Enriched Mechanically Accelerated Compost on the Growth of Tissue-CulturedBanana Seedlings

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Abstract

The experiment on Enriched Mechanically Accelerated Compost (EMAC) obtained from household and agricultural wastes (vegetables and fruits) of Zamboanga City was evaluated singly or in combination with other organic sources on tissue-cultured banana seedlings (lakatan variety) under greenhouse condition. The objective was to utilize the wastes by converting it to ecofriendly organic fertilizer mainly to reduce cost. The biodegradable garbage was processed and composted by the Local Government Unit (LGU) using a Material Recovery Facility (MRF) and was enriched with various microorganisms (EM) added with Carbonized Rice Hull (CRH). Complete Randomized Design (CRD) was employed with eight treatments replicated three times. The following were the treatments: T1-untreated (Control), T2-100% EMAC, T3-50% EMAC+50% chicken dung, T4-100% chicken dung, T5-50% EMAC+50% vermicast, T6-100% vermicast, T7-50% EMAC+50% commercial organic fertilizer (COF) and T8-100% COF. Results revealed that 50 days after re-bagging of lakatan seedlings, the application of 100% EMAC (T2) and 50% EMAC+50% chicken dung (T3) had comparable performance in affecting height and length of leaves of the banana seedlings followed by the rest of the treatments. Seedlings with no fertilizer (untreated) and with Commercial organic fertilizer (COF) application showed lower height and shorter length of leaves. Similar trend follows on the stem diameter and leaf area. In terms of the width of leaves, T2 remained to have higher mean but a combination of 50% chicken dung with EMAC showed to be significantly lower than T2. The number of leaves formed, however, was not significantly affected by the application of EMAC in comparison to other treatments, but significantly different than that of commercial fertilizer (T8) and the control (T1). Based on these findings, the application of EMAC as bio fertilizer can be further evaluated in the field utilizing vegetables, cereals and industrial crops due to its high organic

matter content.

Keywords: Enriched Mechanically Accelerated Compost, tissue-cul tured, Material Recovery Facility, Carbonized Rice Hull

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Introduction

The increase in human population requires more food available for consumption. In order to attain such demand, farmers use various chemical fertilizers because agricultural production does not match population growth (Smaling, Nandwa & Janssen, 1997). The uncontrolled and long time use of these chemicals made the soil infertile and had led to environmental pollution and induces various health hazards to humans (Higa and Wididana, 1991). In 1993, the Philippines has about 7,994,663 hectares that is with ultisols soil and this approximately 26.6% of the total land area. Ultisols are highly weathered deep soils with base saturation percentage that is low and are acidic due to a continued chemical fertilizers usage (PCARRD-DOST, 2006). On a global scale, toxic impacts of Agro-chemicals on the agricultural ecosystem, on the health of producers and consumers are becoming more evident. About, 10-20 thousand people die of cancer every year in the developing countries due to chemically grown food (UNEP/GEMS Environment Library No. 5, 1992).

During the time when dramatic increases in crop yields were obtained with the use of inorganic fertilizers, the organic materials were not given importance. But because of modern developments which tend to show unfavorable soil and environment conditions as a result of continued chemical fertilizers usage, many are becoming aware of the potential of organic fertilizers as alternative nutrient source for sustainable agriculture (PCARRD-DOST, 2006). Organic farming has evolved as an approach where a combination of agronomic, biological and physical practices is employed with continued application of organic fertilizers in order to increase and preserve soil fertility (PCARRD-DOST, 2008) and soil productivity (Higa, 1994).

In compliance to RA 9003 known as the Ecological Solid Waste Management Act of 2000, the City Government of Zamboanga, Philippines has initiated the establishment of processing technology to process these biological wastes into organic compost (OCENR, 2000). The Material Recovery Facility (MRF) was conceived utilizing locally fabricated mechanical equipment for accelerated composting in order to partly solve waste disposal problems in the city (OCENR, 2000) and to sustainably ensure the availability of organic fertilizer (Dela Cruz, et. al, 2004). Mechanically Accelerated Compost (MAC) is sold to farmers and fishpond operators at a reasonable price (OCENR, 2002). However, utilization of this compost drastically decline due to claims of poor effect to soil fertility brought about by lower nutrient contents. Thus, efforts had been done to enrich the substrate and rename it as Enriched Mechanically Accelerated Compost (EMAC). This organic fertilizer is a premix of Mechanically Accelerated Compost (MAC) and Effective Microorganisms (EM) added with Carbonized Rice Hull (CHR).

