Advanced Research Journal of Microbiology (ARJM) ISSN 1718-3499, Vol. 6(5), pp. 326-330, September, 2020. Available online at www.advancedscholarsjournals.org © Advanced Scholars Journals

Full length Research paper

Production of Bioorganic Liquid Fertilizer from Oil Cake and Banana Peels

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Accepted 16 June, 2020.

Even though Agricultural sector is the largest contributor for Ethiopia's economic development, yet food insecurity and malnutrition continues to worsen especially in rural areas. In order to overcome such problems there is a need for a paradigm shift in the food production and consumption patterns. Bioorganic liquid fertilizer not only increases bioorganic fertility of crops (in comparison to the control and prototype fertilizer), but also accelerates their maturation and nutrient quality. Thus, the present study was aimed to produce bioorganic liquid fertilizer from oil cake and banana peels through aerobic fermentation in open containers. The result indicated that Phosphorus (P), Potassium (K), Calcium (Ca) and sodium (Na) were found to be significant between bioorganic liquid fertilizer and compost tea (used as a control) solutions. However, there were no significance differences with respect to Carbon(C), Nitrogen (N), and Magnesium (Mg) contents of the solutions. It was also indicated that percentage macronutrient compositions of bioorganic fertilizer solution was found to be greater than those of compost tea solution in all studied macronutrients. The performance of Ethiopian mustard irrigated with bioorganic fertilizer solution indicated that above ground biomass per plant was found to be significant with the highest mean weight being 126.28gm for pot irrigated with bioorganic liquid fertilizer.

Keywords: Compost tea, Electrical conductivity, Organic Fertilizers, Plant macronutrients.

INTRODUCTION

Agricultural practices are a collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while taking into account economical, social and environmental sustainability (Ojiewo, 2009). It focuses on economically and efficiently producing sufficient, safe and nutritious food; sustaining and enhancing natural resources; maintaining viable farming enterprises, and thereby contributing to improved and sustainable livelihoods. Inorganic chemical fertilizers have contributed a lot to agricultural production since 1960s era of green revolution. However, continuous/excessive use of inorganic/chemical fertilizers has resulted in depletion in soil fertility & pollution in surface water bodies, rapid rate of nutrients loss in different forms & increases the soil acidity with nitrification, emission of ammonia, methane, nitrous oxide & elemental nitrogen from the soil system as a result of denitrification, incomplete nutrient supply of macronutrients. Even though organic fertilizers supply all materials required by the crop plants, they are not without limitations as: low efficiency: since required in large amount, take long time (more than 3 months to decompose), may carry some toxic substances, pathogenic microbes, & harbor pests, the composition may not be uniform : excess of some nutrients and/or shortage of some other nutrients (PCT, 2013).

Application of organic manures as a source of macro and micronutrients and to give humus as a flavonic and humic acid contents in soil and also responsible for improving both the physical and the biological properties of the soil (Abou El-Magd *et al*., 2006). Compost has ability to improve soil properties by chemically (nutritionally). The usage of waste materials as organic manure has a economical value, its large disposal creates environmentally threatening operation (Sim and Wu, 2010). Bioorganic fertilizer contains macro and micro-nutrients, vitamins, amino acids and useful microflora characterized in that in addition to set of mineral nutrients for plants in the proportion, as well as effective micro-organisms (PCT, 2013). In light of such

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justifications the present study has planned to produce bioorganic fertilizer through aerobic co-fermentation of oil cake and banana peels.

MATERIALS AND METHODS

The experiment was conducted in Central laboratory of Haramaya University. 6kg oil cake was collected from Hamaressa edible oil factory, and 6kg banana peels was obtained from collection at home. Compost tea that was used as a control was obtained from Bate district, Haramaya. Fermentation solution was prepared by mixing 500g teff flour to one liter of groundwater following the procedure used by Unnisa (2015).

