PREPARATION AND APPLICATION OF ORGANIC FERTILIZERS FROM VEGETABLE WASTES, COW DUNG, SESAME MEAL CAKE AND EFFECTIVE MICROORGANISM SOLUTIONS

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Abstract

Organic fertilizers were prepared from the selected materials such as wastes of vegetables, cow dung, sesame meal cake, rice straw and the prepared EM solution under aerobic and anaerobic conditions. To know the effect of lime on the prepared fertilizers, quick lime powder was used. The aerobic digesters (4' × 6'× 0.75') were used in aerobic conditions. The anaerobic digesters (11.5″ × 13.5″) were used in anaerobic conditions. The successive layers of selected materials were done and prepared EM solution was added over the layers. Organic fertilizers were performed by composting. The elemental contents of prepared organic fertilizers were determined by Energy Dispersive X-Ray Fluorescence (EDXRF) spectroscopic method. The physical properties, the moisture contents and pH values of prepared organic fertilizers were determined. The total nitrogen, total phosphorus and total potassium contents of the prepared organic fertilizers were determined by instrumental methods. The amount of organic carbon and organic matter of the prepared organic fertilizers were also determined. The properties of prepared aerobic organic fertilizers were compared with anaerobic organic fertilizers. To show the effect of the prepared organic fertilizers, the plantations on those of vegetables such as Chinese cabbage, lettuce and radish were carried out by using four kinds of prepared organic fertilizers and the plant growth was compared.

Keywords: organic fertilizer, effective microorganism solution, vegetable wastes, sesame meal cake, aerobic condition

Introduction

Generally, both organic and inorganic fertilizers are used for the cultivation of vegetables. With the escalating interest in organic vegetable cultivation due to its health and environmental benefits both locally and globally, intensified research on all aspects of organic farming is timely and urgent (Vimala *et al*., 2010).

One of the main goals of every organic farmer is to build long-term soil fertility and tilth by feeding the soil with a variety of natural amendments. The regular addition of compost is one of the best ways to enhance soil organic and humic content, which helps to build a fertile soil structure. Such as soil structure makes better use of water and nutrients. It is easier to till and, overall, is better able to achieve optimum yields on a long-term basis (Baldwin and Jackie, 2006).

Compost, as a product of recycling processes, can be a very appropriate input material for organic farming, provided the composting process is well-managed, the input materials are free of contaminants, and the resulting product is applied according to the system's ecological needs (Streminska and Raviv, 2016).

High-quality compost is one of the essential organic matter inputs, along with green manures, used to manage soil health in organic farming and gardening systems (Miles, 2015).

Compost “happens” either aerobically (with oxygen) or an aerobically (without oxygen) when organic materials are mixed and piled together (Cooperband, 2002).

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Composting is a natural process in which fresh organic matter (animal manure, food wastes, green wastes, agricultural residues, etc.) is transformed into more stable humus-like substances, nutrients are being recycled and energy is being produced (Streminska and Raviv, 2016).

EM has a great potential to be used in accelerating the composting process and increased nutrient in compost. Microorganisms (EM) is a mixture of organisms that has a reviving action on humans, animals, and the natural environment. (Mayer *et al*., 2010). Application of EM in composting of organic matter showed positive result in the decomposition process and the mineralization. EM controls the temperature and reduces pathogens in the compost to produce good quality of compost (Saravanan *et al*., 2013). EM compost had fast decomposition rate, rich in nutrients, more microbial activities, good germination and more yields compared with compost without EM (Khan and Ishaq, 2011). The aim of this research is to prepare the organic fertilizers from vegetable wastes cow dung, sesame meal cake and EM solutions under different conditions and to apply the prepared organic fertilizers on cultivation of some vegetables.

Materials and Methods

Sample Collection

Vegetable waste was collected from local market, Chanmyatharsi Township, Mandalay Region. Cow dung and rice straw were collected from Taung Pyone Village, Madaya Township, Mandalay Region. Sesame meal cake was collected from Local market, Mandalay Region. Slaked lime solution (pH 9.5) was prepared and added into vegetable waste (Figure1).

