tones per hectare)**
K1	1:1:1	
K2	2:1:1	
K3	3:1:1	
Bo		Control without moringa leaves 5
B1		bokashi moringa 10
B2		bokashi moringa 20
B3		bokashi moringa 30
B4		bokashi moringa 40

Observations included plant height (cm), number of leaves, root length (cm), number of primary roots, fresh weight of roots (g), dry weight of roots (g), and wet weight of plant canopy (g). the dry weight of plant canopy (g). Data was analyzed using ANOVA (analysis of variance). If the results of the ANOVA showed significant effect, to see the difference between the treatments, a further test is carried out using a 5% honest significant difference (HSD) test.

2.2. Research Procedure

2.2.1. Moringa Leaves Bokashi Production

Making moringa leaf bokhasi is carried out as shown in the chart below (Kinasih *et al*., 2021). The stages of the research, namely germination and nursery of Moringa were carried out as shown in the chart below (Kurniawan, 2019).

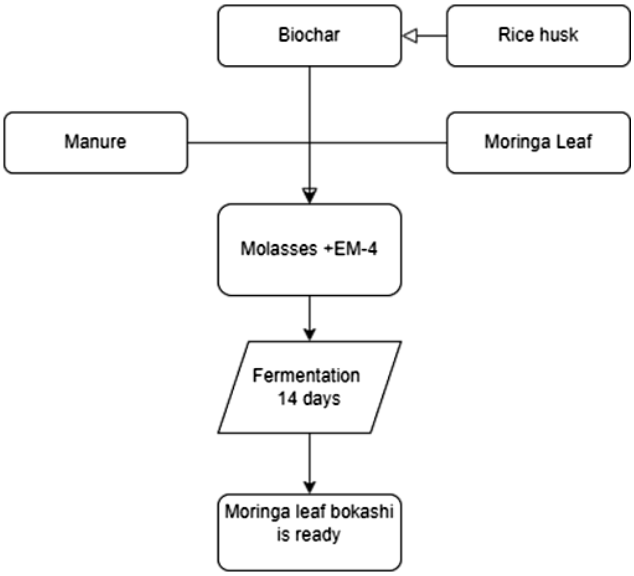

Figure 1. Steps to prepare moringa leaves bokashi

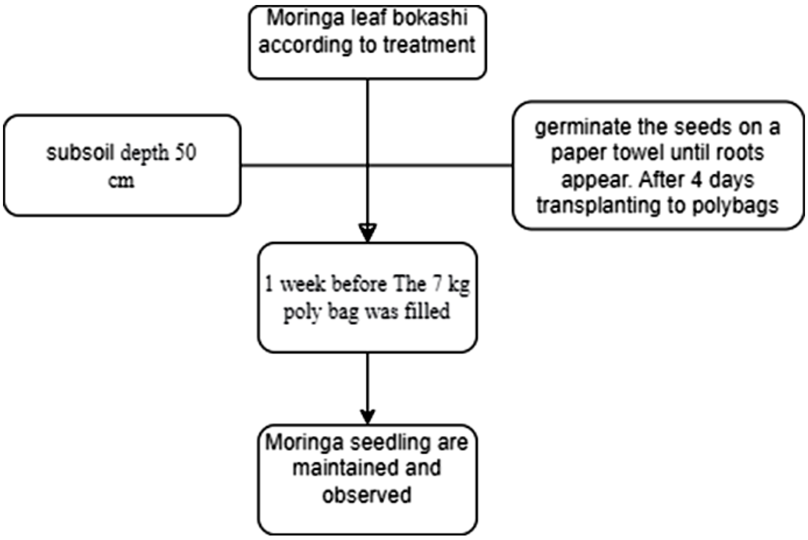

Figure 2. Steps of moringa leaves bokashi application on moringa seedlings

3. RESULTS AND DISCUSSION

The results of the analysis of variance (ANOVA) on all observed variables are presented in Table 2. The interaction treatment between moringa leaf bokashi composition and dose showed no significant effect on all observed variables. The bokashi composition treatment showed a significant effect on the variables of plant height, canopy wet weight and number of primary roots. However, it showed no significant effect on the number of leaves, root wet weight, root length, root dry weight, and canopy dry weight variables. The dose treatment showed a significant effect on the variables of plant height, number of leaves, root dry weight and canopy dry weight.

