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Microbic Biotechnology in the Making of Organic Fertilizer and its Role on Soil and Cocoa Plants

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Abstract

One of the problems that is often encountered in mineral soils that have a low pH is the content of organic matter and low soil nutrient status. Organic matter is very important because it is able to improve the physical, chemical and biological properties of the soil. Organic wastes cannot be directly utilized by plants and must be composted first by soil microorganisms into nutrients that can be absorbed by plants. The use of microorganisms and organic matter in agriculture is done because it can increase the availability of nutrients in the soil and its absorption for plants and form soil structures to become more loose, reduce the weight of clay-textured soil and increase the amount and biological activity of the soil which synergistically can increase seedling plant growth. This research was carried out in Lima Puluh Koto district of West Sumatra Province for 8 months from March to October 2018. The purpose of this study was to obtain the most appropriate dosage tithonia of compost and microorganisms to increase cocoa plant production. The design used in factorial randomized block design with DMNRT follow-up at a level of 5%, consisting of 2 factors, the first factor was the dose of Tithonia compost and the second factor was the dose of Pseudomonas fluorescens + Trichoderma harzianum microorganisms. responses from parameters observed were N, P, and K soil and plants, as well as the average weight of wet cocoa beans per plant. The results showed no interaction between compost tithonia and Pseudomonas fluorecens and Tricoderma harzianum microorganisms on all response parameters in cocoa plants.

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But the administration of compost tithonia and Pseudomonas fluorecens and Tricoderma harzianum has an effect on all response parameters in cocoa plants. The administration of Tithonia compost was obtained in the treatment of 10 kg / plant and microorganisms at a dose of 400 ml *Pseudomonas fluorecens* + 4 kg *Tricoderma harzianum.*

Keywords: Cocoa Plants; compost; tithonia; microorganisms.

1. Introduction

Damage to agricultural land increases with increasing population and increasing area of critical land. Critical land is land that is currently less productive in terms of agricultural use, because its use does not pay attention to the principles of soil and water conservation. One effort in reclaiming critical land or non-productive land is the use of organic fertilizers and decomposer microorganisms. Now organic fertilizers and decomposer microorganisms are becoming a concern of agricultural and environmental experts because of the impact caused by the high use of chemical fertilizers and pesticides that cause land degradation. The application of organic fertilizers and decomposer microorganisms is a way to restore soil fertility or an attempt to improve the physical, chemical and biological properties of soil due to loss of nutrients transported by plants through crop yields, and efforts to increase crop production. Improvement of soil fertility by returning organic matter into the soil is one of the efforts to increase soil and plant productivity [1]. Reference [2] states that to increase the productivity of dryland agriculture in the tropics including Indonesia in a sustainable manner can be done through mulching, minimum tillage, addition of organic matter, calcification, optimization of cropping patterns, and land conservation.

The use of microorganisms in agriculture has a positive impact to enrich the availability of nutrients in the soil through the process of decomposition / mineralization of organic materials that convert organic compounds into inorganic compounds [3]. Soil microbes have a beneficial role in the agricultural sector, which is to play an active role in destroying organic waste, recycling plant nutrients, fixing biological nitrogen, dissolving phosphate, stimulating growth, organic biocontrol and assisting nutrient absorption. Microbial-based biotechnology was developed by utilizing the important roles of these microbes. Reference [4] showed that giving various types of microbes (Pseudomonas fluorescens and Trichoderma harzianum) in the process of making Thitonia compost had a very significant effect on the value of C / N ratio, total N, P content and K content of compost. Reference [5] reported that the use of *Trichoderma harzianum* and *Pseudomonas fluorescens* microorganisms was able to increase the availability of P-available reaching 97.4%, increasing the effectiveness of controlling leaf spot disease in peanut plants to 49.7% so that it could be used as biological pesticides, and can increase dry seed production per plot of peanut plants from 91.7 dry seeds per plot (treatment without microorganisms) to 172.4 seeds (treatment with microorganisms *Trichoderma harzianum* and *Pseudomonas fluorescens*). Cocoa plants are as Superior commodity in West Sumatra, especially in Limapuluh Kota Regency as a source of livelihood for farmers. According to [6] that cocoa crop yields at the farm level are not optimal due to lack of knowledge of farmers in utilizing microorganisms as biological fertilizers in cocoa plantations. In connection with this problem, a study was conducted on the Development of Microbial Biotechnology in the Manufacture of Organic Fertilizers and Their Role on Soil and Plants.