(a) (b) (c) (d) (e)

Figure 1 (a) Vegetable waste, (b) Cow dung powder, (c) Sesame meal cake, (d) Slaked lime solution and (e) Rice straw

Preparation of Effective Microorganism Solutions

1 kg of fresh small pieces of vegetable waste, 1 kg of cow dung and 1 kg of sesame meal cake were put into the anaerobic digester by successive layers and one liter of purified water was added into the anaerobic digester. The neck of the digester was entwined with teflon. It was tightly sealed with the lid connecting delivery tube (pipe). While the preparation of effective microorganism solutions, biogas was evolved. After the production of biogas for 5 days, the anaerobic digester was tightly sealed and kept for one month (Figure 2). After one month, the mixture in the anaerobic digester can be used as EM solution.

Figure 2 Preparation of EM solution by anaerobic digester

Preparation of Organic Fertilizers

Sampling

Vegetable waste samples were cut into small pieces about one inch. Sesame meal cake were ground to get powder samples. The cow dung sample was pounded and sieved with 60 mesh sieve to get powder. Rice straw samples were cut into small pieces.

Preparation of organic fertilizers under aerobic conditions

2 kg of rice straw, 2 kg of sesame meal cake, 500 mL of effective microorganism (EM) solution, 2 kg of vegetable wastes, and 2 kg of cow dung were put layer by layer and this layering process was done for two times. It was put into aerobic digester (4' × 6' × 0.75 ') and stored for two months (Figure 3)

Preparation of layer by mixing waste with EM

Layering process

Figure 3 Procedure of organic fertilizers under aerobic condition

Turning over the sample under aerobic conditions

During decomposition the layers were turned over regularly, in order that it remains well aerated and all the materials were converted into compost. The first turning over was done after two weeks. The second turning over took place after two weeks. Then each turning over was done after one week. If necessary, water was sprinkled over the container during the process. After two months, decomposition was complete because the plant materials were changed into an unrecognizable crumbly dry mass. However, some stalks do not decompose completely and can still be seen (Figure 4).

After two weeks After four weeks After six weeks After eight weeks

Figure 4 Changes of prepared organic fertilizers during eight weeks

Preparation of organic fertilizer under anaerobic condition

For anaerobic condition, 11.5" inches diameter and 13.5" height of plastic container with lid having same capacity was used in aerobic condition and tightly closed (Figure 5). 1 kg of rice straw, 1 kg of sesame meal cake, 500 mL of EM solution, 1 kg of vegetable wastes and 1 kg of cow dung were weighed and put layer by layer into anaerobic digester with lid and highly sealed to get compost for two months.

Four organic fertilizers were prepared under different conditions.

(i) aerobic conditions by the use of lime and without lime (prepared organic fertilizers, POF A1 and A2).

(ii) anaerobic conditions by the use of lime and without lime (prepared organic fertilizers POF An1 and An2).

Figure 5 Preparation of anaerobic organic fertilizers

Some Parameters of Prepared Organic Fertilizers

Determination of pH

About 25 g of sample was weighed accurately and placed into a bottle and 100mL of distilled water was added and then the pH of prepared organic fertilizers was measured by pH meter.

Determination of moisture content

Accurately weighed 10 g of sample powder was added into a Petri dish previously dried and cooled in a desiccator. The dish containing the sample was placed in an oven and dried for 30 min at 101°C ± 1°C. The dish was then removed from the oven and cooled in a desiccator at room temperature and weighed. It was repeated until constant weight was obtained.

Determination of nutrients, organic carbon and organic matter

Total nitrogen, total P_2O_5, total K_2O, organic carbon and organic matter of the prepared organic fertilizers were determined at Department of Agriculture (Land Use), Mandalay by using Atomic Absorption Spectroscopic method and Walkey and Polack's Methods.

Determination of Elemental Analysis of Prepared Organic Fertilizer

Elemental analysis of prepared organic fertilizers was measured at Department of Chemistry, Monywa University by applying EDXRF (Energy Dispersive X-Ray Fluorescence Spectroscopy) Method.

Determination of Plant Height of Three Vegetables by Using Prepared Organic Fertilizers

Organic farming was carried out by using prepared organic fertilizer (POF A1, POF A2, POF An1, POF An2) for selected vegetable such as Chinese cabbage, lettuce and radish. To evaluate

the effect of prepared organic fertilizers on the plants, plant heights of 10 plants for each were recorded and mean heights of those were determined after 45 days plantation.