Experimental Procedure and Data Collection

Aerobic Digestion:

The fermentation process was carried out under aerobic condition in two replications based on the method suggested by PCT (2013) as follow: clamps of oil cake and chopped banana peels were formed in the open container covered with cotton cloth (the proportion of the cake: peels = 1:1). The starting clamp components were successively arranged in layers with a height of 0.4 m each. The formed clamps were sprayed with diluted activated microbiological formulations including yeast and lactic bacteria. The microbial formulations were prepared from yeast powder and coagulated milk (as a source of lactic acid bacteria) with non-chlorinated water in the proportion of 1:50. Mixing and spraying water on the clamp was done periodically. The fermentation process was done in open container at ambient temperature for aerobic microbiological fermentation, until cycle of a fertilizer production completed (being without any flavor).

The output components of the bioorganic fertilizer was left in the open container to complete finishing of the technological process of the fertilizer production. The degree of readiness of the bioorganic fertilizer was determined according to physico-mechanical and organoleptic properties (homogeneity, looseness, lack of smell).

When the above conditions are observed the duration of a complete technology cycle was taken around 40 to 50days. Finally quantitative analysis for composition of macronutrients in bioorganic fertilizer was determined as per procedures below.

Determination of major plant macronutrient minerals

Nitrogen contents of fertilizer solution and compost tea (control solution) were determined by the Kjeldahl method consists of three steps: digestion, distillation, & titration. The percentage nitrogen was calculated according the equation:

$$\%\mathbf{N} = ([(\mathbf{ml\ standard\ acid\ x\ N\ of\ acid}) - (\mathbf{ml\ blank\ x\ N\ of\ base})] - (\mathbf{ml\ std\ base\ x\ N\ of\ base})\ \mathbf{x\ 1.4007}) / (\mathbf{weight\ of\ sample\ in\ grams})$$

Where “N” represents normality. “ml blank” refers to the milliliters of base needed to back titrate a reagent blank if standard acid is the receiving solution, or refers to milliliters of standard acid needed to titrate a reagent blank if boric acid is the receiving solution. When standard acid is used as the receiving solution.

The Phosphorus Content was determined by acid (HNO_3) oxidation in the presence of vanadium ammonium molybdate. Sodium and potassium were determined by atomic absorption method.

Determination of Quality of Bioorganic Fertilizer Solution

PH measurement

PH measurement was based on procedure used by Patel and Lakdawala (2014) as follow:

Calibration Standard Preparation: two buffers was selected that bracket the expected sample pH. The first near the electrode isopotential point (pH 7) and the second buffer near the expected sample pH. A pH 7.00 buffer pouch was opened or a graduated cylinder was to transfer 30 mL of pH 7.00 buffer into a 50 mL beaker.

Sample Preparation:

40 mL of the sample liquid bioorganic fertilizer was measured by using a graduated cylinder into a 50 mL beaker. The beaker was covered with a watch glass. The electrode was placed in a prepared sample with the electrode tip fully immersed in the solution. The measure key was pressed on the meter. The pH icon flashed as the measurement was being made. Determination of the quality of bioorganic fertilizer solution based on PH range was based on the standard Table 1.

Electrical Conductivity (EC) Measure

A 2:1 by volume method was used to measure EC based on modified procedure used by Rhoades *et al*., (1999). Whereby a volume of mix was measured and twice as much water was added. The electrical conductivity (EC) is a measure of the total soluble salts, or the soluble nutrients (or ions) present in a growing media. The determination of electrical conductivity (EC) is made with a conductivity cell by measuring the electrical resistance of a 1:2 solute: water suspension. The determination of EC generally involves the physical measurement of the materials' electrical resistance (R), which is expressed in ohms. The reciprocal of resistance is conductance (C). It is expressed in reciprocal ohms, i.e., mhos. When the cell constant is applied, the measured conductance is

Table 1: Rating of bioorganic fertilizer solution based on pH values

Category	Range of pH value	Suggestion for remedy of bioorganic fertilizer solution
Acidic	<6.5	Requires liming for reclamation
Normal	6.5-7.8	Optimum for most crops
Alkaline	7.8-8.5	Requires application of organic manures
Alkali	>8.5	Requires gypsum for amelioration

Source: Patel and Lakdawala (2014).

converted to specific conductance (i.e., the reciprocal of the specific resistance) at the temperature of measurement. Electrical conductivity meter & cell measures fraction of the specific resistance; this fraction is the cell constant (K = R/Rs).