2. Experiment Method

2.1. Experiment Design

The experiment was carried out using a factorial randomized block design consisting of 2 factors. Factor I is compost Tithonia (T) which consists of 5 dose levels, namely:

T0 = 0 kg / tithonia compost

T1 = 2.5 kg / tithonia compost

T2 = 5.0 kg / tithonia compost

T3 = 7.5 kg / tithonia compost

T4 = 10.0 kg / tithonia compost

Factor II is a microorganism (M) mixture between Pseudomonas fluorescen and Trichoderma harzianum, which consists of 5 dose levels, namely:

M0 = Without *Pseudomonas fluorecens* + Tricoderma harzianum

M1 = 100 ml *Pseudomonas fluorecens* + 1 kg *Tricoderma harzianum*

M2 = 200 ml *Pseudomonas fluorecens* + 2 kg *Tricoderma harzianum*

M3 = 300 ml *Pseudomonas fluorecens* + 3 kg *Tricoderma harzianum*

M4 = 400 ml *Pseudomonas fluorecens* + 4 kg *Tricoderma harzianum*

Each treatment was repeated 3 times so that 3 x 5 x 5 = 75 experimental units were obtained. Before the experiment was carried out (initial soil analysis) and after two (2) months of the experiment an analysis of the nature of the soil and the (leaf) cocoa was carried out.

2.2. Implementation of Research

The preparation for conducting the research is as follows:

a. Making thitonia compost.
b. Propagation of Trichoderma harzianum microorganisms, Pseudomonas fluorescen.
c. Analysis of the chemical properties of compost (N, P, K, C / N ratio)
d. Composite soil sampling for initial chemical analysis (N, P, K, pH), and plant samples for initial chemical analysis (N, P, K)

e. In the soil, samples of cocoa plants were given various treatments according to the prescribed combination of treatments.
f. Maintenance of cocoa plants (Weeding, basic fertilization (inorganic), and pest control.

After 2 months the soil and plant samples were analyzed using various methods as follows:

a. Determine the level of rganic ingredients by **heating method**
b. Determining pH by **electrometry method**
c. Determines total N using the **Kjeldahl method**.
d. Determine the available P by the **Bray method.**
e. Determine K-available using the **Bray method**
f. Determine the best type of organic fertilizer. To find out the best types of fertilizers, namely by looking at the effect that gives the best results on the observed variables which are statistically analyzed.
g. Observation of plant growth and harvest.

2.3. Variable Observed

Observations were made before the experiment was carried out (analysis of the initial soil, compost and plants) and after five (5) months of testing carried out observations of:

a. The content of N, P, K soil and plants
b. Production of cocoa plants (wet seed weight per plant)

2.4. Data analysis

The research data of the observations were tested by analysis of variance and if the treatment showed a significant influence, then proceed with DMNRT at the level of α 5%.

3. Results and discussion

3.1. Preliminary analysis of the study

Table 1: Chemical analysis of nutrients in soil compost and cocoa leaves before the study

No	Chemical Properties	Compost	Soil	Leave Cocoa
1.	N	2.04%	0.34%	0.95%
2.	P	0.39%	3.83 ppm	0.18%
3.	K	0.72%	0.88 Cmol/kg	1.25%
4.	C (%)	33.05		-
5.	C/N ratio	16.20		-
6.	pH (H2O)	-		-

3.2. Nitrogen (N) Total (%) Content Land

Statistical analysis showed that there was no interaction between Tithonia compost and *Pseudomonas fluorescens* + *Trichoderma harzianum* on the N total soil content. While increasing the dose of Thitonia has an effect on the amount of N total soil, as well as an increase in the dose of *Pseudomonas fluorescens* + *Trichoderma harzianum.*

Table 2: Effect of Compost Tithonia and Microorganism Fertilizers on the N content of Total (%) Soil on cocoa plants

