

Production and Characterization of Bio-Organic Fertilizer from Agricultural Wastes

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Abstract – The current demand in the practice of agriculture is through organic production approach. This study documented the experiences on the production of bio-organic fertilizer utilizing Bio-Plus Activator and agricultural wastes. Within the span of two months (November-December), three batches of raw materials (1 ton/batch) were processed in the two production sites. Raw materials utilized includes: 1) batch 1 - rice straw, goat manure, carbonized rice hull, 2) batch 2 – rice straw, carabao manure, and carbonized rice hull, and 3) batch 3 – saw dust, chicken dung and carbonized rice hull.

A ton of raw materials was processed inside a shed. There was no observed foul odor coming from compost pile within the decomposition period, which ranges from 22 to 27 days. Sweetening and curing lasted for 10 to 14 days while raw material recovery ranges from 47.29 to 68.9%.

Using only manual labor, production activities (collection of raw materials up to bagging) requires 6 to 9 man-days for every ton of raw materials. The total N content of each of the three batches is comparable to that of the commercial organic fertilizer (1% N – 5%P – 1%K), so as with the total K content except for batch 2 which is a little bit lower. Total P content of each of the three batches were low compared to the commercial organic fertilizer.

Keywords – Bio-organic Fertilizer, Agricultural Wastes, Bio-Plus Activator, Organic Fertilizer.

I. INTRODUCTION

The increasing cost of chemical fertilizers coupled with the growing awareness on the possible hazard of synthetic chemicals on health and the environment [3], and the issue on sustainable development has brought wide interest on organic agriculture. The Philippine government has recognized this reality, thus Executive Order 481 on the “Promotion and Development of Organic Agriculture in the Philippines” was issued.

Nowadays, organic-based agricultural production is rapidly emerging technology in the Philippines, which partly solves waste disposal problems through conversion of biodegradable wastes into organic compost; this ensures the availability of organic fertilizer for crop production [2]. Recently, as more and more organic fertilizers are produced and utilized, its benefits have become more evident and measurable, too. The use of microorganisms in organic fertilizer production has also been introduced.

Bio-organic fertilizer is processed inoculated compost from any organic material that has undergone rapid decomposition by the introduction of homogeneous microbial inoculants [5]. It is also called microbial fertilizer for it contains unique beneficial microorganisms (i.e. bacteria, fungi, algae, earthworm) that fix atmospheric nitrogen, mobilize and release nutrient elements in the

soil, promote plant-growth promoting substances, and act as biocontrol agent against pest and diseases.

This research is conducted in order to establish a system that will enable small and sustainable farmers produce their own organic fertilizers utilizing the available organic materials present in the farm. A Bio-Plus Activator (BPA) is incorporated in the production. BPA is claimed to have a scientific formulation consisting of 25 beneficial microorganisms [6]. It contains 7 types of bacteria for decomposition, enzyme production and nutrient transformation; 3 types of bacteria for decomposition of polysaccharides and enzyme production; 3 types of bacteria for enhanced decomposition, compost “sweetening” and probiotics production; 5 types of bacteria for nitrogen fixation and nutrients transformation; and 7 fungi for decomposition, probiotics production and nutrient transformation.

II. METHODOLOGY

A. Establishment of Bio-Organic Fertilizer Production Sites

The Naval State University–Biliran Campus in Biliran, Biliran, Philippines served as the base station of the study. The production site in the campus was ideal considering the following criteria and requirements for bio-organic fertilizer production: 1) accessibility to transportation and to the sources of raw materials, 2) a shed with concrete flooring and adequate space for mixing, turning, composting, curing, sieving and bagging, 3) source of water to be used during mixing, 4) available manpower to gather the farm waste materials and do composting activities up to bagging, 5) accessible location for showcasing, and 6) accessibility to the researchers to regularly monitor and gather data.

The study considers also a farmer-cooperator who is willing to produce bio-organic fertilizer in his locality, follow the production protocols, and willing to provide the necessary inputs and facilities required in the production activities. This mechanism allows a wider coverage to facilitate information dissemination and validation activities which will be subsequently conducted in relation to bio-organic fertilizer production. Mr. William E. Mangubat of Brgy. Sabang, Naval, Biliran was the cooperator in this study.

