PREPARATION AND CHARACTERIZATION OF ORGANIC FERTILIZERS MADE FROM BAT GUANO, RICE HUSK ASH AND GROUNDNUT LEAVES

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Abstract

Organic fertilizers are carbon-based compounds that increase the productivity and the growth quality of plant, and soil fertility. In the present work, the organic fertilizers were prepared using bat guano , rice husk ash, groundnut leaves with three different weight ratios of 1:1:1 (OF-1), 1:2:1 (OF-2) and 1:3:2 (OF-3) by compost heap method. Some chemical properties of the prepared organic fertilizers and the contents of macronutrients and micronutrients were determined by both modern and conventional methods. Organic fertilizers contained high amount of nitrogen i.e., 1.87 % , 1.44 % and 1.22 % and high amount of carbon i.e., 15.45 %, 14.80 % and 14.38 % in OF-1, OF-2 and OF-3 respectively. Low C:N ratios were observed in these fertilizers. Higher amount of macro and micronutrients were found in OF-1 than the other two fertilizers. The prepared organic fertilizers can be used as a substitute to inorganic fertilizers for the crop cultivation.

Keywords: organic fertilizers, rice husk ash, bat guano, groundnut leaves, compost heap method

Introduction

Fertilizers enhance the growth of plants. This goal is met in two ways, the traditional one being additives that provide nutrients. The second one is to enhance the effectiveness of the soil by modifying its water retention and aeration. Fertilizers typically provide, in varying proportions:

Three main macronutrients: nitrogen: leaf growth; phosphorus : development of roots, flowers, seeds, fruit; potassium : strong stem growth, movement of water in plants, promotion of flowering and fruiting; three secondary macronutrients: calcium , magnesium and sulphur; micronutrients: copper, iron, manganese, molybdenum, zinc, boron, and of occasional significance there are silicon, cobalt, and vanadium plus rare mineral catalysts (Arun, 2007).

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The nutrients required for healthy plant life are classified according to the elements, but the elements are not used as fertilizers. Instead compounds containing these elements are the basis of fertilizers. The macronutrients are consumed in larger quantities and are present in plant tissue in quantities from 0.15 % to 6.0 % on a dry matter (DM) (0 % moisture) basis. Plants are made up of four main elements: hydrogen, oxygen, carbon, and nitrogen. Carbon, hydrogen and oxygen are widely available as water and carbon dioxide. Although nitrogen makes up most of the atmosphere, it is in a form that is unavailable to plants. Nitrogen is the most important fertilizer since nitrogen is present in proteins, DNA and other components (e.g., chlorophyll). To be nutritious to plants, nitrogen must be made available in a "fixed" form. Only some bacteria and their host plants (notably legumes) can fix atmospheric nitrogen (N2) by converting it to ammonia. Phosphate is required for the production of DNA and ATP, the main energy carrier in cells, as well as certain lipids.

Micronutrients are consumed in smaller quantities and are present in plant tissue on the order of parts-per-million (ppm), ranging from 0.15 to 400 ppm DM, or less than 0.04 % DM. These elements are often present at the active sites of enzymes that carry out the plant's metabolism. Because these elements enable catalysts (enzymes) their impact far exceeds their weight percentage (Anuradha *et al*., 1992).

Many gardeners combine inorganic and organic fertilizers to receive benefits from both. Both organic and inorganic fertilizers provide plants with the nutrients needed to grow healthy and strong. Organic fertilizers work over time to create a healthy growing environment, while inorganic fertilizers provide rapid nutrition (Eiland *et al*., 2001).

An inorganic fertilizer, also known as chemical fertilizer or a synthetic fertilizer is artificially made in the labs and contains all of the vital primary nutrients such as nitrogen, phosphorus and potassium which are present in the organic fertilizers. Inorganic fertilizer also contains beneficial chemical and mineral deposits and supplies the nutrients necessary to grow plants. The disadvantage of inorganic fertilizers is that it costs much higher than the organic fertilizers (Gupta and Sen, 2013).