Tithonia compost (T)	Microorganism (M)					Average	
	M0	M1	M2	M3	M4		
T0	0.11	0.09	0.09	0.11	0.12	0.10	e
T1	0.11	0.12	0.12	0.14	0.14	0.12	d
T2	0.13	0.16	0.16	0.16	0.17	0.15	c
T3	0.16	0.20	0.21	0.21	0.23	0.19	b
T4	0.21	0.25	0.27	0.29	0.32	0.26	a
Average	0.13 b	0.14b	0.15ab	0.16ab	0.16a		

Remarks: Numbers marked with the same letters are not significantly different according to the 5% DMNRT test

The administration of Tithonia compost with different doses has an effect on the total N of the soil. The N-Total content of the soil without administration of thitonia obtained an average N of 0.10%, while the highest was obtained at a dose of 10kg / plant with a total N content of 0.26%. Increased N content Total soil with the administration of tithonia is possible with weathering of organic matter given, besides the N content of compost tithonia which is the highest contributor to N elements. Reference [7] the administration of organic ingredients (organic fertilizer) into the soil will increase the amount and content of nutrients in the soil, including N elements. The compost value of C / N ratio 16.2 is a value that illustrates that the compost used is compost ripe which can enrich the availability of nutrients in the soil. Reference [8] that the compost C/N ratio ranged from 16-18 is a value that describes ripe compost or is ready to be used as organic fertilizer.

The use of *Pseudomonas fluorescens* + *Trichoderma harzianum* microorganisms by dosing can increase the N content of total soil. Without the administration of microorganisms the average N content total is 0.13%, and increases with increasing doses of microorganisms. The highest average was obtained at a dose of 200 ml of *Pseudomonas fluorescens* + 4 kg *Trichoderma harzianum*. Increased amount The administration of these microorganisms helps in the mineralization process which occurs due to increased decomposition activity. Reference [9]) the addition of a decomposer can increase the nutrient content of compost with the right storage time. Reference [10] While causes active microorganisms in the process of decomposition of organic matter are fungi and bacteria.

3.3. P-available on soil

The organic analysis showed no interaction between Tithonia compost and *Pseudomonas fluorescens* + *Trichoderma harzianum* against the available P-content of soil in the cocoa plant. But independently, Tithonia compost which has a very significant effect on available P soil in cocoa plants.

Table 3: The Effect of Independent Compost Tithonia and Microorganism Fertilizers on the available P content (ppm) of Soil on Cacao plants

Tithonia Compost (T)	Mikroorganisme (M)					Average	
	M0	M1	M2	M3	M4		
T0	0.79	0.81	0.82	0.80	0.79	0.81	d
T1	0.85	1.00	1.07	1.00	1.05	0.98	c
T2	1.07	1.11	1.02	1.12	1.10	1.08	c
T3	1.17	1.24	1.37	1.64	1.63	1.35	b
T4	1.62	2.01	2.12	2.36	2.58	2.03	a
Average	0.97 a	1.04 a	1.07 a	1.14 a	1.14 a		

Remarks: Numbers marked with the same letters are not significantly different according to the 5% DMNRT test

Table 2 giving tithonia fertilizer to cocoa plantations provides different averages for available P content. The lowest available P-content was obtained without the administration of compost tithonia which was 0.81 ppm. Every increase in the dose of compost tithonia occurs with an increase in the amount of P-available content. The highest available P-content is obtained at a dose of 10 kg / plant. Reference [7] giving organic material (organic fertilizer) to the soil will increase the amount and content of nutrients in the soil, including P elements. The compost value of C/N ratio 16.2 analyzed at the beginning of the study is a value that illustrates that compost is used is a mature compost that can enrich the availability of nutrients in the soil. This is corroborated by the opinion of [8], that the value of C/N ratio of compost ranging from 16-18 is a value that describes ripe compost or is ready to be used as organic fertilizer and can contribute nutrient availability in the soil.

The treatment of microorganisms showed no difference for all levels of treatment of available P-soil content. This is presumably because the initial soil pH conditions before the implementation of the study 5.70 were considered not optimal to support the activity of microorganisms for optimal mineralization processes. In the opinion of [3] that the soil pH which is rather neutral to neutral (pH 6.0 - 7.0) will strongly support the activity of microorganisms in conducting mineralization in the soil which enriches the availability of nutrients, including the nutrient P in soil. According to [11] that at low soil pH (acid), nutrient P is strongly bound by Al elements so that it is less available in the soil. In addition, the dose interval of microorganisms used in each treatment is thought to be still low so that it can cause no significant difference in the available P value of the soil, although an increase in the available P value of the soil with increasing doses of microorganisms.

