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The Effect of Green Manure and *Chromolaena-Odorata*-Based Bokashi on Nutrient Soil Content and Maize Growth

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Abstract

The objectives of this study are twofold; firstly, it is intended to determine the soil nutrient contents (e.g., nitrogen, phosphor, potassium, manganese, and magnesium) after the provision of *Chromolaena odorata* organic fertilizer. Secondly, the study is aimed at examining the growth of maize crops after the provision of the same fertilizer. It employed randomized design group consisting of three phases of treatment (i.e., control, fertilizer provision, and provision of Bokashi with *Chromolaena odorata*) and four-times of the repeating process. Furthermore, the variable consists of the contents of soil nutrient before applying the treatment, vegetative growth (i.e., stem height, stem diameter, leaf size, and dry weight of root, stem, and leaf), and generative growth (i.e., weight of unhusked cob, weight of husked cob, number of seeds per cob, width of cob, and weight of 100 seeds). The data were analyzed by using analysis of variance (ANOVA) and it further examined by employing Least Significance Difference test at 5% level. The results reveal that the provision of Bokashi fertilizer (with *Chromolaena odorata* as the material) positively impacts the growth of maize crops rather than the provision of green manure and control fertilizer.

Keywords: Generative Growth, Organic Fertilizer, Vegetative Growth

1. Introduction

Soil fertility, pest infection and plant diseases are the issues for maize farmers in improving the production of maize. Normally, the farmers use fertilizer and synthetic pesticide to tackle such problems without considering the side effects of using such chemicals.

The use of synthetic fertilizer and pesticides is considered a dilemma for the farmers since it is similar with a two-edged sword; these materials are essential to food supplies while the materials are also harmful since it impacts the structure of soil and reduces the soil fertility. Mangkodihardja (as cited in Adriyani, 2006) points out that the dispersion of synthetic pesticide is high; it can reach the percentage 100%. Producing organic fertilizer and pesticide from plants containing compounds that can retain the quality of the soil is able to minimize the risk of using synthetic materials.

Chromolaena odorata is among the plants used as a material for organic fertilizer or pesticide. This plant grows everywhere; it grows particularly well at highland. Despite that the plants are easy to find, people know almost nothing that *Chromolaena odorata* is beneficial for the agricultural activities. *Chromolaena odorata* (L.) (R.M King & H. Rob.) contains considerably high soil nutrients (e.g., 21.94% N, 0.60% P, and 1.58% K); it is also considered as biomass holding the potential to restore the soil fertility. This further improves the growth of the plant.

The benefits of *Chromolaena odorata* as organic pesticide and fertilizer are little known to most of the farmers in Gorontalo by which they are yet to benefit from the plant. On top of that, they consider the plant as just ordinary weeds. Therefore, developing *Chromolaena odorata* as an organic fertilizer is necessary to help the farmers examining the effect of this material on the growth of crops, specifically maize.

This study focuses on the development of the weeds as organic material or the basic material for organic fertilizer Bokashi for the farmers to use to enhance the soil fertility; the effect of this fertilizer to maize crops is further examined as well. It is expected that the awareness of the farmers to use organic fertilizer by maximizing the use of natural resources is increased through this study. Moreover, the objectives of this present study are to examine the biomass and the growth of maize crops provided with *Chromolaena odorata* fertilizer and to analyze the contents of soil nutrients after the provision of the same fertilizer and green manure.