Results and Discussion

Preparation of Organic Fertilizers Under Different Conditions

Under aerobic condition and anaerobic conditions; vegetable wastes, cow dung, sesame meal cake, rice straw and the prepared EM solution with lime and without lime were used to prepare organic fertilizers (POFA1, POFA2, POFAn1 and POFAn 2).

Some Parameters of Prepared Organic Fertilizers Under Different Conditions

According to the results as shown in Table 1, all prepared organic fertilizers were alkaline. The moisture content was the highest 7.5% in POF A1. The moisture contents of fertilizers in anaerobic condition were found to be lower than aerobic conditions.

Table 1 The pH Values and Moisture Contents of Prepared Organic Fertilizers with and without Lime Under Aerobic and Anaerobic Conditions

Organic fertilizer	pH	Moisture (%)
POF A1	9.0	7.45
POF A2	8.5	6.38
POF An1	8.5	5.41
POF An2	8.0	5.37

POF A1 = Prepared organic fertilizer with lime under aerobic condition
POF A2 = Prepared organic fertilizer without lime under aerobic condition
POF An1 = Prepared organic fertilizer with lime under anaerobic condition
POF An2 = Prepared organic fertilizer without lime under anaerobic condition

Nutrient Parameters of Prepared Organic Fertilizers

Total nitrogen content in POFAn1and POFAn2 were greater than those in POF A1and POFA2. Nitrogen content is effective to promote plant growth especially stem and leaf. The highest content of total P_2O_5 (4.91%) were coincidently same in POFAn1and POFAn2 whereas the content of K_2O (%) in all fertilizers were found to be ranged between 1.31-1.99%. Organic carbon (27.23%) and matter (49.64%) of POFAn1 were found to be the highest out of four different organic fertilizers. The results are shown in Table 2 and Figures 6 and 7.

Table 2 Nutritional Values of Prepared Organic Fertilizers

Nutrient	Aerobic Organic Fertilizer		Anaerobic Organic Fertilizer	
	POF A1	POF A2	POF An1	POF An2
Total Nitrogen (%)	2.01	1.64	2.44	2.52
Total P_2O_5 (%)	2.44	1.85	4.91	4.91
Total K_2O (%)	1.78	1.99	1.31	1.89
Organic carbon (%)	17.28	16.58	27.23	25.08
Organic matter (%)	29.80	28.59	49.64	43.24