The use of effective microorganisms (EM) technology was developed at the University of Ryukyus, Okinawa, Japan in the early 1980's by a distinguished Professor of Horticulture, Dr. Teruo Higa. He found that the beneficial microorganisms has the capacity to influence decomposing organic matter and turn them to plant utilizable manure because of the selected species of micro-organisms such as the predominant populations of Lactic Acid bacteria, yeasts, a number of photosynthetic bacteria and actinomycetes. Effective microorganisms application revitalizes the agricultural land, enhances the plant health, growth and yield (Lin, 1991) because it improves the soil chemical nature suitable for the plant to grow (Krishnapriya, et.al., 2012), increases aeration and water holding capacity (PCARRD-DOST, 2006). Regular additions of organic matter will create a soil that is biologically active, improved soil structure, enhanced capacity of the soil to hold nutrients and a diverse pool of microbes is activated to break down organic matter into plant-available nutrients. Effective microorganism technology has become popular worldwide especially in the developed countries. In the Philippines particularly in Zamboanga City, this technology has not been accepted and there is a lack of scientific information to assess its effect.

Our nation has set its goal towards food security. In order to attain this, the Department of Agriculture has lined up programs geared towards food sustainability, productivity and profitability through expanding the area of banana production (DA, 2008). Banana is the prime fruit commodity of the country in terms of area planted and commercial value. It is the most economically important fruit crop and the only locally fruit available year-round. It has constantly brought in export earnings, positioning the country among the top five world producers of fresh bananas (PCAARRD, 2012). Although banana is a native to Southeast Asia, of the 57 banana cultivars, Lakatan is commonly grown throughout the country where climatic conditions favor its growth. It can be grown from the poorest to the richest type of soil with varying success but it can adapt well in soil that is rich in organic matter (DA, 2010). A number of research and development (R&D) efforts have been done to increase production and to help farmers, particularly those who work in small-scale farms (PCAARRD, 2012).

The utilization of Enriched Mechanically Accelerated Compost (EMAC) as biofertilizer has not been evaluated on crops hence, the objectives of this research were to determine the influence of Enriched Mechanically Accelerated Compost (EMAC) on soil fertility, evaluate its effectiveness to tissue cultured seedlings and determine the economic benefits of EMAC.

Methods

The experimental area was laid out in a Complete Randomize Design (CRD) with eight treatments replicated three times. The treatments are the following: T1-untreated (Control), T2 (100% EMAC), T3 (50% EMAC+50% Chicken Dung), T4 (100 ChickenDung), T5 (50% EMAC+50% Vermicast), T6 (100% Vermicast), T7 (50% EMAC+50% Commercial Organic Fertilizer or COF) and T8 (100% COF).

Approximately two-month old tissue-cultured lakatan seedlings selectively prepared in the nursery. The seedlings were re-bagged using a polyethylene bag with a size of 16”x20”. Each seedling was carefully transplanted with a soil medium enhanced with Enriched Mechanically Accelerated Compost (EMAC) as biofertilizer.

Prior to re-bagging, soil samples were collected from all 240 pots and submitted for analysis at the Bureau of Soils and Water Management (BSWM), Zamboanga City. All organic substrates were also submitted for analysis to determine the pH, OM, P and K contents. Soil samples were again collected from each treatment 30 days after re-bagging for another analysis in the laboratory.

The Mechanically Accelerated Compost (MAC) taken from the Local Government Units (LGU) was brought to the College of Agriculture tissue culture nursery. This was sorted to remove unwanted debris present during the bagging. Effective microorganism (EM) solution was prepared at a ratio of 20 ml Effective Microorganisms Activated Solution (EMAS) to a one liter of distilled water. The solution was poured slowly using a sprinkler for every 50 kilograms of Mechanically Accelerated Compost (MAC). The substrate was mixed thoroughly using a shovel in a clean and dry pavement. This substrate was added with Carbonized Rice Hull (CHR) at a ratio of one 1:1 which means one part mixed substrate and one part carbonized rice hull to form an Enriched- mechanically Accelerated Compost (EMAC). A prepared Enriched Mechanically Accelerated Compost (EMAC is shown in Figure 1.