Table 2. ANOVA recapitulation of the effect of the composition and dosage of moringa leaf bokashi fertilizer on the growth of moringa seedlings

No	Variable	Composition	Dosage	Interaction
1	Plant Height (cm)			
	Age 2 Weeks After Planting (WAP)	5.68 **	1.36 ns	ns
	b. Age 4 Weeks After Planting (WAP)	9.45 **	6.04 **	0. 77 ns
	c. Age 6 Weeks After Planting (WAP)	2.44 *	5.79 **	0. 57 ns
	Age 8 Weeks After Planting (WAP)	3.81 *	7.41 **	1.41 ns
2	Number of Leaves			
	Age 2 Weeks After Planting (WAP)	0.00 ns	0.95 ns	0. 41 ns
	Age 4 Weeks After Planting (WAP)	1.60 ns	7.73 **	1.02 ns
	Age 6 Weeks After Planting (WAP)	0.21 ns	3.38 *	1.15 ns
	Age 8 Weeks After Planting (WAP)	0.26 ns	1.25 ns	0.58 ns
3	Root wet weight (g)	1.37 ns	2.84 *	0.62 ns
4	Canopy Wet Weight (g)	3.64 *	1.76 ns	0.92 ns
5	Root Length (cm)	0.83 ns	2.36 ns	0.78 ns
6	Number of Primary Roots	3.48 *	2.08 ns	0.80 ns
7	Root Dry Weight (g)	1.19 ns	2.00 ns	0.88 ns
8	Canopy Dry Weight (g)	1.16 ns	3.48 *	0.54 ns
	F-Table 5 %	3.32	2.69	2.27
	F-Table 1 %	5.39	4.02	3.17

Note: ** = very significant, *= significant, ns = non-significant

3.1. Plant Height (cm)

Based on the ANOVA in Table 2 the treatment of the moringa leaf bokashi composition had a very significant effect on plant height at age 2 and 4 WAP and had a significant effect at age 8 WAP. Treatment of moringa leaf bokashi dose alone gave a very significant effect on plant height aged 4,6,8 WAP. The composition of the K1 treatment showed the highest plant height, significantly different from the K2 and K3 treatments at the ages of 2, 4, and 8 WAP. Treatments K1 and K3 showed no significant difference in plant height at 8 WAP, as shown in Figure 3.

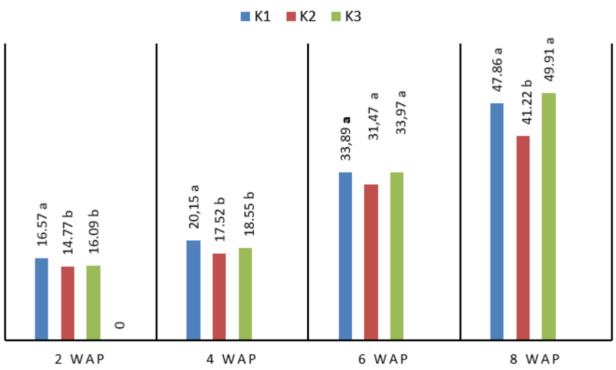

Figure 3. The influence of the composition of Moringa leaf bokashi on plant height

Growing media factors influence the growth of plant height in moringa. The planting media mixed with soil with moringa leaf bokashi fertilizer with K1 treatment, which consisted of a ratio of moringa leaves to biochar, and cow manure was 1:1:1

giving a higher moringa plant height as the K2 treatment, namely the same composition as a ratio of 2:1:1. Plant height given one part of moringa leaf bokashi was not different from that of moringa leaf bokashi which was added twice or even three times. The cytokinin content in the K1 treatment as a growth regulator in moringa leaves is sufficient to encourage plant height growth (Lubis *et al*., 2019) and functions to prevent plant stunting (Maryani, 2012).