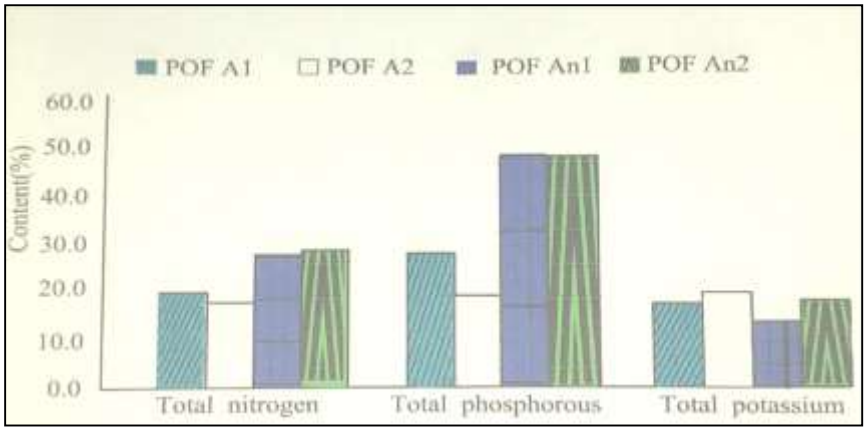

Figure 6 Total (NPK) content of prepared organic fertilizers

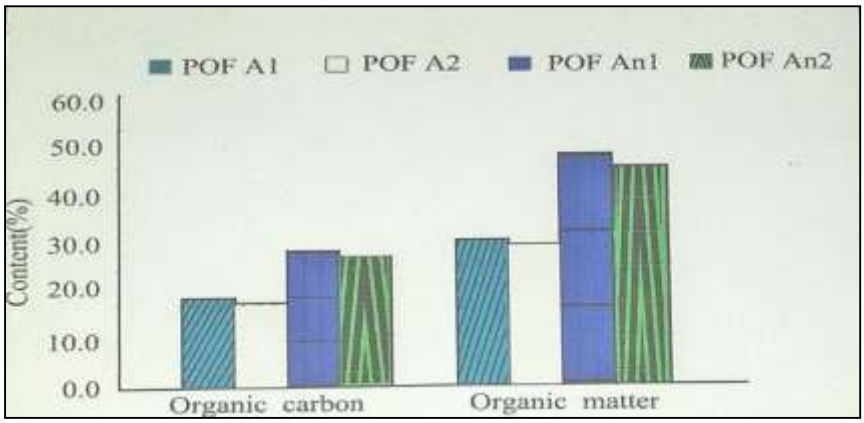

Figure 7 Organic carbon and organic matter content of prepared organic fertilizers

Elemental Analysis of Prepared Organic Fertilizers

Elemental composition of prepared organic fertilizers analyzed by EDXRF are presented in Table 3 and shown in Figure 8. Silicon was found to be the highest followed by calcium, potassium and manganese in all prepared organic fertilizers. The essential elements for plant growth such as P, S, Fe, Mn and Cu were also detected in prepared organic fertilizers.

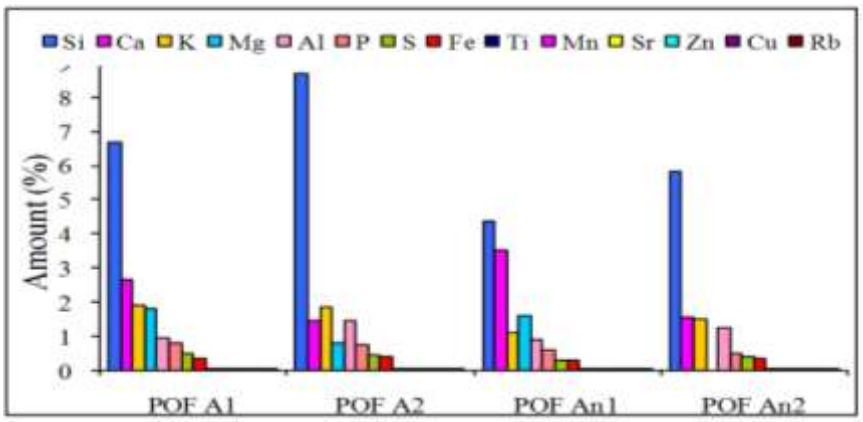

Figure 8 Elemental contents of different prepared organic fertilizers

Table 3 Relative Abundance of Elements in Different Organic Fertilizers by EDXRF

No.	Elements	Relative Abundance (%)			
		POF A1	POF A2	POF An1	POF An2
1	Si	6.685	8.677	4.351	5.828
2	Ca	2.675	1.441	3.532	1.537
3	K	1.892	1.883	1.120	1.505
4	Mg	1.820	0.810	1.589	-
5	Al	0.969	1.457	0.910	1.279
6	P	0.829	0.756	0.610	0.521
7	S	0.510	0.450	0.319	0.402
8	Fe	0.370	0.397	0.311	0.350
9	Ti	0.035	0.048	0.045	0.056
10	Mn	0.026	0.026	0.020	0.019
11	Sr	0.007	-	0.007	0.007
12	Zn	0.006	0.005	0.006	0.005
13	Cu	0.004	0.004	0.004	0.003
14	Rb	0.004	-	-	-
15	Zr	-	0.006	0.005	0.005
16	Cr	-	0.004	-	0.003

Plant Height of Three Vegetables by Using Different Organic Fertilizers

This data was recorded from 10 Chinese cabbage planted by prepared organic fertilizers after 45 days. In Table 4, the plant height of chinese cabbage grown on POFAn1 was found to be the highest. The control under same condition was comparatively studied.