2. Materials and Methods

The research materials are *Chromolaena odorata*, maize crops “Bisi-2” variety, EM4, molasses, bran, cattle dung, and rice straws. Furthermore, this research employed randomized design group consisting of three phases of treatment (i.e., control, fertilizer provision, and provision of Bokashi with *Chromolaena odorata*) and four-times of the repeating process. Furthermore, the variable consists of the contents of soil nutrient before applying the treatment, vegetative growth (i.e., stem height, stem diameter, leaf dimension, and dry weight of root, stem, and leaf), and generative growth (i.e., weight of unhusked cob, weight of husked cob, number of seeds per cob, width of cob, and weight of 100 seeds). The data were analyzed by using analysis of variance (ANOVA) and it further examined by employing

Least Significance Difference test at 5% level. This study was conducted at Bone Bolango regency, on 500 m² land which was divided into 12 experiment spaces with 2 x 4 m² width for each space. Other analyses were conducted at different sites, i.e., PTPG Laboratory, Tolangohula (analysis of soil nutrients contents), Food Technology Research Center or *Balai Pengkajian Teknologi Makanan* laboratory (water content analysis), and Botanical laboratory Universitas Negeri Gorontalo (vegetative growth analysis).

3. Results and Discussion

3.1 Analysis of Soil Nutrients

This present study is aimed at examining the effect of the provision of green manure and *Chromolaena odorata* Bokashi on the nutrient soil contents. The results of soil nutrient contents are provided in Table 1 as follows.

Table 1. Analysis of soil nutrients contents before and after the provision of green manure and *Chromolaena odorata* bokashi

No.	Sample Code	Analysis Results			
		Pre-Planting	Post-Planting		
			Green Manure	Bokashi	Control Fertilizer
1.	C-Organic (%)	0.87	0.99	1.08	1.00
2.	Nitrogen (%)	0.13	0.13	0.16	0.15
3.	P ₂ O ₅ (ppm)	55	55	109	58
4.	K ₂ O (ppm)	214	402	489	448
5.	Mn (ppm)	0.20	0.68	0.74	0.25

The results reveal that there is no difference in the soil organic matter, consisting of Nitrogen and Manganese, of pre and post-treatment. This phenomenon is closely related to the soil nutrients contents within the *Chromolaena odorata*. The nutrients are well-known for containing a high level of several compounds, e.g., N, P, and K which also serve as the basic materials of organic fertilizer. However, there is no difference regarding the content of the compounds C, N, and Mn in pre and post-treatment; this is due to the characteristics of each compound. In response to this, Wijaya (2008) argues that the content of soil nutrients is formed through some processes, such as mineralization, soil weathering, and decomposition of soil particles. However, these processes are unable to balance the loss of soil nutrients due to the situation where the residue of the agricultural production does not remain in the crop fields.

Based on the analysis, the characteristic of N compound, which further mineralized into NO_3 , is the factor of the low level of this compound. Yet, the unstable nature of Nitrite contained in the soil will be washed away from the root zone in a certain period (in barren conditions or during high rainfall period). To maintain the content of nitrite, planting alternate crops or applying relay cropping or polyculture with two or three plants with varied rooting depths.

3.2 Vegetative Growth Parameter

3.2.1 Width of Crops

The following Table 2 shows the measurement of the maize crops in terms of the average results of each treatment in different periods (i.e., 25, 35, and 45 days after planting).

Table 2. Average stem width (cm) of maize crops on each treatment

TREATMENT	AVERAGE STEM WIDTH (cm)		
	25 days after planting	35 days after planting	45 days after planting
Control Fertilizer	35	111.1	225.3
Green Manure	38.4	131.5	242.9
Bokashi	44.1	145	258.8

The results of ANOVA test reveal that each treatment significantly affects the growth of the stem of crops on day 25, 35, and 45 after planting. Least Significance Difference test on level 5% is further conducted to examine the effects of each treatment. The results of the test are shown in Table 3.

Table 3. Results of least significance difference test on each treatment

Treatment	Average Stem Width (in cm)											
	during Observation											
	25 days after planting				35 days after planting				45 days after planting			
Control Fertilizer	35 ^a	35 ^a	31 ^a	40 ^b	12 ^{1c}	10 ^{0a}	105 ^a	118 ^b	237 ^b	214 ^a	226 ^a	224 ^a
Green Manure	41 ^b	38 ^b	40 ^b	35 ^a	124 ^c	127 ^c	130 ^c	145 ^c	258 ^c	242 ^b	240 ^b	232 ^a
Bokashi	43 ^c	40 ^b	43 ^c	51 ^d	140 ^d	151 ^f	144 ^e	145 ^c	260 ^f	272 ^g	250 ^c	253 ^d

Description: Number followed by a letter does not indicate a significant difference.