Organic fertilizers come from plant and animal sources. These fertilizers have a slower release of nutrients as they need to be decomposed by soil microorganisms. They are easy on plant roots but take longer to become effective. Organic fertilizers are naturally occurring fertilizers (e.g, compost, manure). Organic fertilizers are essential for maintaining the soils health. Cow dung and chicken manure are excellent source of soil organic matter as well as phosphorus and potassium. Microorganisms in the soil decompose organic material making its elements available for use by plants. Organic fertilizers improve the structure of the soil and retain soil moisture. Organic fertilizers release nitrogen slowly and consistently. Organic fertilizers do not burn the plants like some chemical fertilizer. Organic fertilizers increase the number of beneficial organisms in the soil which help convert soil nutrients into a form that can be readily absorbed by plants (Hua *et al.*, 2009).

Rice husk is an agricultural residue which accounts for 20 % of the 649.7 million tons of rice produced annually worldwide (FAO, 2008). In rice producing areas paddy rice is transported and dried at milling machine. During milling of paddy about 78 % of weight is received as rice, broken rice and bran. Rest 22 % of the weight of paddy is received as husk. Rice bran is sold to pig and poultry farmers and rice husk is left at the milling machine which pile up and it is used as fuel in the rice mills to generate steam for the parboiling process (Murimi and Gbedemah, 2018). This husk contains about 75 % organic volatile matter and the balance 25 % of the weight of this husk is converted into ash during the firing process, is known as rice husk ash (RHA). This RHA in turns contain around 85 % - 90 % amorphous silica.

Bat guano is the feces of bats rich in carbon, nitrogen, vital minerals and of course beneficial microbes (Shetty *et al.*, 2013). Bat guano typically contains 10 % nitrogen, 3 % phosphorus and 1 % potassium. Nitrogen promotes rapid, green growth, making bat guano a useful fertilizer, especially for lawns. Phosphorus promotes root growth and supports flowering, while potassium helps plants grow strong stems. In addition to the presence of these major nutrients in bat guano, it also has micronutrients plants need for healthy growth. Bat guano fertilizer can benefit the texture of the soil. It helps hold together loose soils and makes dense soils lighter. Guano is not easily leached out of the soil, so it benefits the plants and soil much longer than some

inorganic fertilizers which are more readily displaced. Bat guano contains microbes which benefit the soil and plants.

Groundnut cultivation is common as a major food crop in many popular countries. According to the World Food and Agriculture Organization, the major groundnut producing countries are India, China, USA, Indonesia and Myanmar (Nalluri and Karri, 2018). The groundnut belongs to the pea and bean family and is a legume. The groundnut is the only nut that grows below the earth. But it is considered as nut because of its high nutritional value. The groundnut plant is a variable annual herb, which grows up to 50 cm in height. The flowers of the plant develop a stalk which enters into the soil, forms a pod containing generally two seeds. They become mature in about two months, when the leaves of the plant turn yellow. The plant is then removed from the earth and allowed to dry. After three to six weeks they are separated from the plant.

At present, most vegetable plants are cultivated with soil supplemented with chemical fertilizers, which causes ecological damage to the environment. An alternative method is required to replace the use of chemical fertilizers for the growth of vegetable plants. In most countries, million tons of different agricultural wastes are produced annually, but desperately the major fraction of it is burned or left neglected, leading to environmental pollution (Torkashvand, 2010). The use of organic waste in agriculture can reduce the need of chemical fertilizer and restore the organic carbon deficiency in the soil.

Organic fertilizers were prepared from waste materials viz., rice husk ash and tea residue (Thazin Nyo, 2009), water hyacinth and rice straw (Thida Min , 2005) and bat guano (Theingi Shwe, 2007). However, in this study, organic fertilizers were prepared by using different ratios of bat guano, rice husk ash and groundnut leaves by compost heap method. This study was aimed to prepare organic fertilizers with high nutrient contents from waste materials as an alternative to chemical fertilizers.

Materials and Methods

Sample Collection and Preparation

The rice husk ash sample was collected from rice mill in Aung Lan Township, Magway Region. It was dried in air, ground and sieved into 80 mesh size and stored in air-tight plastic bags. Then rice husk ash sample was obtained.

The bat guano sample was collected from Pyay Township, Bago Region. It was dried in air, ground and sieved into 80 mesh size and stored in air-tight plastic bags. Then bat guano sample was obtained.