Table 4 Plant Height of Chinese Cabbage after 45 days Plantation by Different Organic Fertilizers

Sample	Plant Height (inches)				
	POFA1	POFA2	POFAn1	POFAn2	Control
1	10.50	9.50	10.00	11.00	9.50
2	11.00	10.00	10.00	11.00	9.50
3	11.00	10.50	11.50	11.50	9.50
4	11.00	10.50	12.00	11.50	10.00
5	12.00	10.50	12.00	12.00	11.00
6	12.00	10.50	12.00	12.00	11.00
7	12.00	10.50	12.00	12.00	11.50
8	12.00	10.50	12.00	12.00	11.50
9	12.00	11.50	12.00	12.00	11.50
10	13.00	12.00	12.00	12.00	12.00
Mean ± SD	11.65 ± 1.17	10.60 ± 0.72	11.80 ± 0.69	11.70 ± 0.42	10.75 ± 0.39

This data was recorded from 10 plants of lettuce. According to Table 5, plant height of lettuce cultivated by using POFAn1 was found to be the highest followed by POF A2.

Table 5 Plant Height of Lettuce after 45 days Plantation by Different Organic Fertilizers

Sample	Plant Height (inches)				
	POFA1	**POFA2**	**POFAn1**	**POFAn2**	**Control**
1	6.50	7.50	7.00	7.00	5.00
2	7.50	8.00	7.00	7.50	6.00
3	8.00	8.00	7.50	8.00	7.00
4	8.00	8.00	7.50	8.00	7.00
5	8.00	8.00	8.00	8.00	7.50
6	8.50	8.50	8.50	8.50	7.50
7	8.50	8.50	8.50	8.50	7.50
8	9.00	9.00	8.50	8.50	8.00
9	9.00	9.00	9.00	9.00	8.00
10	9.00	10.00	9.00	9.00	8.00
Mean ± SD	8.20 ± 0.40	8.45 ± 0.74	8.50 ± 0.68	8.20 ± 0.63	7.15 ± 0.89

This data was recorded from 10 plants of radish. According to Table 6, plant height of radish by using POFAn1 was found to be the highest and control was found to be the lowest.

Table 6 Plant Height of Radish after 45 days Plantation by Different Organic Fertilizers

Sample	Plant height (inches)				
	POFA1	**POFA2**	**POFAn1**	**POFAn2**	**Control**
1	13.00	10.50	12.00	11.50	9.00
2	13.00	11.00	12.50	12.00	9.50
3	13.00	11.50	13.00	12.00	9.50
4	13.00	11.00	13.00	12.50	10.00
5	13.00	12.00	13.00	13.00	10.00
6	13.00	12.00	13.50	13.00	10.50
7	13.00	13.00	13.50	14.00	11.00
8	13.00	14.00	13.50	14.00	11.00
9	13.50	15.00	14.00	14.50	11.50
10	14.00	16.00	15.00	15.00	12.00
Mean ± SD	12.95 ± 0.40	13.00 ± 1.9	13.30 ± 0.82	13.15 ± 1.31	10.40 ± 1.05

Plant heights of vegetables: Chinese cabbage, lettuce and radish with control were comparatively recorded after 45 days cultivation. Among these, POFAn1 prepared from organic fertilizer with lime under anaerobic condition was found to have the maximum plant height 11.80inches (Chinese cabbage), 8.5inches (lettuce) and 13.30inches (radish), respectively (Figures 9, 10 and 11). Plot sites of three vegetable cultivation using different organic fertilizers after 45 days were also presented in Figures 12, 13 and 14.

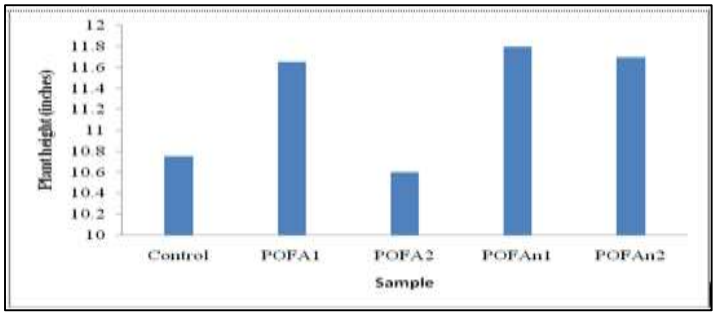

Figure 9 Comparison of plant height on different organic fertilizers (Chinese cabbage)