3.4. K Exchangeable content (Cmol / kg) of soil

Statistical analysis showed that there was no real interaction between Tithonia compost with *Pseudomonas* *fluorescens + Trichoderma harzianum* in its effect on the exchangeable K content, but independently, both Tithonia compost and microorganisms gave a highly significant effect on K exchangeable Soil on cocoa plants.

Table 4 states that the average value of K exchangeable of Tithonia compost for all treatments had a significantly different effect on the K exchangeable value when compared with without tithonia compost except for the 2.5 kg Tithonia/plant compost treatment. There was no difference between the treatment without compost tithonia and 2.5 kg of Tithonia compost/plant, presumably because the dosage used was still low or insufficient to influence the addition of K exchangeable value in the soil. The use of compost tithonia in the other treatments showed a difference in mean values of K exchangeable. This is presumably because in this treatment the dosage of compost tithonia was sufficient to increase the value of K exchangeable in the soil. According to [7] the provision of organic ingredients (organic fertilizer) into the soil will increase the amount and content of nutrients in the soil, such as N, P, K, Mg and others.

Table 4: Effect of Independent Compost Tithonia and Microorganism Fertilizers on K exchangeable (Cmol/kg) Soil on Cocoa plants

Tithonia Compost(T)	Mikroorganisme (M)					Average	
	M0	M1	M2	M3	M4		
T0	0.23	0.26	0.26	0.26	0.25	0.25	d
T1	0.24	0.28	0.28	0.30	0.30	0.28	d
T2	0.28	0.31	0.33	0.34	0.36	0.31	c
T3	0.33	0.40	0.42	0.43	0.44	0.40	b
T4	0.41	0.50	0.55	0.58	0.63	0.51	a
Average	0.27 b	0.31 a	0.32 a	0.33 a	0.34 a		

Remarks: Numbers marked with the same letters are not significantly different according to the 5% DMNRT test

The treatment of microorganisms did not show any significant difference for all levels of the K exchangeable content of the soil except when compared to treatment M0 showed a noticeable difference, this is presumably because the initial soil pH conditions as shown in Table 1 of 5.70 (rather sour) were considered insufficient optimal to support the activity of microorganisms to carry out the mineralization process in the soil optimally even though there appears to be an increase in the K exchangeable content in line with the addition of microorganism doses. In accordance with the opinion of [3] that the soil pH is rather neutral to neutral (pH 6.0 - 7.0) will strongly support the activity of microorganisms in carrying out mineralization processes in the soil which enriches the availability of nutrients including nutrients K in soil. Giving various doses of *Pseudomonas fluorecens + Tricoderma harzianum* did not give an effect on the K exchangeable value on the soil, this is presumably because besides the mineralization process has not run optimally also because the microorganism dose interval given is small.

3.5. *Content* of N (%) Cocoa Leaf

Table 5 shows that without the administration of compost tithonia the N content of the leaves of the cocoa plant is very low at 1.20%, without the administration of *Pseudomonas fluorecens* + *Tricoderma harzianum* the average N content in the leaves of the cocoa plant is 1.38%. Increasing the dosage of Tithonia compost up to 10.0 kg/Tithonia compost plant gets an N content in 1.76% leaves, as well as increasing the dose of microorganism to 400 ml *Pseudomonas fluorecens* + 4 kg *Tricoderma harzianum* gets the highest N content in plant leaves with N content in leaves of 1.56%. This is consistent with that obtained by [12] using bokashi with each increase in dosage giving an increase in the amount of nitrogen content in the leaves.