Figure 1. Enriched Mechanically Accelerated Compost (EMAC)

Garden soil was gathered, sorted and cleaned. EMAC and other organic substrates were applied as basal fertilizers at the rate of 1.0 ton/hectare. Each sample pot was applied with 625.0 grams of organic substrate singly or in combination following the rate of each treatment.

Initial data were gathered a day after re-bagging. Succeeding collections were done on the 20th, 35th and on the 50th day after re-bagging with the following parameters:

1. **Number of leaves formed**. This was done by counting the leaves of every sample plants after the application of Enriched Mechanically Accelerated Compost (EMAC) and other organic sources. Each plant will have three leaves at the start of the study.

2. **Plant height in cm**. The height in cm was gathered using a meter stick measuring from the base of the plant to the tip of the longest leaf.

3. **Length of leaf**. The leaf of the seedlings from bottom, middle and top most were measured in centimeters using a meter stick from the base to the tip of the leaf.

4. **Width of leaf**. The width of each leaf in cm obtained from the bottom middle and top portion was measured using a meter stick across the expanded portion of the leaf.

5. **Stem Diameter in cm**. The pseudo stem was measured using a caliper near the base of the stem just right above the soil media.

Results

Table 1 showed the different sources of organic fertilizer with the corresponding nutrient analysis. Commercial Organic Fertilizer (COF) yielded the highest in nitrogen (N) content (4.94%) followed by chicken manure (1.26%) and Enriched Mechanically Accelerated Compost (EMAC) (1.21%), vermicast (0.80%) and Mechanically Accelerated Compost (MAC) (0.73%). While for phosphorus (P), Commercial Organic Fertilizer (COF) remained the highest (9.62%) followed by Mechanically Accelerated Compost (MAC) (4.33%), Enriched Mechanically Accelerated Compost (EMAC) (3.02), chicken manure (2.80%) and vermicast (2.30%).

In terms of Potassium (K), however, Enriched Mechanically Accelerated Compost (EMAC) yielded the highest with 3.60% followed by Mechanically Accelerated Compost (MAC) (1.21%), Commercial Organic Fertilizer (0.97%), vermicast (0.70%) and chicken manure (0.67%).

Table 1
Analysis of the different substrates from different sources

Kinds of Substrate	N (N03 & NH4)	P (P2O5)	K (K2O)	Moisture Content
Mechanically Accelerated Compost (MAC)	0.73	4.33	1.21	22.5%
Enriched Mechanically Accelerated Compost (EMAC)	1.21	3.02	3.60	10.0%
Vermicast	0.80	2.30	0.70	20.0%
Chicken Dung	1.26	2.80	0.67	14.0%
COF (Analysis from supplier)	4.94	9.62	0.97	-

Source: Bureau of Soils and Water Management Laboratory Results, Reg. IX, Z.C.

For instance, chicken manure has been found to be high in nitrogen (N) and contains a good amount of phosphorus (P), potassium (K) and other micronutrients. It is desirable organic fertilizers because of its high nitrogen content (Ghosh, et al., 2010). On the other hand, vermicast has been found to contain nutrients in a form that are readily taken up by the plants such as nitrates (NO3), exchangeable phosphorus (P), soluble potassium (K), Calcium (Ca), and Magnesium (Mg). It has also been shown to reduce the incidence of plant diseases and very rich in vitamins, enzymes, antibiotics, growth hormones and microflora (ERF, 2012).

It is imperative that growers must understand the basic steps of nitrogen (N) availability and other nutrients in manure and composts once it is incorporated in the soil (PCARRD, 2006) in the process called **mineralization**.

At 30 days after re-bagging, soil samples were again collected for analysis in all treatments. As shown in **Table 2**, T2 (100% EMAC) has the most **favorable pH value, high in organic matter (OM) and potassium (K)**. The values may explain the present condition of the soil in T2 (100% EMAC) and it is closely comparable to T3 (50% EMAC plus 50% chicken manure), T4 (100% chicken manure), T5 (50% EMAC plus 50% vermicast), and T6 (100% vermicast). The data appeared to have changes on pH, organic matter (OM) and potassium (K) after EMAC application over time.