B. Bio-Organic Fertilizer Production Protocol

This study utilizes the Bio-Plus Activator (BPA) as the catalyst for bio-organic fertilizer production. The production protocol was provided during an orientation-briefing conducted by the regional project personnel at the Eastern Visayas Intergrated Agricultural Research Center in Abuyog, Leyte, the Philippines.

The recommended composition of organic materials and the corresponding amount (% by weight) that will be used in the production of bio-organic fertilizer are the following: biomass material (55%), chicken dung or animal manure (35%), carbonized rice hull (10%), and BPA (0.5%). In this study, biomass materials refer to any biodegradable materials which are mostly crop waste products and processing residues.

The production procedures are as follows: (1) Dividing the organic materials into a manageable number of sets; (2) Piling of the organic materials one after the other and broadcasting of BPA in every pile of raw material; (3) Moistening the dry organic material up to a maximum of 80% moisture level before broadcasting the activator; (4) Procedures 2 and 3 are repeated until all the organic materials are completely piled; (5) Mixing of the pile immediately before covering with a canvas or 'sakolet'; (6) Turning again of the pile after 2-3 days and every 2-3 days thereafter until all organic materials are fully decomposed; (7) The decomposed materials are allowed to cure/sweeten for 8-10 days. Curing/sweetening was done by completely removing the pile cover and continuously turning the decomposed materials everyday to further lower the temperature and reduce the moisture content; and (8) Sieving of the compost using a 1/8" wire mesh. This was followed immediately by bagging.

Full decomposition of raw materials was determined using the guidelines provided by Cuevas [1] as follows: 1) the temperature in all parts of the pile drops to 33-35°C, or

approximately air temperature, 2) the different materials in the substrate are no longer recognizable, 3) the compost is dark brown to black, and looks like soil, and 4) the ripe compost does not emit a foul odor. When the pile was already fully decomposed, sweetening and curing followed until the moisture content reduced to not more than 20%.

C. Material Sources Used in Bio-Organic Fertilizer Production

Within the span of two (2) months (November-December) three (3) batches were processed in the two production sites (2 batches in the base station, and 1 batch in Brgy. Sabang, Naval). Each batch utilized more or less one (1) ton (fresh weight) of waste materials. Table 1 presents the raw proportion of materials used in each batch of bio-organic fertilizer production.

The raw materials used in NSU-Biliran Campus site were farms wastes collected as fresh within the Campus and the adjacent barangay and were acquired without any cost except for the labor and transportation in hauling the materials. While for the Sabang, Naval production site, the saw dust and chicken manure were bought from the saw mill and poultry farm, respectively, in an adjacent barangay. The carbonized ricehull was acquired free from the adjacent barangay also.

In NSU-Biliran Campus, the waste materials were weighed using a platform type weighing scale, while in Sabang, Naval, the raw materials were weighed using a 'hanging' type weighing scale.

Table 1. Raw Materials Used in Bio-Organic Fertilizer Production

Batch No.	Production Site	Raw Materials	Quantity, kg (% from total)
1	NSU-Biliran, Biliran	Rice straw (fresh)	629 (56.8%)
		Goat manure (fresh)	374 (33.8%)
		Rice hull (ash & carbonized)	100 (9%)
		Bio-Plus Activator	5 (0.5%)
2	NSU-Biliran, Biliran	Rice Straw (15 days after harvest)	585 (56.2%)
		Carabao manure (fresh)	351 (33.7%)
		Rice hull (ash & carbonized)	100 (9.6%)
		Bio-Plus Activator	5 (0.5%)
3	Sabang, Naval	Sawdust	561 (55.2%)
		Chicken dung	350 (34.4%)
		Carbonized ricehull	100 (9.8%)
		Bio-Plus Activator	5 (0.5%)

D. Data Collection, Gathering and Observations

To establish basic information on bio-organic fertilizer production in Biliran Province, data were collected and observations noted right from the first activity which was the collection of raw materials until the bagging of the final product.