Table 5: Effect of Compost Tithonia and Microorganism Fertilizers on N (%) content on the leaves of Cocoa plants

Tithonia Compost(T)	Mikroorganisme (M)					Average	
	M0	M1	M2	M3	M4		
T0	1.06	1.15	1.16	1.41	1.44	1.20	d
T1	1.42	1.47	1.49	1.51	1.52	1.47	c
T2	1.51	1.53	1.53	1.56	1.57	1.53	c
T3	1.53	1.60	1.67	1.71	1.73	1.63	b
T4	1.64	1.79	1.80	1.81	1.83	1.76	a
Average	1.38 c	1.44 bc	1.46 b	1.55 a	1.56 a		

Remarks: Numbers marked with the same letters are not significantly different according to the 5% DMNRT test

The N content in cacao leaves before the study was 0.95%. An increase in the content of cocoa leaves can be caused by available nutrients in the soil by giving compost thitonia and an increase in nutrient uptake, especially N elements so that the amount of N content in the leaves increases. This is in accordance with the opinion of [13] Increasing plant N uptake is related to the increase in plant dry weight, improvement of plant root development, and increase in N soil availability.

3.6. Content P (%) Cocoa Leaf

Table 6 shows the difference in percentage content of P in plant leaves. Without titration, P content in cocoa leaves was 0.49%, which was originally 0.18% P content in the leaves of the cocoa plant. Each increase in the dose of tithonia increases the average percentage of P content in cocoa leaves. The highest average P content in cocoa leaves was obtained at T4, which was 0.83%.

This increase in P content in cocoa leaves can be caused by the P content in green tithonia leaves which has an average of 0.37% [14] Apart from that the speed of release of nutrients that occurs in tithonia is faster than that of other organic ingredients. Reference [15] reported the percentage of P-nutrient release originating from tithonia faster than other sources of organic matter, on the 84th day tithonia had already merged with the soil. The fast release of P elements made from tithonia makes plants able to utilize the nutrients released by these organic ingredients.

Table 6: Effect of Independent Compost Tithonia and Microorganism Fertilizers on P content (%) on the leaves of Cocoa plants

Tithonia Compost (T)	Mikroorganisme (M)					Average	
	M0	M1	M2	M3	M4		
T0	0.45	0.49	0.51	0.50	0.54	0.49	d
T1	0.53	0.52	0.53	0.56	0.63	0.53	d
T2	0.59	0.63	0.65	0.68	0.68	0.64	c
T3	0.65	0.70	0.75	0.78	0.83	0.72	b
T4	0.75	0.84	0.87	0.88	0.89	0.83	a
Average	0.56 c	0.58 bc	0.61 b	0.63 ab	0.67 a		

Remarks: Numbers marked with the same letters are not significantly different according to the 5% DMNRT test

The content of P elements in plant leaves can be influenced by the administration of N and K fertilizer. The higher the dose of N and K fertilizer is given, the higher the P content of the leaf. The high content of P elements in the leaves of cocoa plants is possible by the role of N elements in plants. Apart from that, an increase in N availability in the soil can be absorbed by plants, so that it can spur P uptake and cause leaf P levels to increase. [16] reports that the availability of N elements can stimulate P uptake and vice versa.

3.7. Content K (%) Cocoa Leaf

Table 7 The administration of thitonia and soil microbes shows no interaction with the K content, but the administration of tithonia shows different averages for each dose and so does the administration of soil microbes. Without the administration of tithonia, the lowest average was 0.76%. The higher the dose of tithonia, the higher the elemental content of K increases at 10 kg/plant, the content of K elements in the leaves increases to 1.23%. Before the implementation of the research, the content of K in the leaves of the cocoa plant was 1.25%. The K content in the leaves of the plant which declined after the implementation of the study was possible because the element K is a mobile element in the plant, so that displacement is very possible. According to [17] Potassium is the most abundant cation in phloem sap (almost 80% of total cations) as a consequence of filling photosynthate results and the mechanism of transporting photosynthate products through phloem to photosynthate wear organs. Reference [18] that organic plays an important role in the synthesis of carbohydrate transport and photosynthesis.