Table 2
Analysis of soil samples 30 days after re-bagging

Treatment	pH	OM%	P (ppm)	K (ppm)
Soil medium used	5.66	1.0	70	365
T1 30 Days After Re-bagging (DAR)	6.2	0.5	24	365
T2 (30 DAR)	7.0	1.0	50	500+
T3 (30 DAR)	7.2	0.5	100+	500+
T4 (30 DAR)	7.2	0.5	100+	500+
T5 (30 DAR)	7.1	0.5	60	500+
T6 (30 DAR)	7.2	0.5	60	465
T7 (30 DAR)	7.6	0.5	77	500+
T8 (30 DAR)	8.2	0.5	90	500+

Source: Bureau of Soils and Water Management Laboratory Results, Reg. IX, Z.C.

Figures 2, 3 & 4 showed a comparison on the growth performance of banana seedlings with EMAC and with no application of EMAC.

Figure 2. Tissue-Cultured Lakatan Seedlings Prior to Re-bagging (no fertilizer)

Figure 3. Tissue-Cultured Lakatan Seedlings 30 Days after Re-bagging.

Figure 4. Tissue-Cultured Lakatan Seedlings 50 Days after Re-bagging.

Average Number of Leaves

As shown in **Table 3**, the application of Enriched Mechanically Accelerated Compost (EMAC) has not significantly affected the number of leaves formed in comparison to treatments 3, 4, 5, 6, and 7. based on the ANOVA. Treatment 2 (100% EMAC), however, appeared to be significantly different than that of T1 (untreated) and T8 (commercial organic fertilizer). The data showed that T2 (100% EMAC) obtained the highest number of leaves with an average mean of 4.67 as compared to T1 (3.67) and T8 (3.67) respectively.

Table 3
Average number of leaves of banana seedlings after application of EMAC 50 days after re-bagging (DAR)

Treatment	Replication			Total	Mean
	1	2	3		
T1	4.0	4.0	3.0	11.0	3.67 b
T2	5.0	5.0	4.0	14.0	4.67 a
T3	4.0	4.0	5.0	13.0	4.33 ab
T4	4.0	5.0	4.0	13.0	4.33 ab
T5	4.0	4.0	4.0	12.0	4.00 ab
T6	5.0	4.0	4.0	13.0	4.33 ab
T7	4.0	4.0	4.0	12.0	4.00 ab
T8	4.0	3.0	4.0	11.0	3.67 b
CV % 12.12					
Significance: NS					

*NS-None Significant, *-Significant, **-Highly Significant*

Treatment 2 (100% EMAC) has been found comparable to T3 (50% EMAC + 50% chicken manure), T4 (100% chicken manure) and T6 (100% vermicast), all three with equal average mean of 4.33, followed by T5 (50% EMAC + 50% vermicast) and T7 (50% EMAC + 50% COF), both with an equal average mean of 4.00 respectively. . Plants inoculated with EM and organic manures (e.g. MAC, chicken manure and vermicast) recorded the highest number of leaves. Another observations made was on the change in terms of the microbial diversity and their interaction in soils brought about by the application of EM (Primavesi & Konji, 1997).

Average Plant Height (cm)

As shown in **Table 4**, there was a significant difference among treatments on the height of banana seedlings (var. lakatan) as statistically analyzed.

Table 4

Average plant height in centimeters of banana seedlings after application of EMAC 50 days after re-bagging (DAR)

Treatment	Replication			Total	Mean
	1	2	3		
T1	58.0	58.5	53.1	169.6	56.53 bc
T2	83.1	77.1	73.4	233.6	77.87 a
T3	78.1	79.3	76.3	233.7	77.90 a
T4	73.1	73.6	73.1	219.8	73.27 a
T5	71.4	79.9	68.5	210.8	73.23 a
T6	76.1	73.8	74.4	224.4	74.77 a
T7	62.5	62.6	60.3	185.4	61.80 b
T8	54.4	51.6	53.0	159.0	53.00 c
CV % 4.48					
Significance: **					

*NS-None Significant, *-Significant, **-Highly Significant*

T2 (100% EMAC) and T3 (50% EMAC + 50% chicken manure) exhibited the highest plant height with (77.87 cm) and (77.90 cm) respectively, followed by T6 (100% vermicast) with 74.77 cm, T4 (100% chicken manure) with 73.27 cm, T5 (50% EMAC + 50% vermicast) with 73.27 cm, T7 (50% EMAC + 50% COF) 61.80 cm. Least were T1 (untreated) with 56.53 cm and T8 (100% COF) 53.00 cm.