The data collected includes the following: 1) acquisition cost of raw materials, 2) handling cost, 3) time duration and number of laborers for each phase of activity, 4) fresh weight of raw materials, 5) number of days from mixing to decomposition, 6) temperature of the compost pile, 7) weight of the final product, 8) moisture content of the final product, and 9) Total NPK content and pH of the final product.

Temperature was measured before every turning by inserting a laboratory thermometer on different parts of the compost pile at about 15 cm deep. The moisture content of decomposed pile was determined by gravimetric method using a laboratory oven and a platform balance. Sieved samples of the three batches were sent to Visayas State University in Baybay, Leyte, Philippines for NPK and pH analysis.

III. RESULTS AND DISCUSSION

A. The Bio-Organic Fertilizer Production Sites

The NSU-Biliran production site is located inside the lower campus. The production site is a half-concrete

building, with a concrete floor (5m x 9m area) and a G.I. roofing. The resident of the adjacent cottage was at first apprehensive about the location of the project due to the perception that the covered compost pile will generate unpleasant odor, which may cause risk to health. However, it was found out during the actual composting process that no observed odor was generated from the compost pile. The above observations proved the claim that BPA removes foul odor.

It was observed that the production area could accommodate two (2) batches (1 ton raw materials/batch) at the same time based on the available floor/working space for mixing and turning as observed during the process. Newly mixed 1-ton compost pile utilized only about 9 sq. meters of the floor area which decreases in space utilization as the pile is turned and had undergone decomposition.

The concrete flooring was observed to provide advantage during the turning of the compost pile than if the flooring would only be earth. Soil contamination is eliminated and the heat and moisture in the compost pile could somehow be preserved.

In Brgy. Sabang, the building in the production site is a half-concrete with concrete flooring (4 m x 6 m), and a G.I. sheet roofing. It is located just about 10 meters from a chapel. Similar with the experience in NSU-Biliran, there

were apprehensions on the chosen site due to possibility of unpleasant odor from the fertilizer production. But with proper orientation about one of the benefits of BPA – to remove foul odor, the cooperator was convinced to push through with the chosen site.

The above experiences and observations suggest that production site of bio-organic fertilizer production using BPA could be established within the community or in the backyard without any observed hazard that may be brought about by foul odor from the compost pile.

B. Decomposition, Sweetening and Curing Period and Raw Material Recovery

The number of days from piling to full decomposition was recorded in each batch of production. As presented in Table 2, the decomposition period of the raw materials ranges from 22 to 27 days. Batch 1 took much longer time to decompose (27 days) compared to the other 2 batches. Aside from the fact that Batch 1 utilized freshly harvested rice straw, such longer decomposition time was observed to be partly due to insufficient and non-uniform amount of moisture applied to the raw materials during mixing. This was found out during the turning of the pile when it was observed that some portions which have been very dry differ in appearance as to their state of decomposition compared to those portions receiving enough moisture.

Table 2. Bio-Organic Fertilizer Production Data

Batch No.	Decomposition Period (days)	Sweetening and Curing Period (days)	Total Weight of Final Product at 20% MC (kg)	Raw Material Recovery (%)
1	27	10	524	47.29%
2	22	11	634	60.12%
3	25	14	700	68.9%

The above observation prompted the researchers to use a sprinkler during the mixing of Batch 2 in order to apply sufficient and uniform amount of water to the raw materials. Pace [4] reported that composting materials should be maintained within a range of 40% to 65% moisture. During the turning of the compost pile, the appearance of the raw materials was observed to be more or less uniform as to the state of decomposition. It was found out that the decomposition time was reduced to 22 days. Decomposition time could somehow be attained in a much shorter time if the rice straw were chopped into smaller pieces.

Despite sufficient and uniform amount of moisture applied to the raw materials during mixing, Batch 3 took 25 days to fully decompose. The considerable length of time is expected since Batch 3 uses saw dust as the main substrate which has a higher carbon-nitrogen ratio.

For the three batches, the temperature of the compost pile was monitored before every turning. A maximum temperature of 69^oC was observed to have been maintained during the 4th up to the 13th day of the compost pile.

Sweetening and curing ranges from 10 to 14 days. It was observed that sweetening and curing period was delayed due to high moisture content of the decomposed materials which still need to be brought down to not more

than 20%. Sun-drying the mature compost may speed up the removal of excess moisture as what has been done by the IBS Rapid Composting Technology [1].