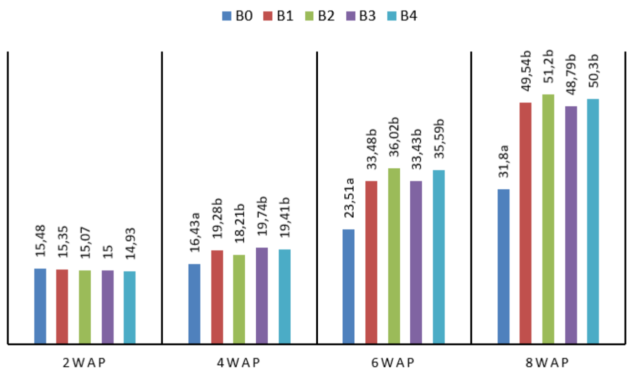

Figure 4. The effect of moringa leaf bokashi dosage on plant height at different plant age

Bokashi fertilizer without applying Moringa leaves, namely the composition of biochar and cow manure at a controlled dose of 5 tons per hectare, gave lower plant height growth than moringa leaf bokashi fertilizer at a dose of 10 tons per hectare. Giving a dose of 10 tons per hectare is enough for the growth of moringa plant height because the height of Moringa plants will not increase even though the dose is increased to 40 tons per hectare as shown in Figure 4.

Similar research results reported by Kinasih *et al.,* (2021) also showed that a dose of 20 tons per hectare of bokashi from palm fronds with moringa leaves in a ratio of 1: 1 tons per hectare on the height of red chili plants. Adding moringa leaves to bokashi has led to savings in using only 10 tons per hectare. Based on research reported by Kusuma *et al.* (2021), using cow manure without a mixture of moringa leaves at a dose of 15 tons per hectare speeds up harvest time for chili plants is significantly different from the above, namely 20 and 25 tons per hectare. Adding moringa leaves to the bokashi fertilizer mixture causes lower fertilizer doses resulting in savings in using organic fertilizers.

3.2. Number of Leaves

The treatment of the composition of moringa leaf bokashi fertilizer showed no effect on the number of leaves as shown in Figure 3. The average number of leaves of moringa plants at 2 WAP was 7.5. At 4 WAP increased to 10.3 to 11.0, increased at 6 WAP to 10.5, and to 11 at the age of 8 WAP.

The dose of 10 tons per hectare showed the same number of leaves as the treatment at the higher dose, namely the 20-40 tons per hectare treatment, but significantly different from the control dose of observations 4 and 6 WAP, as shown in Table 3.

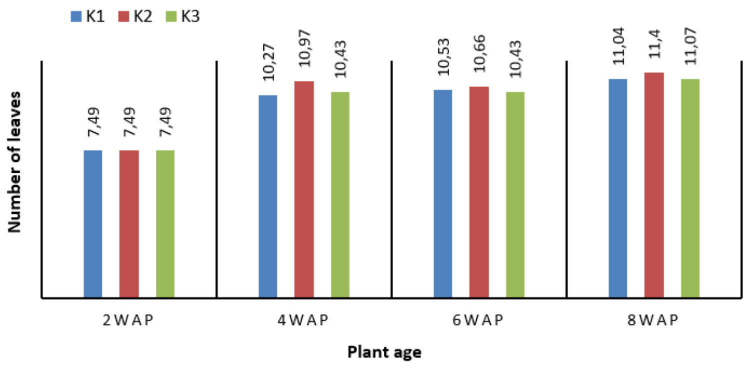

Figure 5. Number of leaves at the age of 2, 4, 6, dan 8 WAP

Table 3. The effect of Moringa leaf bokashi dosage on the number of leaves

Doses (tons per hectare)	Number of leaves			
	2WAP	4WAP	6WAP	8WAP
B0 (control)	7.48a	8,17 b	9,70 b	11.24a
B1(10)	7.46a	11,16 a	11,36 a	11.17a
B2 (20)	7.52a	11,36 a	10,48 a	11.14a
B3 (30)	7.50a	11,18 a	10,5 a	11.11a
B4 (40)	7.49a	10.78 a	10.7 a	11.26a

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

Giving a dose of 5 ton/ha (control) without the use of moringa leaves showed that the number of leaves formed was less than in other treatments. Giving a dose of moringa leaf bokashi of 10 ton/ha was able to accelerate leaf formation because it was not significantly different from the above dose treatment. Gardner *et al*. (2008) said that the number of leaves and leaf size are influenced by genotype and environment. The application of moringa leaf bokashi fertilizer at a dose of 10 ton/ha is enough to improve subsoil chemically, namely the provision of nutrients for photosynthetic activities (Fitter & Hay, 1991). The resulting photosynthate is used to form leaf organs so that the number of leaves produced is significantly different from the control dose.