Average Length and Width of Leaves

Table 5 showed that there was significant difference among treatments on the length of leaves of banana seedlings (var. lakatan) as analysis of variance revealed.

T2 (100% EMAC) and T3 (50% EMAC + 50% chicken manure) obtained the longest leaf with 35.10 cm and 35.23 cm respectively comparable to T6 (100% vermicast) with 34.20 cm. this was followed by T4 (100% chicken manure) with 33.87 cm, T5 (50% EMAC + 50% vermicast) with 33.07 cm, and least were T1 (untreated) with 27.47 cm and T8 (100% COF) with 27.10 cm respectively.

Table 5
Average length of leaves in centimeters of banana seedlings after application of EMAC 50 days after re-bagging.

Treatment	Replication			Total	Mean
	1	2	3		
T1	27.1	28.3	27.0	82.4	27.47e
T2	36.2	35.3	33.8	105.3	35.10 a
T3	35.3	35.5	34.9	105.7	35.23 a
T4	33.9	33.8	33.9	101.6	33.87 bc
T5	33.1	33.2	32.9	99.2	33.07 c
T6	34.8	33.7	34.1	102.6	34.20 ab
T7	29.6	30.3	29.1	89.0	29.67 d
T8	27.0	26.8	27.5	81.3	27.10 e
CV % 1.89					
Significance: **					

*NS-None Significant, *-Significant, **-Highly Significant*

Table 6
Average width of leaves in centimeters of banana seedlings after application of EMAC 50 days after re-bagging.

Treatment	Replication			Total	Mean
	1	2	3		
T1	11.4	12.1	11.8	35.3	11.77 e
T2	15.7	16.4	15.1	47.2	15.73 a
T3	15.3	14.9	14.6	44.8	14.93 b
T4	13.8	13.8	13.8	41.4	13.80 c
T5	13.8	13.8	13.8	41.4	13.80 c
T6	14.3	13.9	14.3	42.5	14.17 c
T7	12.2	12.3	12.5	37.0	12.33 d
T8	11.2	10.8	11.0	33.0	11.00 f
CV % 2.33					
Significance: **					

*NS-None Significant, *-Significant, **-Highly Significant*

Consistently, in terms of width, T2 significantly obtained bigger width of leaves when compared to other treatments (Table 6) and also appeared to be highly significantly different as revealed by the analysis of variance. Although T3 ranked second (14.93 cm) but not comparable to T2 and the rest of the treatments.

Average Stem Diameter

Table 7 showed the average stem diameter of banana seedlings (var. lakatan). Based on the results, data revealed that there was a significant difference among treatments on the stem diameter of lakatan seedlings as revealed by analysis of variance (SAS 9.3.1).

T2 (100% EMAC) and T3 (50% EMAC + 50% chicken manure) obtained the larger stem diameter with 2.37 cm and 2.30 cm respectively followed by T4 (100% chicken manure) with 2.13 cm, T5 (50% EMAC + 50% vermicast) with 2.07 cm, T7 (50% EMAC + 50% COF) with 1.90 cm, and least are T1 (untreated) with 1.77 cm and T8 (100% COF) with 1.70 cm.

The application of effective microorganism (EM) as biofertilizer influenced the growth of banana seedlings (Ghosh, et al., 2010). EM inoculation affected significantly stem diameter of banana seedlings. In general, EM combined with EMAC seemed to have direct impact on the vegetative growth and development of banana seedlings (Lakatan).

Table 7.
Average stem diameter in centimeters of banana seedlings after application of EMAC 50 days after re-bagging.

Treatment	Replication			Total	Mean
	1	2	3		
T1	1.8	1.8	1.7	5.3	1.77 d
T2	2.4	2.3	2.4	7.1	2.37 a
T3	2.3	2.3	2.3	6.9	2.30 a
T4	2.1	2.1	2.2	6.4	2.13 b
T5	2.1	2.1	2.0	6.2	2.07 b
T6	2.2	2.1	2.1	6.4	2.13 b
T7	1.9	1.9	1.9	5.7	1.90 c
T8	1.7	1.7	1.7	5.1	1.70 d
CV % 2.23					
Significance: **					

*NS-None Significant, *-Significant, **-Highly Significant*

Previous studies have demonstrated a consistent positive response with the use of effective microorganisms (EM) with organic matter (OM) in crop production and indicate the potential of this technology to reduce fertilizer use, increase the yield and quality of crops (Higa, 1991).