Often, and herein, specific conductance is referred to as electrical conductivity, EC:

$EC = 1 / R_s = K / R$.

Procedure for conductivity:

0.746 g KCl was dissolved (previously dried at 105 °C for 2 hours) and the volume was made to 1 L with CO_2 free deionised water. This solution has an electrical conductivity of 1.413 dS/m at 25 °C. Then 1:2 biorganic fertilizer solution : water suspension was prepared by weighing 10 g air-dry bioorganic fertilizer solution (<2 mm) into a bottle. 50 mL deionised water will be added, and mechanically shaken at 15 rpm for 1 hour to dissolve soluble salts. Determination of the quality of bioorganic fertilizer solution based on EC range was as in Table 2. Electrical conductivity can be converted to estimate total dissolved solids by using the following equation (Detay, 1997):

$TDS(ppm) = 0.64 \times EC(\mu S/cm) = 6.4 \times EC mS/cm = 640 \times EC(dS/m)$.

Table 2: Rating of bioorganic fertilizer solution based on electrical conductivity (EC)

Range of EC	Rate of bioorganic fertilizer solution
< 0.8 ds/m	Normal
0.8-1.6 ds/m	Critical for salt sensitive crops
1.6-2.5ds/m	Critical to salt tolerant crops
2.5 ds/m	Injurious or toxicity to most crops

Source: Patel and Lakdawala (2014).

Pot experiment for testing bioorganic fertilizer solution

The fertilizer solution was tested by growing Ethiopian mustard in pot experiment. The experimental design was completed randomized design (CRD) in two replications. Soil sample was taken randomly from the field and placed in pots.

Four Ethiopian mustard seeds were planted in each pot. In the experimental pots half liter of bioorganic fertilizer was added during planting. However, in the control group no nutrient was applied only 500ml of water was added to each pot during planting. Then both experimental and control groups were irrigated with water as it was needed so as to prevent moisture stress. Thereafter 3 to 4 leaf stage half liter of fertilizer solution was added to experimental group. That is totally one liter of fertilizer solution was used.

Quantitative data were analyzed by using quantitative method such as frequency, percentage and mean and standard deviation using Microsoft office excel and SAS software (Version 9.2).

RESULT AND DISCUSSION

Production of Bioorganic liquid fertilizer through aerobic fermentation

The bioorganic liquid fertilizer solution produced from mixture of oil cake and chopped banana peels (3kg each) through aerobic co-digestion in open containers covered with cotton cloth (so as to prevent the entry of flies) for 45 days at room temperature. The experiment was replicated twice. It was found that 4 liters of bioorganic liquid fertilizer solution were produced from 6kgs of co-fermented substrates. Further dilution can be conducted depending on the economy of the user and performance evaluation. As fertilizer requirement depends on nature of the soil, crop plant types and other environmental factors. Similar study was conducted by PCT (2013) who recommended aerobic fermentation of organic wastes as an efficient process of solution fertilizer production. The rising prices of fertilizer in market looking for an idea to force someone else to meet the needs of the crops they planted (Food Waste to Energy and Fertilizer, 2010). In addition, chemical fertilizer if used continuously can made microorganism in the soil becomes dead and causing the soil to be infertile (Mason *et al*., 2011). Utilization of organic food waste as a liquid fertilizer is expected to solve these problems and can help increasing the economy by farmers and housewives in the village (Unnisa, 2015).

Determination of Plant Macronutrient Composition of biorganic Liquid fertilizer solution

Macronutrient composition of bioorganic fertilizer and compost tea solutions was shown in Table 3. Phosphorus (P), Potassium (K), Calcium (Ca) and also sodium (Na) were found to be significant between bioorganic liquid fertilizer and compost tea (used as a control) solutions.

However, there were no significance differences with respect to Carbon(C), Nitrogen (N), and Magnesium (Mg) contents of the solutions.