3.8. Results of wet seed weight of ICS 13 clone cocoa plant (g / plant)

Table 8 shows no interaction between the administration of tithonia and microorganisms, but the administration of tithonia gives a different average for each seed weight of cocoa plants, and so does the administration of microorganisms giving different averages. Without the administration of tithonia it was the lowest average of 513.17 g/plant, the highest weight was obtained by giving compost tithonia with a dose of 10 kg plant to get a weight of 881.33 g/plant. This increase in weight allows the fulfillment of the amount of nutrients needed by plants, given the unusually high content of tithonia. According to [14] the nutrient content in Tithonia compost is quite high at 3.5% N, 0.37% P, and 4.1% K. The administration of microorganisms showed that weight gain was almost the same at each increase in dose, but the highest wet weight of cocoa beans was obtained at a dose of 400 ml dose of *Pseudomonas fluorecens* + 4 kg of *Tricoderma harzianum*. Giving microorganisms can encourage an increase in the wet weight of the seeds of the cocoa plant. This is possible because many elements can be provided by microorganisms, because microorganisms are very active in helping the process of weathering organic matter. According to [19] Thrichodermas fungi are actively involved in the decomposition of cellulose, hemicellulose, and lignin in organic matter. The composting process can be accelerated to one month by inoculation of cellulolytic fungi such as *Aspergillus* and *Trichoderma* [20] because of its ability to produce enzymes that can reduce cellulose, hemicellulose and lignin [21].

Table 7: Effect of Independent Compost Tithonia and Microorganism Fertilizers on K content (%) on the leaves of Cocoa plants

Tithonia Compost(T)	Mikroorganisme (M)					Average	
	M0	M1	M2	M3	M4		
T0	0.73	0.73	0.75	0.81	0.82	0.76	e
T1	0.81	0.91	0.94	1.02	1.07	0.92	d
T2	1.06	1.09	1.09	1.10	1.11	1.09	c
T3	1.09	1.13	1.17	1.18	1.21	1.14	b
T4	1.20	1.23	1.23	1.25	1.26	1.23	a
Average	0.92 d	0.97 cd	0.99 bc	1.03 ab	1.05 a		

Remarks: Numbers marked with the same letters are not significantly different according to the 5% DMNRT test

Table 8: Effect of independent compost tithonia and microorganisms on the wet seed weight of cocoa plants (g/plants)

Kompos Tithonia (T)	Mikroorganisme (M)					Average	
	M0	M1	M2	M3	M4		
T0	525.00	481.00	518.67	528.00	530.67	513.17	d
T1	513.67	521.67	540.67	544.33	580.33	530.08	d
T2	568.33	643.67	666.67	692.67	722.00	642.83	c
T3	720.33	749.33	757.67	767.33	845.00	748.67	b
T4	815.67	867.00	915.00	927.67	925.33	881.33	a
Average	581.83 b	598.92 b	620.92b	633.08b	669.50a		

Remarks: Numbers marked with the same letters are not significantly different according to the 5% DMNRT test

4. Conclusion

The results showed no interaction between compost tithonia and Pseudomonas fluorecens and Tricoderma harzianum microorganisms on all response parameters in cocoa plants. But the administration of compost tithonia and Pseudomonas fluorecens and Tricoderma harzianum has an effect on all response parameters in cocoa plants. The administration of Tithonia compost was obtained in the treatment of 10 kg / plant and microorganisms at a dose of 400 ml *Pseudomonas fluorecens* + 4 kg *Tricoderma harzianum*.

References

[1]. Rusastra,W., Saptana dan A. Djulin. Roadmap Pengembangan Pupuk Organik Dalam Mendukung Pengembangan Pertanian Di Indonesia. Jurnal Departemen Pertanian. Buku VI : Pp 167-211. http://pse.litbang.deptan.go.id/ind/pdffiles/Anjak 2005 VI 05.pdf. 2005.

[2]. Safuan, L.O. 2002. Kendala Pertanian Lahan Kering Masam Daerah Tropika dan Cara Pengelolaannya. Internet : http://www.rudyct.com/PPS702-ipb/05123/laode_safuan.htm. October 27 2002. Juli 20 2019.

[3]. Subba Rao, Mikroorganisme Tanah dan Pertumbuhan Tanaman, 2nd edition. Universitas Indonesia Press. Pp 1-352. 2010.

[4]. Mangunsong, A., Soemarsono, Soemarsono., Muzakkir, Muzakkir. Bioteknologi mikroba dalam pembuatan pupuk organic dan peranannya terhadap tanah. Laporan Penelitian. Politeknik Pertanian Negeri Payakumbuh. 2013.