Estimated Cost

The economic benefit of Enriched Mechanically Accelerated Compost (EMAC) is shown in Table 8. The results showed that of the treatments, T6 (100% vermicast) found to be very expensive followed by T5 (50% EMAC plus 50% vermicast), T8 (100% COF) and T7

(50% EMAC plus 50% COF). T2 (100% EMAC) is closely equal with T3 (50% EMAC plus 50% chicken manure) and T4 (100% chicken manure) and T1 (control, untreated).

The kind of organic substrates used has something to do with the economic side of growing lakatan seedlings. Investing in organic farming using vermicast is still very expensive than using other available organic composts, although it has been scientifically proven by many researchers that it is very rich in elemental nutrients.

Table 8
Estimated cost 50 Days after Re-bagging

Particular	Estimated Cost in Peso Per Hectare							
	T1	T2 (100% EMAC)	T3 (50% EMAC + 50% CM)	T4 (100% CM)	T5 (50% EMAC + 50% Vermi)	T6 (100% Vermi)	T7 50% EMAC + 50% COF)	T8 (100% COF)
A.Variable Costs: 1.Inputs -Seedlings (@ 25.00 per Seedling x 1600 hills)	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
.Fertilizers - Organic:								
a. MAC	-	750.00 (@ 37.50 per bag x 20 bags)	375.00 (@ 37.50 per bag x 10 bags)	-	375.00 (@ 37.50 per bag x 10 bags)	-	375.00 (@ 37.50 per bag x 20 bags)	-
b. Vermicast	-	-	-	-	4,000.00 (@ 8.00 per kilo x 500 kgs.)	8,000.00 (@ 8.00 per kilo x 1,000 kgs.)	-	-
c. Chicken Manure	-	-	**350.00** (@ 35.00 per bag x 10 bags)	**700.00** (@ 35.00 per bag x 20 bags)	-	-	-	-
d. Commercial Organic Fertilizer (COF)	-	-	-	-	-	-	**2,000.00** (@ 200.00 per bag x 10 bags)	**4,000.00** (@ 200.00 per bag x 20 bags)
e. EM1 (@ 550.00 per liter)	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00

Table 8. [continued]

f. Carbonized Rice Hull (CRH)	-	500.00 (@ 0.50 per kilo x 1,000 kgs.)	250.00(@ 0.50 per kilo x 500 kgs.)	-	250.00 (@ 0.50 per kilo x 500 kgs.)	-	250.00 (@ 0.50 per kilo x 500 kgs.)	-
B. Labor Cost: Hauling, Land Preparation, Planting, Irrigation, Weeding and Sanitation	11,880	11,520	11,520	11,520	11,520	11,520	11,520	11,520
C. Contingency	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00
Total Cost	53,630	55,240	54,965	54,690	58,615	61,990	56,615	57,990

Note. Costs are in Philippine Peso

The primary material of Enriched Mechanically Accelerated Compost (EMAC) is cheap and available the whole year round. Since, the based-material is from the consolidated agricultural waste products, using EMAC is not only economically viable but also helping our City from transporting most of these biodegradables (agricultural wastes) to landfills On the other hand, the cheapest and the most common is the application of chicken manure. For years, this substrate has been found to be efficient and effective. However, on the basis of the results the 100% chicken manure is not comparable to EMAC.

Discussion

In relation to the soil analysis Enriched mechanically Accelerated Compost (EMAC) showed to have more nutrient components than the rest of the organic substrates utilized in this study. Although PCARRD (2006) suggested that all organic substrates may have a potential effect on the growth of seedlings as it plays an important role in the development of plant height, stem and the formation of leaves due to enhanced soil aggregation and nutrients held in organic combinations. These organic substrates are released for use by plants through the action of various microorganisms (Higa, 1991).   Generally, 70-

80% of the phosphorous (P) and 80-90% of the potassium (K) will be available from manure and composts. Organic nitrogen (N) is unavailable for uptake until microorganisms degrade the organic compounds that contain it. Through microbial reactions, organic fertilizer when incorporated in the soil, provides the soil the advantage to include slow release of nutrients, long-term benefits to the soil, long-term benefits to the environment and will help corrects imbalances (Aguilar, et al., 2010).