Factors, e.g., other soil nutrients and sufficient water supplies also affect the increase of crops width; this resonates to the results seen in Nugroho (2015). Nitrogen is particularly a

compound that helps the growth of stem and leaf. Moreover, sufficient supply of this compound in the soil helps photosynthesize and increase the results of the process. This further advances the growth of the crops. Environmental aspect, i.e., sunlight exposure also contributes to this process.

3.2.2 Stem Diameter

The results of average stem diameter on each treatment are shown in Table 4 as follows.

Table 4. Average stem diameter (cm) of maize crops on each treatment

TREATMENT	AVERAGE STEM DIAMETER (cm)		
	25 days after planting	35 days after planting	45 days after planting
Control Fertilizer	0.8	2.2	2.3
Green Manure	1.2	2.7	2.8
Bokashi	1.4	2.9	3.2

Least Significance Difference test on level 5% is further conducted to examine the effects of each treatment. The results of the test are shown in Table 5 as follows.

Table 5. Results of least significance difference test on each treatment

Treatment	Average Stem Diameter (cm) during Observation											
	25 days after planting				35 days after planting				45 days after planting			
Control Fertilizer	0.89 ^a	0.8 ^a	0.64 ^a	0.95 ^b	2.23 ^a	2.16 ^a	2.23 ^a	2.23 ^a	2.32 ^a	2.23 ^a	2.29 ^a	2.39 ^b
Green Manure	1.43 ^b	1.05 ^b	1.21 ^d	1.11 ^c	2.55 ^b	2.61 ^b	2.61 ^b	2.87 ^c	2.71 ^c	2.93 ^d	2.87 ^d	2.87 ^d
Bokashi	1.34 ^f	1.27 ^e	1.37 ^f	1.59 ^h	2.87 ^c	3.02 ^c	3.02 ^c	2.87 ^c	3.18 ^e	3.18 ^e	3.12 ^e	3.18 ^e

Description: Number followed by a letter does not indicate a significant difference

The widest stem diameter is the maize crops with Bokashi treatment, followed by the crops with green manure. This is because the nutrients within Bokashi support the vegetative growth of the crops.

3.2.3 Leaf Sizes

The average results of the measurement of the leaf on each treatment are provided in the following Table 5.

Table 5. Average results of leaf sizes (cm²) on each treatment

TREATMENT	AVERAGE LEAF SIZE (cm ²)				
	5 days after planting	15 days after planting	25 days after planting	35 days after planting	45 days after planting
Control Fertilizer	8.1	35.2	457.3	721.2	724.1
Green Manure	10.9	61.4	459.1	799	802.2
Bokashi	10.1	67.6	449	860.1	873.2

Table 5 shows that the increase in leaf size is directly proportional to the age of vegetative growth of maize crops. The increase of leaf sizes on day 35 to 45 after planting is a bit slower due to the fact that the vegetative growth of the crops has reached its max.

Least Significance Difference test on level 5% is further conducted to examine the different effects of each treatment. The results of the test are shown in Table 6 as follows.

Table 6. Results of least significance difference test on each treatment

Treatment	Average Leaf Sizes/During Observation											
	15 days after planting				35 days after planting				45 days after planting			
Control Fertilizer	38 ^b	37 ^b	45 ^b	21 ^a	696 ^a	728 ^a	750 ^a	712 ^a	695 ^a	731 ^a	750 ^a	721 ^a
Green Manure	62 ^d	59 ^d	64 ^d	61 ^d	756 ^b	787 ^c	789 ^c	866 ^d	760 ^b	789 ^c	790 ^c	870 ^d
Bokashi	58 ^c	65 ^d	71 ^d	76 ^c	859 ^d	861 ^d	859 ^d	862 ^d	865 ^d	869 ^d	886 ^d	871 ^d

Description: Number followed by a letter does not indicate a significant difference.