The raw material recovery was very low for Batch 1 (47.29%) due to high moisture content of the rice straw used (freshly harvested from the field) aside from the fact that the manure used was fresh having a moisture content at field capacity. Batch 3 has higher raw material recovery (68.9%) which may be due to the type of biomass material used (saw dust) which has higher carbon-nitrogen ratio and which have lower moisture content compared to the materials used in Batches 1 & 2.

C. Activities and Labor Utilization

Table 3 shows the different activities conducted to produce bio-organic fertilizer from farm waste materials. Production activities were done manually using hand tools (i.e. spade, spading fork, and manual sieve) since there were no available processing machines such as shredder or sieve in the production sites.

For Batches 1 & 2 which used rice straw as the main biomass, hauling utilized more labor compared to other activities since the material is bulky to transport. The result suggests that utilizing rice straw as main biomass material in bio-organic fertilizer production, the processing site should be established near the material source in order to minimize labor in gathering and

transporting the raw materials. Another option could be the reduction of the volume of raw materials at source by shredding or by any other means before transporting to the production site – this could somehow reduce labor in handling of raw materials.

It was found out also that manual sieving of finished product is highly laborious (2 man-days for Batches 1 & 2,

1 man-day for Batch 3). This is due to big lumps of decomposed materials which will not pass and may clog to the wire mesh sieve. For commercial bio-organic fertilizer production, a compost pulverizing machine and a mechanized sieve may help reduce the labor required to do the activity.

Table 3. Labor utilized in the production of 1-ton raw material to bio-organic fertilizer

Activities	Labor Utilized (man-days)		
	Batch 1	Batch 2	Batch 3
1. Hauling of Raw Materials	4.00	4.00	1.50
2. Weighing the raw materials	0.25	0.25	0.38
3. Mixing the raw materials	1.00	0.25	0.94
4. Turning of raw materials	1.38	0.66	2.25
5. Sweetening and curing	0.69	0.50	0.58
6. Sieving and bagging	2.00	2.00	1.00
Total Labor Utilized (man-days)	9.32	7.66	6.64

D. Chemical Analysis of the Produced Bio-Organic Fertilizer

Table 4 presents the result of analysis of the macro elements and pH of the produced bio-organic fertilizers from the three batches. Total NPK content of the three batches is almost similar except for Batch 2 which has very low Total P and K content. The pH of final product is alkaline (7.36 to 8.78) which is usual for composts [1]. The Total N of the produced bio-organic fertilizer in the 3 Batches is comparable with the N content of the commercial organic fertilizer available in Naval, Biliran which has an analysis of 1% N - 5% P - 1 K%. Total K for

batches 1 (1.35%) and 3(1.287%) are comparable with the commercial organic fertilizer. However, the total P for all the batches were very low compared to the commercial organic fertilizer (5% P).

The above result suggests that combination of raw materials used in the 3 batches is slightly inferior compared to the commercially organic fertilizer in terms of the macro-element content. Further experiments using different raw materials and their combinations are presently initiated by the university in order to come up with a product with higher macro-element content.

Table 4. Chemical Analysis of the Produced Bio-Organic Fertilizer

Batch	'Fresh' Raw Material Composition (% by weight)	Chemical Analysis			
		Total N (%)	Total P (%)	Total K (%)	pH
1	56.8% rice straw: 33.8% goat manure: 9% carbonized-rice hull ash: 0.5% BPA	1.18	1.07	1.35	8.78
2	52.2% rice straw : 33.7% carabao manure : 9.6% carbonized-rice hull ash : 0.5% BPA	0.92	0.24	0.774	8.08
3	55.2% sawdust : 34.4% chicken dung : 9.8% carbonized-rice hull ash : 0.5% BPA	0.93	1.3	1.287	7.36

IV. CONCLUSION

Bio-organic fertilizer production using farm waste materials and BPA could be accomplished within the household level utilizing only manual labor. Production has no health hazard or pollution that may be brought about by foul odor from the compost pile.

With proper combination of raw materials and BPA, bio-organic fertilizer produced can have nutrient components comparable to that of the commercially available fertilizers.

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