The role of effective microorganism (EM) as the primary component of Enriched Mechanically Accelerated Compost (EMAC) in this study, believed to be a quick composter and can provide a longer synergistic solution of microorganisms that will help promote beneficial enzymes, nutrients, and proteins. As a biofertilizer, effective microorganism (EM) is considered as the most effective alternative to chemicals (Higa, 1994).

Results of soil analysis after 30 days of bagging the seedlings , shows that various organic fertilizers differ in their effectiveness to soil fertility and the response of lakatan seedlings as manifested on their growth in Figures 2 & 3. The effect on growth depends on the kind and volume of nutrients readily available for uptake. Aguilar, et al., (2010) emphasized the need of an appropriate analysis (soil analysis) prior to application of organic fertilizers. This may help farmers to better understand the values of nitrogen (N), phosphorus (P), Potassium (K) and micronutrient contents of each organic source and its significance in determining the volume of compost and manure needed for a specific application to a particular crop.

Loss of organic matter (OM) in soil is often identified as one of the main factors contributing to declining soil fertility. When soil is unhealthy it is unfit to sustain crop productivity and only organic fertilizers can rehabilitate unproductive soils (Comia, 1999). In this case, liming was needed in order to correct the slight acidity of the soil which neutralizes toxic effects of excessive amount of acidic elements present in the soil, promotes desirable microbial activities and improve the physical condition of the soil (DA-RFU-IX, 2009), at the same time will help promote soil-water-air relationship and nutrient availability (PCAARRD, 2006).

There is a need to return organic matter into the soil in order to reinvigorate it. Traditionally, much of what was produced was consumed on the farm. This system allowed for the limited removal of soil nutrients since there was an opportunity to return most of the nutrients back to the land (Lickacz & Penny, 2001) and through a series of biological processes of organic matter (OM) in the soil like farm residues and other organic wastes in which microorganisms like bacteria, fungi, and actinomycetes will consume and breakdown organic materials in the soil into a stable forms (Higa, 1994); and helps restore depleted soil to a healthy pH balance (Porter, 2008).

In terms of the number of leaves in Table 3, the significant increase on leaf number on Treatments 2, 3, 4, 5, 6 and 7 supports the findings of Matthew and Higa, (2005) in their study on maize. They attributed the increase of leaves and photosynthetic activities to the continued supply of nutrients and hormones from effective microorganism (EM). Ghosh, et al., (2010) affirmed this finding that effective microorganism (EM) inoculation improved leaf production. Plants inoculated with EM and organic manures (e.g. MAC, chicken manure and vermicast) recorded the highest number of leaves. Another observations made was on the change in terms of the microbial diversity and their interaction in soils brought about by the application of EM (Primavesi & Kinjo, 1997). In Sri Lanka, the application of EM to organic matter (OM) in soils is the best method for rapid release of nutrients to plants (Sangakkara & Marambe, 1996) and application of organic matter made up of leguminous leaves and rice straws greatly influenced the growth and development of tomato. Thus, effective microorganism (EM) incorporated with organic matter has a significant role in maintaining productivity of cropping systems (Pretty, 1996).