The above table shows that the provision of Bokashi gives the best results in terms of the leaf sizes. The nitrogen compound within Bokashi is able to support the growth of the leaf. This resonates to Wijaya's argument (2008) that the provision of the compound advances the growth of parts of crops which are responsible for photosynthesizing. Furthermore, crops with sufficient supply of compound N will form the larger size of leaves containing a high level of chlorophyll which enables the crops to produce carbohydrate or assimilate in a plentiful amount to support the vegetative growth.

3.2.4 Dry Weight of Root, Stem, and Leaf

The results of average measurement of the dry weight of several parts, i.e., root, stem, and leaves on each treatment are shown in Table 7 as follows.

Table 7. Average dry weight of root, stem, and leaf on each treatment

TREATMENT	AVERAGE DRY WEIGHT OF ROOT, STEM, AND LEAF (Gram)				
	5 days after planting	15 days after planting	25 days after planting	35 days after planting	45 days after planting
Control					
Fertilizer	0.06	0.6	37.9	79.1	80
Green Manure	0.1	1.1	42.7	101.4	111
Bokashi	0.2	1.2	48.6	126.8	147.9

Least Significance Difference test on level 5% is further conducted to examine the effects of each treatment. The results of the test are shown in Table 8 as follows.

Table 8. Results of least significance different test of average dry weight of root, stem, and leaf on each treatment

Treatment	Average Dry Weight of Root, Stem, and Leaf/During Observation											
	5 days after planting				15 days after planting				25 days after planting			
Control	0.08 ^a	0.06 ^a	0.05 ^a	0.05 ^a	0.67 ^b	0.64 ^b	0.75 ^b	0.34 ^a	38 ^a	41 ^b	37 ^a	36 ^a
Fertilizer												
Green	0.12 ^c	0.10 ^b	0.11 ^c	0.11 ^c	1.03 ^c	1.17 ^d	1.13 ^d	0.88 ^b	45 ^d	42 ^b	41 ^b	43 ^c
Manure												
Bokashi	0.21 ^e	0.13 ^d	0.14 ^d	0.13 ^d	1.20 ^e	1.44 ^f	1.18 ^e	1.10 ^d	47 ^e	51 ^g	50 ^f	47 ^e

Table 8. Cont'd

Treatment	Average Dry Weight of Root, Stem, and Leaf/During Observation							
	35 days after planting				45 days after planting			
Control Fertilizer	77 ^a	73 ^a	80 ^a	87 ^a	70 ^a	75 ^a	82 ^b	81 ^b
Green Manure	100 ^c	96 ^b	99 ^c	112 ^d	107 ^c	104 ^c	119 ^d	114 ^c
Bokashi	146 ^f	123 ^c	120 ^c	118 ^c	140 ^c	150 ^e	149 ^e	153 ^f

The provision of fertilizer with N compound is able to improve the concentration of phosphorus within the crops; it further stimulates the growth of the root by which it enhances the absorption capacity and its speed in absorbing soil nutrients (Fahmi *et al.*, 2010). Enhanced soil nutrients absorption by the root automatically affect the growth of stem and leaves by which it increases the dry weight of a plant. The increase of the weight indicates that the soil nutrients are sufficiently supplied.

3.3 Generative Growth Parameter

3.3.1 Weight of Unhusked Cob

The average results of the measurement of the unhusked cob on each treatment are provided in the following Table 9.

Table 9. Average weight of unhusked cob (gr) on each treatment

TREATMENT	AVERAGE WEIGHT OF CROPS WITH UNHUSKED COB (gr)
CONTROL FERTILIZER	205.7
GREEN MANURE	217.9
BOKASHI	220.1

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The results of ANOVA test on determining the effect of treatment (i.e., the provision of control fertilizer, green manure, and Bokashi) reveal a significant influence towards the weight of unhusked cob of maize crops. Least Significance Difference test on level 5% is further conducted to examine the effects of each treatment. The results of the test are shown in Table 5 as follows.