[5]. Dharma, S., F. Maulina,Yulensri. Aplikasi Mikroorganisme dan Bahan Organik Sisa Panen Sebagai Substitusi Pupuk dan Pestisida Kimia Untuk Meningkatkan Produksi Kacang Tanah. LUMBUNG Vol.6 No.1. Jurnal Penelitian Politeknik Pertanian Negeri Payakumbuh. 2007

[6]. Herman, Ekasari Ramadhani, Djuniarty. IbM Kelompok Tani Dalam Teknis Budidaya Tanaman Kakao Di Kabupaten Sopeng. Majalah Aplikasi Ipteks NGAYAH Vol. 7 No.2 Desember 2016.

[7]. Hakim, N. 1986. Dasar-Dasar Ilmu Tanah. Universitas Lampung Press. Pp 1-256.

[8]. Murbandono, L. HS.,1982. Membuat Kompos.Penebar Swadaya. Anggota IKAPI. Jakarta. 1982.

[9]. Wahyuni, S.H., Nasution, D.P.Y. Pengujian Nilai hara makro kotoran ayam yang di dekomposisi Trichhoderma viride. Jurnal Pertanian Tropik. Vol 5 No. 3. Pp 441-446. 2018.

[10]. Atmojo, S.W. Peranan bahan organic terhadap kesuburan tanah dan upaya pengelolaannya. Sebelas maret university Press. Surakata. 2003.

[11]. Elita, N., Agustamar,Yulensri. Korelasi Mikroorganisme Pelarut Fosfat dan Pupuk P Dalam Pola SRI-Organik Untuk Meningkatkan Mutu Sawah Intensifikasi Serta Produksi Padi. Artikel Ilmiah. Jurnal Penelitian LUMBUNG.Vol.12 No.1 Januari 2013.

[12]. Safria, Imam Wahyudi, , Ramlan Ali. Pengaruh pemberian bokashi daun gamal terhadap serapan nitrogen dan hasil tanaman jagung manis (Zea mays saccarata) pada entisol sidera. J. Agroland Vol. 24 No. 3 : 190 – 198. Desember 2017

[13]. Wahyudi, I. Manfaat Bahan Organik Terhadap Peningkatan Ketersediaan Fosfor dan Penurunan Toksisitas Aluminium di Ultisol. Disertasi Program Doktor. Universitas Brawijaya. Malang. 2009.

[14]. Jama, B., C.A. Palm, R.J. Buresh, A. Niang, C. Gachengo, G., Nziguheba, B. Amadalo, Tithonia diversifolia as a green manure for soil fertility improvement in western Kenya: a review agroforestry system. Vol 49 No. 2 :201–221. 2000.

[15]. Partey S. T., S. J. Quashie-Sam., N. V. Thevathasan., A. M. Gordon. Decomposition and nutrient

release patterns of the leaf biomass of the wild sunflower (Tithonia diversifolia): a comparative study with four leguminousagroforestry species Agroforest System Vol 81 Pp 123–134. 2011.

[16]. Amin, Z. Interaksi N (Urea)-P (SP-36) terhadap pertumbuhan dan hasil jagung Madura di lahan mediteran merah kuning. J. Saintek 11:7-13. 2004.

[17]. Cakmak, I., 2005. The role of potassium in alleviating detrimental effects of abiotic stresses in plants. J. Plant Nutr. Soil Sci., Vol. 168: Pp 521-530. 2004.

[18]. Marschner, H.,. Mineral nutrition of higher plants. Academic Press, San Diego, CA., 2nd Edition, Pp: 299-312. 1995

[19]. Goyal. S, D.K. Dhull, K.K. Kapoor. Chemical and biological changes during composting of different organic wastes and assessment of compost maturity. Bioresour Technol. Vol. 96:1584–1591. 2005.

[20]. Dayana A., R., A.R. Roshanida, M.I. Rosli, M.F., S. F. Zahrah, J. M. Anuar., C.M. Nazrul Adha. Bioconversion of empty fruit bunch (EFB) and palm oil mill effluent (POME) into compost using Trichoderma virens, Afr. J. Biotechnol 10 (81):18775–18780. 2012.

[21]. Saili, N.S., S. Siddiquee, C.M.W.V. Ling, M. González, S.V. Kumar. Lignocellulolytic activities among Trichoderma isolates from Lahad Datu, Sabah and deception island, Antarctic. J. Microb. Biochem. Technol. 6 (5):295–302. 2014.