The groundnut leaves sample was collected from Aung Lan Township, Magway Region. It was dried in air, ground and sieved into 80 mesh size and stored in air-tight plastic bags. Then groundnut leaves was obtained.

Preparation of Organic Fertilizers

The organic fertilizers were prepared by mixing the three samples in three different weight ratios as shown below.

	Bat guano		**Rice husk ash**		**Groundnut plants**	
OF-1	100 kg	:	100 kg	:	100 kg	(1:1:1)
OF-2	75 kg	:	150 kg	:	75 kg	(1:2:1)
OF-3	50 kg	:	150 kg	:	100 kg	(1:3:2)

(OF= organic fertilizer)

Three piles of these prepared fertilizers were placed on a plastic sheet and the size of each pile was 1.5 m wide, 1.5 m long and 1.5 m height. Once a week the waste materials were mixed thoroughly to prevent overheating. Watering was done regularly to add moisture content in the composting materials. After 3 months the composts were harvested.

Determination of Physicochemical Properties of Organic Fertilizers and Soil

The pH of organic fertilizers were determined by using a pH meter and the moisture of organic fertilizers were determined by using Oven drying

method. The organic carbon content and the organic matter contents of organic fertilizers were determined by using wet oxidation using the Walkley-Black dichromate digestion method (Ho *et al*., 2010 ; Walkey and Black,1947) . The total N of organic fertilizers were determined by using Kjeldahl digestion method. The C:N ratio was calculated from the measured values of organic carbon content and total N. The total P_2O_5 of organic fertilizers were determined by using visible spectrophotometric method. The total K_2O of organic fertilizers were determined by using flame photometric method. The total Ca, Mg, Mn, Fe, Zn, Cu of organic fertilizers was determined by using Atomic Absorption Spectrometry. The total S of organic fertilizers was determined by using turbidity method. The relative abundance of elements of organic fertilizers was determined by using Energy Dispersive-X-ray Fluorescence Spectrometer ((Shimadzu EDX-8000).

Results and Discussion

Chemical Properties of Organic Fertilizers

Table 1 shows pH, moisture percent, organic matter content, organic carbon content, total N content, and C:N ratio of the prepared organic fertilizers. It was observed that OF-1 and OF-2 were slightly acidic (pH 6.48 and pH 6.68) whereas OF-3 was almost neutral (pH 7.28). These pH values are acceptable for plant growth. Moisture content in OF-1 (11.09 %) was nearly two times higher than those of other two organic fertilizers (5.47 % and 5.48 %). High contents of organic matter (24.82 % - 26.66 %) and organic carbon (14.38 % - 15.4 5%) in three organic fertilizer were not much different. Total nitrogen contents were in the range of 1.22 % to 1.87 %. According to Havlin *et al*.(1999), total nitrogen contents of the soil is categorized as < 0.15 % as low, 0.15 % - 0.25 % as medium and > 0.25 % as high. Thus, the prepared organic fertilizers contained high amount of the total nitrogen content. Moreover, highest nitrogen content (1.87 %) and lowest C:N ratio (8.26) were observed in OF-1 prepared by same weight ratio of bat guano, rice husk ash and groundnut plants(1:1:1). Increase of rice husk ash in OF-2 (1:2:1) decreased the total nitrogen content of organic fertilizer OF-2, and increased the C:N ratio of the organic fertilizer (OF-2). Similar effect was

observed in organic fertilizer OF-3 (Figure 1). Any organic matter that has a C:N ratio generally smaller than 30:1 is considered as green (nitrogen rich materials) because they are more fresh and moist while any organic matter that has a C:N ratio generally larger than 30:1 is considered as brown (carbonaceous materials) because they are dry (Planet Natural, 2018). The optimum C:N ratio of good quality compost is considered as 10-20:1 since compost within this range is unlikely to immobilize or deplete plant available nitrogen (Nathakumaran and Sobana ,2017)). The C:N ratios of the prepared organic fertilizers were found to be low since green materials like as bat guano and groundnut plant were used for composting.