It also indicated that percentage macronutrient compositions of bioorganic fertilizer solution was found to be greater than those of compost tea solution in all studied macronutrients. This finding was in accordance with Unnisa (2015) who produced liquid fertilizer from vegetable waste.

Table 3: Macronutrient composition of bioorganic fertilizer solution and compost tea

Treatment	P (%)	K (%)	Ca (%)	Mg (%)	Na (%)
Compost tea	0.21±0.02b	1.12±0.22b	2.72±0.02a	0.87±0.16a	1.85±0.21b
Bioorganic solution	1.70±0.34a	3.42±0.72a	1.60±0.13b	2.12±0.80a	2.86±0.20a

Means followed by same letter within a column were not significantly different at 0.05. Probability level based on DMRT (Duncan's Multiple Range Test).

Table 4: Quality of liquid fertilizer solution

Treatment	C	N	CN	PH	EC
Compost tea	30.65±4.03b	3.48±0.31a	8.79±37a	5.50±0.42b	0.55±0.04b
Biorganic fertilizer solution	53.85±0.85a	4.37±0.56a	12.45±1.79a	7.66±0.06a	0.80±0.03a

Means followed by same letter within a column were not significantly different at 0.05. Probability level based on DMRT (Duncan's Multiple Range Test). PH: power of hydrogen; EC: electrical conductivity; C:N: carbon to nitrogen ratio.

Determination of the quality of Bioorganic liquid fertilizer

The quality of biorganic liquid fertilizer solution produced in the present study was measured with respect to PH, EC and C:N ratio as in Table 4. It was indicated that both compost tea and bioorganic liquid fertilizer solutions fulfill the basic requirements of plant macronutrients (Table 4) with respect to electrical conductivity and C:N ratio. However the PH needs adjustment to the neutral. The carbon content of fertilizer solution in the present study, was found to be 53.85%. The determination of natural carbon in composts serves in an indirect way as measure of accessible nitrogen. In most of the fertilizer cases the minimum carbon content or organic matter was found to be approximately 6-7% (Monisha and Rameshaiah, 2016).

Testing the bioorganic liquid fertilizer through pot experiment

In the present study, the bioorganic liquid fertilizer produced was evaluated by growing Ethiopian mustard (*Brassica carinata*) in pot experiment in two replications. It was indicated in Table 5 that the performance of Ethiopian mustard irrigated with bioorganic fertilizer solution was performing better than compost tea solution and the control experiment (that was irrigated with water only). Above ground biomass per plant was found to be significant with the highest mean weight being 126.28gm for pots treated with bioorganic liquid fertilizer solution. However, there was no significance difference between the control experiment (water) and the bioorganic fertilizer solution for number of leaves per plant. This finding was in accordance with previous report by Unnisa (2015) who conducted pot culture experiments in triplicate to test the toxicity of the organic liquid fertilizer for seed germination. Liquid fertilizer has many advantages because of easy process, inexpensive and no side effects.

Table 5: Performance of Ethiopian mustard in greenhouse

Treatment	BM	NLP
Control (without fertilizer)	37.80±3.44c	5.50±0.71a
Compost tea	80.46±6.0b	5.50±0.71a
Bioorganic fertilizer solution	126.28±8.70a	4.50±0.71a

Means followed by same letter within a column were not significantly different at 0.05. Probability level based on DMRT (Duncan's Multiple Range Test). BM: biomass weight per plant (gm); NLP: number of leaves per plant.

CONCLUSIONS

The present study has produced quality organic fertilizers from locally available substrates having diverse composition of minerals. since commercially available chemical fertilizer supplies not only limited number of macronutrients but also expensive Small holder farmers can easily produce it locally and use it so as to reduce dependence on chemical fertilizers and their devastating effect on the environment. Studies are required to optimize fermentation durations and conditions. Field evaluation of the fertilizer solution and its impact on the quality of the nutrients should have to studied. The bioorganic fertilizer solution produced in the present study will be helpful for hydroponic farming. Thus, studies are required to evaluate the fertilizer solution in hydroponic experiment.

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