Table 10. Results of least significance difference test on each treatment

TREATMENT	AVERAGE WEIGHT OF UNHUSKED COB (GR)			
CONTROL FERTILIZER	213.1 ^b	190 ^a	201.7 ^a	217.8 ^c
GREEN MANURE	217.5 ^c	221.8 ^c	218.6 ^c	215.8 ^b
BOKASHI	224.4 ^c	220.5 ^c	235.8 ^d	225.1 ^c

Description: Number followed by a letter does not indicate a significant difference.

It is believed that the weight of unhusked cob is determined by the size of the cob and seed of maize crops. This is echoing the results seen in Utama *et al.* (2013) that the best growth of maize crops is the contributing factor of several processes, such as flowering, cob forming, and seeds filling; it results in an increase in the weight of the cob.

On day 33 to 55 after the crop begins to germinate, the crops grow faster and so as the accumulation process of the dry materials. Soil nutrients and water supply are indispensable to advance the growth of crops. Plants are sensitive to drought and lacking soil nutrients by which it affects the growth of the cob.

On top of that, such conditions reduce the number of seeds per cob due to smaller cob size. This results in a drop in the production of the crops (Subekti *et al.*, 2002).

3.3.2 Husked Cob Weight

The average results of the measurement of the weight husked cob on each treatment are provided in the following Table 11.

Table 11. Average weight of husked cob on each treatment

TREATMENT	AVERAGE WEIGHT OF HUSKED COB
CONTROL FERTILIZER	142.8
GREEN MANURE	156.8
BOKASHI	179

The results of ANOVA test in determining the effect of treatment reveal a significant influence towards the weight of unhusked cob of maize crops. Least Significance Difference test on level 5% is further conducted to examine the different effects of each treatment. The results of the test are shown in Table 12 as follows.

Table 12. Results of least significance difference test on each treatment

TREATMENT	AVERAGE WEIGHT OF HUSKED COB			
CONTROL FERTILIZER	152.3 ^b	120 ^a	131.4 ^a	167.6 ^c
GREEN MANURE	136.9 ^a	169.3 ^d	160.4 ^b	160.4 ^b
BOKASHI	199.2 ^c	172.1 ^d	164.7 ^c	179.9 ^d

During seed filling, maize crops require compound N and P in which Sirappa and Rajak point out that these compounds will be absorbed until the crops are ripening while compound K is essential in the silking process. These compounds flow to some growing parts of crops, e.g., stem, leaves, stamen (male flowers), and seeds. Nurhayati (2002) asserts that the increased weight of the maize cob is closely related to the results of photosynthesizing flowed into this part. The higher the results of photosynthesize flow to the cob, the bigger the maize cob.

3.3.3 Total Seeds per Cob

The average results of the seeds per cob on each treatment are provided in the following Table 13.

Table 13. Total seeds per cob on each treatment

TREATMENT	AVERAGE TOTAL SEEDS PER COB
CONTROL FERTILIZER	374.7
GREEN MANURE	417.6
BOKASHI	460.2

Table 13 shows the number of maize seeds per cob which is different on each treatment.

The results of ANOVA test in determining the effect of treatment reveal a significant influence towards the seed amount per cob. Least Significance Difference test on level 5% is further conducted to examine the different effects of each treatment. The results of the test are shown in Table 14 as follows.

Table 14. Results of least significance difference test on each treatment

TREATMENT	TOTAL SEEDS PER COB			
CONTROL FERTILIZER	384 ^b	364 ^a	327 ^a	424 ^c
GREEN MANURE	417 ^b	437 ^c	408 ^b	408 ^b
BOKASHI	481 ^f	420 ^c	467 ^d	473 ^e

Description: Number followed by a letter does not indicate a significant difference

3.3.4 Width of Cob

The measurement of the width of the cob on each treatment is provided in the following Table 15.