Macro and Micronutrients

Primary macronutrients (N, P, K) and secondary macronutrients (Ca, Mg, S) in prepared organic fertilizers are shown in Table 2. OF-1 prepared by mixing equal amount of bat guano, rice husk ash and groundnut leaves was found to have high amount of primary macronutrients N (1.870 %) P_2O_5 (0.952 %) and K_2O (0.619 %) (Figure 2). Moreover, among secondary micronutrients highest Ca (13.210 %) and S (0.268 %) contents and second highest content of Mg (5.023 %) were observed in OF-1 (Figure 3). In general, OF-1 contained higher amount of macronutrient contents.

Table 1: pH, Moisture, Organic Matter Contents and C/N Ratios of Three Types of Organic Fertilizers

Properties	Organic Fertilizers		
	OF-1	**OF-2**	**OF-3**
pH	6.48	6.68	7.28
Moisture(%)	11.088	5.473	5.483
Organic matter (%)	26.66	25.525	24.82
Organic carbon (%)	15.446	14.803	14.383
Total N(%)	1.87	1.44	1.22
C/N ratio	8.26	10.28	11.79

OF-1= bat guano+ rice husk ash+ groundnut plants (1:1:1)
OF-2= bat guano+ rice husk ash+ groundnut plants (1:2:1)
OF-3= bat guano+ rice husk ash+ groundnut plants (1:3:2)

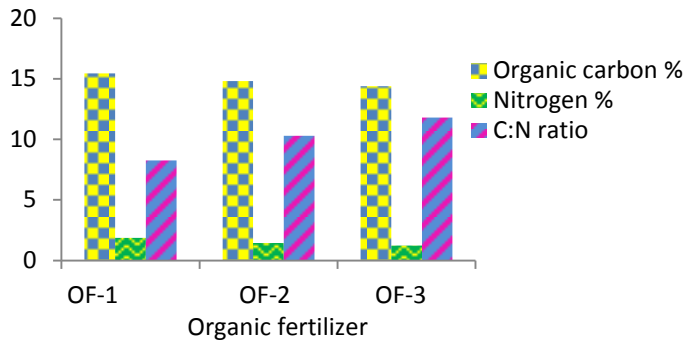

Figure 1: Organic carbon content , nitrogen content and C:N ratio of three organic fertilizers (OF-1,OF-2 and OF-3)

Table 2: Macronutrients in the Prepared Organic Fertilizers

Macronutrients	Concentration (%)		
	OF-1	OF-2	OF-3
N	1.870	1.440	1.220
P_2O_5	0.952	0.708	0.768
K_2O	0.532	0.460	0.619
Ca	13.210	4.410	5.189
Mg	5.023	4.211	6.129
S	0.268	0.226	0.218

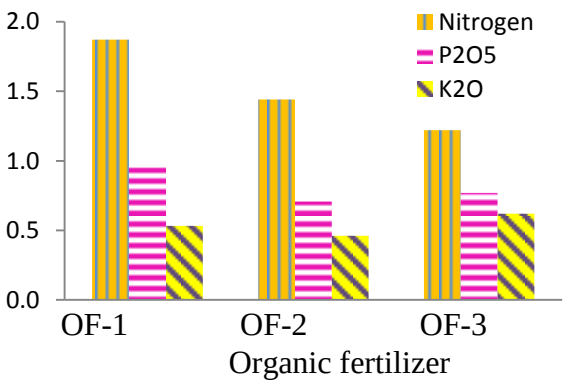

Figure 2: Primary macronutrients nitrogen, phosphorus and potassium contents of three organic fertilizers (OF-1,OF-2 and OF-3)

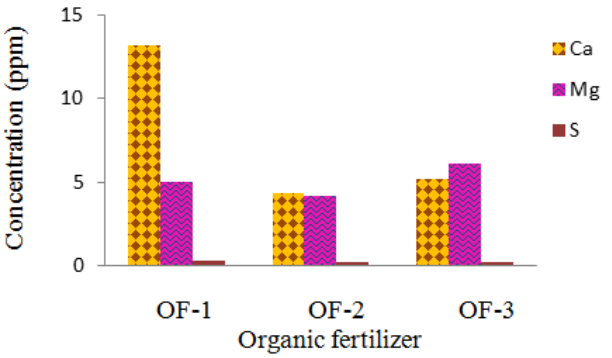

Figure 3: Secondary macronutrients calcium, magnesium and sulphur contents of three organic fertilizers (OF-1,OF-2 and OF-3)