3.3. Canopy Dry Weight and Root Wet Weight

Based on the ANOVA treatment of moringa leaf bokashi doses showed a significant effect on canopy dry weight and root wet weight. The control dose (B0) showed the lowest canopy dry weight of 8.41 g and the 10 tons per hectare treatment (B1) showed the highest canopy dry weight of 16.43 g. Treatment doses above 10 tons per hectare, namely treatments B2, B3, and B3, showed significantly different dry weights with a dose of 10 tons per hectare (B1) and a control dose (B0). Canopy dry weight at a dose of 20-40 tons per hectare, which is 15.5-14.9 g, is lower than canopy dry weight at a dose of 10 tons per hectare, which is 16.43 g, as shown in Figure 6.

A dose of 10 tons per hectare has been able to chemically improve the subsoil as proven that the dry weight of the canopy is higher than the control and the other three treatments. The dry weight of the plant canopy is the accumulation of the results of photosynthetic activities stored in the plant because of the accumulation of nutrients absorbed by the roots and then translocated throughout the plant body and finally stored as a food reserve which will be measured in the dry weight of the plant canopy (Maryani, 2012).

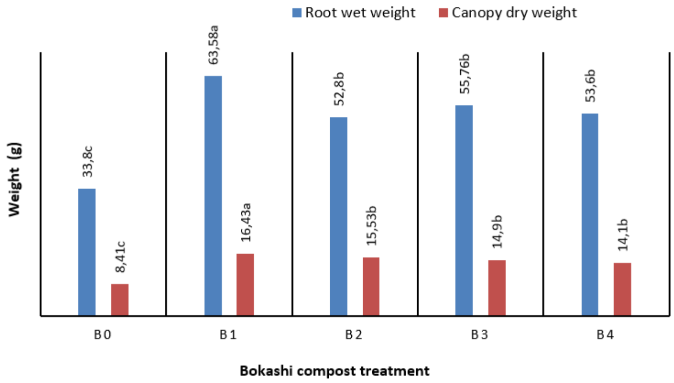

Figure 6. Effect of moringa leaf bokashi dosage on shoot dry weight (red) and root wet weight (blue)

The dose treatment of moringa leaf bokashi fertilizer showed a significant effect on the fresh weight of the roots as shown in Figure 6. The treatment of the dose of moringa leaf bokhasi fertilizer at a dose of 10 ton/ha with a root wet weight of 63.58 g was significantly different from the control, which was 33.8 g. The treatment dose of B1, which is 10 tons per hectare, has been able to improve the physical properties of subsoil, which was originally dense and dense in structure, to become more crumbly and friable. Hidayat, *et al.* (2020) stated that subsoil soils cause inhibition of root growth as a result of the physical properties of the soil which are not good which can be corrected by bokashi moringa leaves.

Improvement of subsoil chemically is indicated by more root growth. The wet weight of the roots at the dose of B3 was significantly different from the doses of B2 and B4. The addition of moringa leaf bokashi fertilizer at a dose of 30 tons per hectare showed a higher fresh root weight of 55.76 g compared to treatments B2 and B4, namely 52.8 g and 53.6 g. The addition of moringa leaf bokashi doses is an effort to add nutrients to plants in the hope that they will be absorbed by plants, but the increasing doses are not in line with plant absorption because Moringa seedlings are only observed until the age of 8 WAP. increased (Gardner *et al*., 2008).

3.4. Canopy Wet Weight and Number of Primary Roots

Based on the ANOVA treatment, the composition of the moringa leaf bokashi showed a significant effect on shoot wet weight and number of primary roots as shown in Figure 7.