Table 15. Average width of cob of maize crops on each treatment

TREATMENT	AVERAGE WIDTH OF COB (cm)
CONTROL FERTILIZER	17.4
GREEN MANURE	18.6
BOKASHI	19.5

The ANOVA test shows a significant effect towards the width of maize cob. Least Significance Difference test on level 5% is further conducted to examine the effects of each treatment. The results of the test are shown in Table 16 as follows.

Table 16. Results of least significance difference test on each treatment

TREATMENT	AVERAGE WIDTH OF COB			
CONTROL FERTILIZER	18 ^b	16.2 ^a	17.1 ^a	18.1 ^b
GREEN MANURE	19.1 ^c	18.2 ^b	18.6 ^c	18.4 ^c
BOKASHI	19.8 ^c	19.2 ^d	18.9 ^c	20 ^c

Description: Number followed by a letter does not indicate a significant difference.

The best result of cob size parameter is on the crops with the provision of Bokashi. It is supported by the result of analysis of soil nutrients in pre and post-treatment; the compound Mn has undergone a significant increase. This compound plays a major role in the process of cell division and enlargement. Wijaya (2008) argues that deficiency of compound Mn affects cell enlargement the most rather than cell division. In other words, cell enlargement impacts on the growth of the cob size. Deficiency of Mn compounds leads to a condition where stomata are closed. This further blocks the transpiration by which it inhibits the crops to absorb passive-moving compounds or elements, i.e., N and Ca that follow the water flow.

3.3.5 Weight of 100 Maize Seeds

The average results of the accumulation of 100 seeds on each treatment are provided in the following Table 17.

Table 17. Average weight of 100 maize seeds on each treatment

TREATMENT	AVERAGE WEIGHT OF 100 MAIZE SEEDS (gr)
CONTROL FERTILIZER	32
GREEN MANURE	32.7
BOKASHI	35.4

Table 17 shows that there is no significant difference in terms of the number of each treatment.

Least Significance Difference test on level 5% is further conducted to examine the effects of each treatment. The following Table 18 shows the results of the test.

Table 18. Results of least significance difference test on each treatment

TREATMENT	AVERAGE WEIGHT OF 100 MAIZE SEEDS			
CONTROL FERTILIZER	33.5 ^b	30.1 ^a	32 ^a	30.5 ^a
GREEN MANURE	31.4 ^a	34.1 ^c	33 ^b	32.2 ^a
BOKASHI	37 ^f	35 ^e	34.5 ^d	35.1 ^e

Description: Number followed by a letter does not indicate a significant difference.

Crops with the provision of Bokashi show better results in terms of the weight of 100 maize seeds. It is related to the complexity of materials of Bokashi consisting of *Chromolaena odorata*. This plant contains some compounds, such as P and K, useful for supplying soil nutrients required for generative phase. In response to this, Rahimi *et al.* (2013) add that the weight of seed depends on the content of dry materials within the seed. These materials (obtained from the result of photosynthesizing) are used for the process of seed filling.

4. Conclusion

The study concludes that the provision of green manure and Bokashi with *Chromolaena odorata* promotes the soil nutrients quality and also leads to better soil texture and fertility. The provision of green manure and Bokashi with *Chromolaena odorata* contributes to the vegetative growth of maize crops, i.e., leaf sizes, leaf amount, stem width, stem diameter, and dry weight of root, stem, and leaf. The provision of green manure and Bokashi with *Chromolaena odorata* contributes to the generative growth of maize crops, i.e., the weight of husked and unhusked cob, amount of seed per cob, cob size, and weight of 100 seeds.

5. Authors' Contribution

Jusna Ahmad: responsible for research design and data analysis.; Chairunnisa Lamangantjo: participated in data collection and assisted the lead researcher in analyzing the data.

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