Furthermore, micronutrients Fe, Mn, Zn and Cu in the prepared organic fertilizers were determined. The results are shown in Table 3. Among three organic fertilizers OF-1 contained highest amount of secondary nutrients compared to those of OF-2 and OF-3. Among the micronutrients determined Fe contents were found to be highest i.e., 7.707 %, 5.879 % and 6.839 % in OF-1, OF-2 and OF-3, respectively. Lower amounts of other elements were observed. The decreasing order of concentrations of micronutrients in the prepared fertilizers were Fe > Mn > Zn > Cu.

Table 3: Micronutrients in the Prepared Organic Fertilizers

Macronutrients	Concentration (ppm)		
	OF-1	**OF-2**	**OF-3**
Fe	7.707	5.879	6.839
Mn	1.078	0.697	0.698
Zn	0.777	0.459	0.659
Cu	0.146	0.062	0.085

Relative Abundance of Elements in the Prepared Organic Fertilizers

The relative abundance of elements in the prepared organic fertilizers was determined by EDXRF. Figures 4, 5 and 6 show the EDXRF spectra of the prepared organic fertilizers OF-1, OF-2 and OF-3 respectively. Highest amount of silicon contents were found in all prepared organic fertilizers in the

range of 39.394 % to 57.073 % followed by Ca (14.660 % -24.161%), Fe (10.946 % - 15.016 %), K (8.245 % - 10.283 %), P (1.055% - 2.829 %), S (1.961 % - 2.314 %). Other small amounts of elements in these fertilizers also observed (Table 4).