The application of EMAC on plant height of lakatan seedlings, appeared to be more responsive on crop growth According to Higa, (1994), crop growth and development are closely related to the nature of the soil microflora, especially those in close proximity to plant roots as influenced by crop physiological factors, the environment and the biological factors including soil microorganisms. The findings of Higa (1994) were best demonstrated in T2 (100% EMAC) and T3 (50% EMAC plus 50% chicken manure). Both treatments have been found to be more responsive to growth and development as best describe by their consistent shoot growth thereby favoring increase in height. Findings may explain that Enriched Mechanically Accelerated Compost (EMAC) affected the physiology of seedlings such as the synthesis of organic matter (OM), help promote aeration, increase water retention and availability of nutrients brought about by the action of beneficial soil microorganisms or EM (Higa 1994). The application of organic matter with effective microorganism (EM) positively affects the growth and development of roots and shoots (Ghosh, et al., 2004). The application of Enriched Mechanically Accelerated Compost (EMAC) as biofertilizer may have influenced the conversion of important elements from unavailable form into available form through biological processes, which according to Ghosh et al., (2004) can affect mineral nutrition of plants through their influence on growth, morphology and physiology of roots; the physiology and development of plants; the availability of nutrients; and nutrient uptake processes. In this case, Enriched Mechanically Accelerated Compost (EMAC) has been found to favor such conditions and these processes induced the seedlings to grow well in height. Dehghani, Kordlaghari, and Mohamadinia (2013) and Fraszczak, Kleiber, and Klama (2012) stated that effective microorganism (EM) application increased plant height significantly on maize and basil. Both findings indicated that the use of EM in combination with organic substrates can lead to taller plants. Furthermore, the findings explain the importance of soil microorganisms and continued application of organic matter (OM) for the improvement of soil physical and chemical properties which will lead to the increase availability of nutrients in the soil over time. Therefore, bare soils would need constant application of organic matter (OM) with periodic application of effective microorganism (EM).

The increase in length and width of the leaves in Tables 5 and 6 appeared to be related. Based on results, the increase of length and width of banana seedlings were significantly influenced by Enriched Mechanically Accelerated Compost (EMAC) as applied basally on soil. The Effective microorganisms (EM) in soil contributed to nutrient availability within the root zones leading to rapid root development as manifested by plants treated with EMAC. The findings also suggested an increase in nutrient assimilations by the tissue-cultured lakatan seedlings in treatments with EMAC because of better absorbing capacity of plants brought about by better root development which lead to an increase in leaf length of treatments 2 and 3 respectively (Table 5) and an increase in leaf width of T2 (Table 6). It was observed that treatments with EMAC resulted in longer and larger leaf structures and found to be greener, and presumed to have better photosynthetic activity. This observation supports the findings of Chantal, Xiaohou, Weimu, and Iro Ong'or (2010) that increase in leaf length and width was due to the effect of EM on plant roots development followed by better fostering with nutrients to the plant. This indicates an enhanced biomass production and photosynthetic capacity as in increase length and width of beans (Primavesi & Kinjo, 1997) and increase of leaf area (LA) on corn (Higa, 1994). Eventually, an increase in leaf length and width (or leaf area) will result to higher rates of photosynthesis hence increased plant growth. For plants, a high rate of net carbon assimilation can result in higher biomass accumulation, favoring future growth and reproduction. During early stages of leaf growth, synthesis of chlorophyll, proteins and structural compounds is high resulting in high catabolic rates to support energy needs by the plants. Inoculation of effective microorganism can increase the available nutrition for plant roots and improve photosynthesis (Ghosh, et al., 2010). Increase in leaf chlorophyll content could in turn lead to increased protein synthesis of the plants and this could have a direct effect on the plant growth and photosynthesis (Hendry, et al., 1987). Nitrogen is one of the essential nutrients involved as a constituent of biomolecules such as nucleic acids, coenzymes and proteins (Sharma, et al., 1995). Any deviation in these constituents would inhibit the growth and yield of plants. Protein concentrations in plants tend to increase with fertility level of the growth medium (Grant, et al., 1993).

Specifically for stem diameter, a study conducted by Nakano (2007), indicated that plants treated with EM showed the thickest diameter of mature stems of Wisconsin Fast Plants (Brassica rapa) over those plants treated with no EM. In this case, EM in EMAC seems to have a direct impact on the vegetative growth and development of lakatan seedlings.

Due to the significant effect of EMAC singly or in combination with other organic fertilizers on growth improvement of tissue-cultured lakatan seedlings , the potential of being utilized as organic fertilizer to other high value crops require utmost attention.

The application of Enriched Mechanically Accelerated Compost (EMAC) as biofertilizer influenced the growth of banana seedlings particularly on the number of leaves form , stem diameter and height in cm, Enriched Mechanically Accelerated Compost (EMAC) is not only economically viable, available but of reduced costs when compared to inorganic fertilizers. Further more field trials of researches on EMAC application in vegetables, cereals and industrial crops (rubber, oil palm , abaca, cacao and coffee) must be done to establish baseline data on EMAC as effective bio-fertilizer of crops in the region due to its high organic matter content.

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