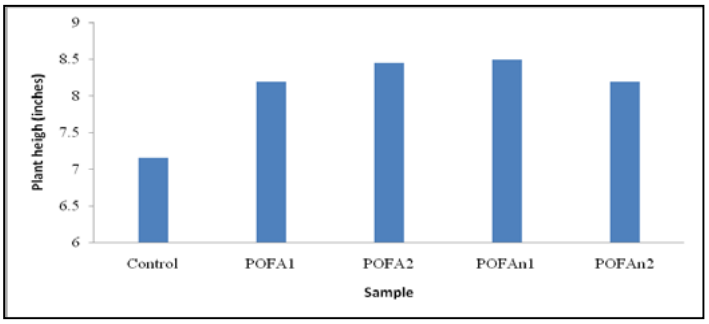

Figure 10 Comparison of plant height on different organic fertilizers (lettuce)

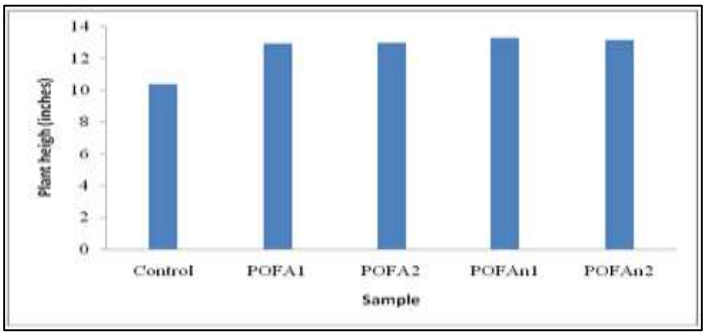

Figure 11 Comparison of plant height on different organic fertilizers (radish)

Figure 12 Plots of Chinese cabbage cultivation by using (I) POFA1, (II) POFA2, (III) POFAn1 and (IV)POFAn2

Figure 13 Plots of lettuce cultivation by using (I) POFA1, (II) POFA2, (III) POFAn1 and (IV) POFAn2

Figure 14 Plots of radish cultivation by using (I) POFA1, (II) POFA2,(III) POFAn1 and (IV) POFAn2

Conclusion

Four different organic fertilizers (POFA1, POFA2, POFAn1 and POFAn2) were prepared from the wastes of vegetables, cow dung, sesame meal cake, the prepared EM solution and rice straw with lime and without lime under aerobic condition and anaerobic condition. From the elemental analysis, the essential trace elements such as silicon, calcium, potassium, aluminium, phosphorous, sulfur, iron, titanium, manganese, zinc and copper were found in all prepared organic fertilizers. The pH of the organic fertilizers were found to be alkaline (8.0-9.0). The moisture contents of the fertilizers were the range of 5.37-7.45 %. The total nitrogen contents of the prepared organic fertilizers were found to be the range of 1.64-2.01 % for aerobic condition and 2.44-2.52 % for anaerobic condition. The total phosphorus contents of the prepared organic fertilizers were found to be the range of 1.85-2.44 % for aerobic condition and 4.91 % for anaerobic condition. The total potassium contents of the prepared organic fertilizers were found to be the range of 1.78-1.99 % for aerobic condition and 1.31-1.89 % for anaerobic condition. The amount of organic carbon and organic matter were the range of 16.58-17.28 %, 25.08-27.73 % for aerobic condition and 28.59-29.80 %, 43.24-49.64 % for anaerobic condition. All prepared organic fertilizers contain adequate amount of nutritional values and should be applied for organic farming. The plantation of vegetables such as Chinese cabbage, lettuce and radish by using prepared organic fertilizers was carried out and the plant growth were compared after 45 days of plantation. It was found that plant heights of Chinese cabbage (11.8 inches), lettuce (8.5 inches) and radish (13.3 inches) in plot 4 by using POF An1 are higher than other plots. . From the observation, using POFAn1 can support more plant growth than others for selected vegetables. POFAn1 can supply more organic carbon (27.73%) and organic matter (49.64%) than that of others to the soil and plants.

Therefore, anaerobic condition should be selected for the mass production of organic fertilizer. The organic fertilizer should be used widely in agriculture instead of /mixed with chemical fertilizer because of their low cost, good fertility of the soil and supplying more trace elements. The obvious advantages of the prepared organic fertilizer are economically viable, convenient and effective. Therefore, prepared organic fertilizer has great potential for applications.

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