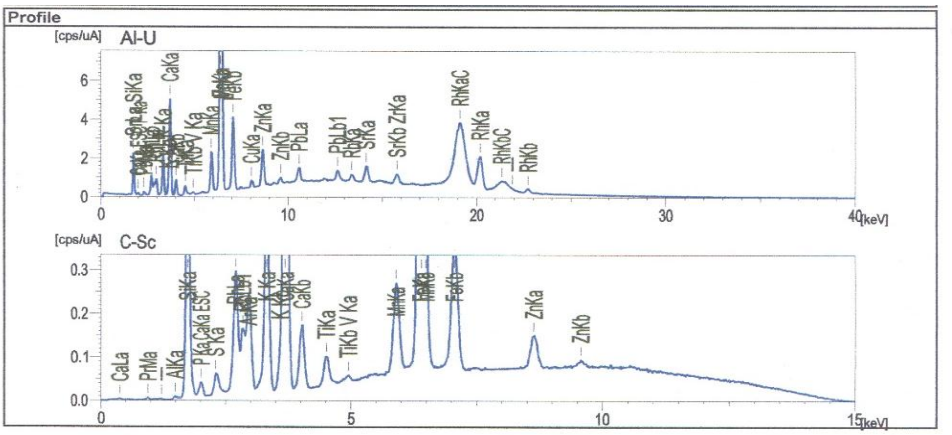

Figure 4: EDXRF Spectra of OF-1

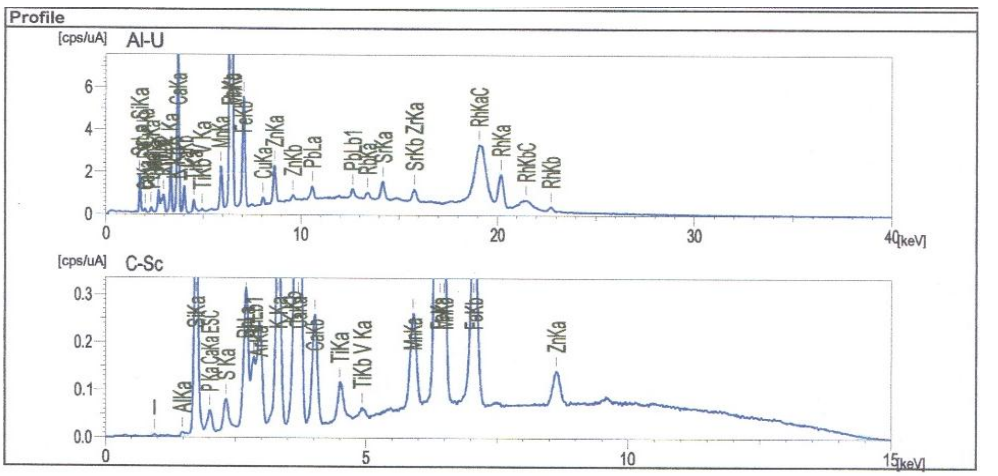

Figure 5: EDXRF Spectra of OF-2

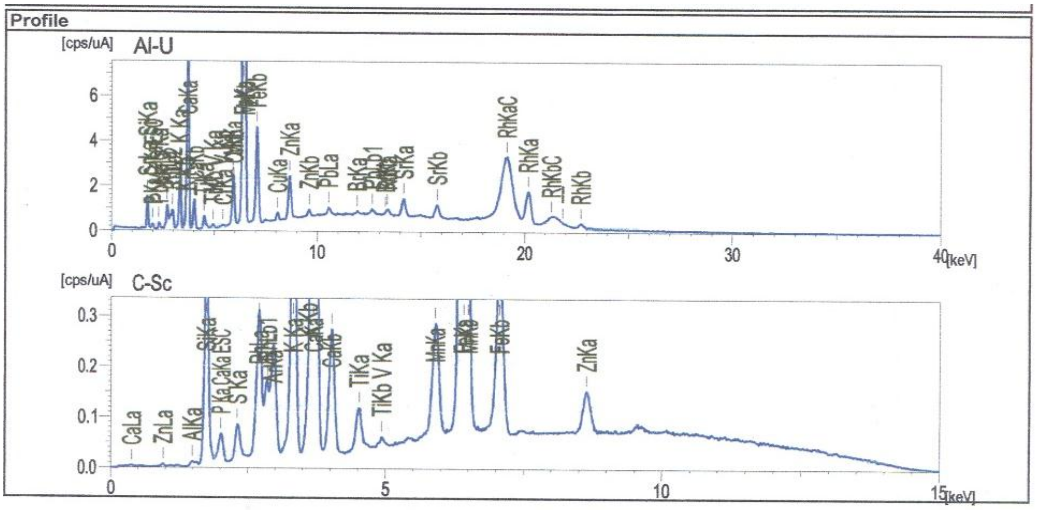

Figure 6: EDXRF Spectra of OF-3

Table 3: Relative Abundance of Elements Present in Organic Fertilizers by EDXRF

No.	Elements	Relative abundance of elements (%)		
		OF-1	**OF-2**	**OF-3**
1	Si	57.073	46.600	39.394
2	Ca	14.660	21.117	24.161
3	Fe	10.946	15.016	14.086
4	K	8.245	8.199	10.283
5	P	2.099	1.055	2.829
6	S	1.961	2.193	2.314
7	Al	1.611	2.370	3.015
8	Mn	1.295	1.246	1.559
9	Ti	0.779	0.914	1.048
10	Zn	0.568	0.560	0.669
11	Pb	0.321	0.271	0.157
12	Sr	0.143	0.153	0.153
13	Cu	0.114	0.119	0.118
14	Zr	0.065	0.083	-
15	Rb	0.062	0.058	0.051
16	V	0.058	0.044	0.068
17	Cr	-	-	0.062
18	Br	-	-	0.032

Conclusion

In this research work, the organic fertilizers (OF-1, OF-2 and OF-3) were prepared by using organic waste materials (bat guano, rice husk ash, groundnut plants) with three different weight ratios *viz*., 1:1:1, 1: 2:1 and 1:3:2 respectively . The prepared fertilizer contained high amount of carbon and nitrogen contents. C:N ratios of the prepared organic fertilizers were found to be low and these fertilizers were categorized as green. Higher amount of macro and micronutrients were observed in OF-1compared to other two fertilizers. Among the fertilizers prepared the organic fertilizer (OF-1) is more appropriate for cultivation of crops and improving the soil fertility. The use of bat guano, rice husk ash, groundnut leaves compost is an effective alternative source to chemical fertilizer, to enhance the yield without affecting the fertility of the soil and environment.

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