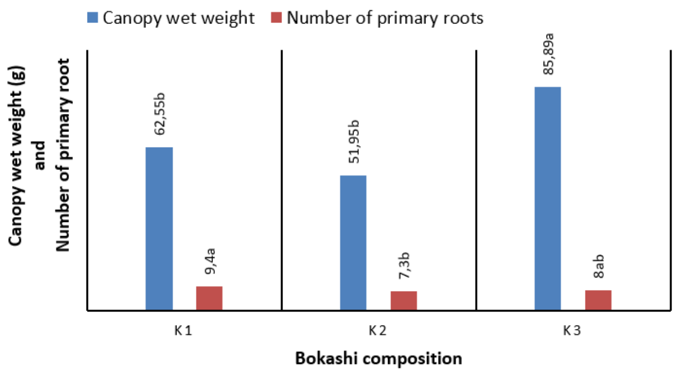

Figure 7. Effect of moringa leaf bokashi composition on shoot wet weight and number of primary roots.

The treatment of the composition of the moringa leaf bokashi fertilizer had a significant effect on the wet weight of the shoots, and it was seen that the K3 composition showed the highest total shoot weight compared to the other treatments. The composition of K3 contains more raw materials for moringa leaves, two times compared to treatment K2 and three times compared to treatment K1. Based on the nutrient test in the laboratory of Bengkulu University, the total nitrogen nutrient content for K3 was 1.42%, K2 was 1.40%, and K1 was 1.25% above the SNI standard, namely >0.40%. Nitrogen nutrient content, which is above SNI, is very good for the vegetative growth of Moringa plants because it can stimulate the formation of green leaf substances which are very important for photosynthesis.

The content of the C/N ratio for the composition of K3 is 15.1, K2 is 13.8, K1 is 14.3, and it meets SNI standard No. 19-7030-2004 C/N ratio is 10-20. These data show that even though the wet weight of K3 is higher than K1 and K2, the nitrogen nutrient content is not too different. The C/N ratios of K1, K2, and K3 are just as good, meaning that nutrients are readily available to plants (Yuniwati *et al*., 2012). According to Gardner *et al*., (2008), wet plant weight is affected by plant humidity. Vegetative growth requires much water, marked by an increase in fresh plant weight, the microorganisms contained in the moringa leaf bokashi fertilizer are entirely active to help fertilize the soil.

Moringa leaf bokashi fertilizer uses EM-4, which is a complete microorganism that functions to accelerate plant growth. The application of moringa leaf bokashi fertilizer allows microbial activity to increase rapidly because moringa leaves, roasted husks, and cow manure are easily decomposed, optimal air, temperature, reasonable humidity, and sufficient oxygen causing the microbes in the bokashi fertilizer to develop better (Tallo & Sio, 2019).

K1 composition showed the highest number of primary roots compared to other treatments. The K1 treatment with 9.4 more roots than the K2 and K3 treatments with 8 and 7 primary roots. The application of bokashi fertilizer with a K1 composition with a 1:1:1 ratio between moringa leaves, biochar and cow dung was able to improve the physical properties of the subsoil soil which was originally Soil structure that is dense and clay and low fertility is better (Andri *et al*., 2016).

4. CONCLUSIONS

The conclusion of this study is that the composition and dosage of Moringa leaf bokashi have a significant effect on the growth of Moringa seedlings independently. The composition of bokashi K1 fertilizer, namely the ratio of moringa leaves, cow dung, and biochar 1:1:1 showed the highest plant height, longest number of primary roots, and highest crown wet weight. Treatment with a dose of 10 ton/ha showed the best results on plant height, number of leaves, wet weight of roots, and dry weight of canopy. It is recommended to use Moringa leaf fertilizer with the composition of moringa leaves, cow manure, and biochar in a ratio of 1:1:1 (K1) and the dose of Moringa leaf fertilizer 10 ton/ha (B1) independently is very good for the growth of moringa plants.

ACKNOWLEDGEMENT

Thank you to the Faculty of Agriculture, University Prof. Dr. Hazairin, SH Bengkulu, and all its supporting units, especially the laboratory of Soil Science University of Bengkulu and to Ovian Ade Putra who have helped carry out this research.

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