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Full length Research paper

Production of Bioorganic Liquid Fertilizer from Coffee Ground and Banana Peels

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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 coffee ground and banana peels through aerobic fermentation in open containers. The result indicated that Phosphorus (P), Potassium (K), calcium (Ca), Magnesium (Mg) 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) and Nitrogen (N) contents of the solutions. Comparison of mineral composition of bioorganic liquid fertilizer and compost tea solutions with the standard for major macronutrients requirement of plants indicated that the composition of both fertilizer solutions in the present study satisfies the standard with bioorganic liquid fertilizer being higher in mean values for most of the studied mineral plant nutrients. The bioorganic liquid fertilizer produced was evaluated by growing lettuce in pots in two replications. It was indicated that the performance of lettuce irrigated with bioorganic fertilizer solution was performing better than compost tea solution and soil grown plant. It can be concluded from the present study that biogranic liquid fertilizer can be produced from locally available substrates like sheep manure and banana peels. Small holder farmers can get economic relief, because by using this technology, thus, they can minimize the use of chemical fertilizer which is being expensive and not environmentally friendly.

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

INTRODUCTION

Organic farming is a system that excludes the use of synthetic fertilizers, pesticides, and growth regulators. Greenhouse technology and horticultural practices differ little between conventional and organic greenhouse production.

The main variations are concerned with pest control and fertility. Although the process is more complicated, it is possible to obtain adequate nutrients from organic sources, but it takes creative management. No single fertilizer will provide all of the essential elements required, a combination of organic products can be devised. Organic fertilizers have not been well researched in greenhouse vegetable production. Organic fertilizers could supply nutrients at the same level as synthetic fertilizers. Products derived from algae, bat guano, fish waste, mineral rocks, animal manures, plant waste, etc. containing nutrient levels can be comparable to conventional, synthetic fertilizers used for greenhouse plant production (Chandra, 2005).

The bioorganic fertilizer obtained through anaerobic fermentation comprises number of growth substances, vitamins, antibiotics, 18 amino acids and useful micro-organisms. However, the disadvantages include lack of finished product of effective micro-organisms balanced according to the generic composition comprising the following dominant genera: lactic fermentation bacteria *Lactobacillus spp,* photosynthetic bacteria and yeast *Spp;* presence in the finished product undesired foreign bacterial microflora, insignificant speed of microbial fermentation in anaerobic conditions; seasonal restrictions on the use of prototype fertilizer depended on the domination of anaerobic cellulose-degrading micro-organisms; constant proportion and a limited set of

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starting components, making it impossible to get a finished product, balanced for specific crops taking into account their biological characteristics and physiological needs; not very high physical-mechanical parameters and the quality of the finished product: high humidity, viscosity, heterogeneity; insignificant content of mineral nutrients and biologically active substances in the finished products (PCT, 2013).

Bioorganic liquid fertilizer not only increases bioorganic fertility of crops (in comparison to the control and prototype fertilizer), but also accelerates their maturation. At the same time the biological value of products is increasing: the content of vitamins and carotene in vegetables is increased and the nitrate content is significantly reduced. The doses of applying fertilizer are reduced 2.0-2.2 times (PCT, 2013). In light of such justifications the present study has planned to produce bioorganic fertilizer through aerobic digestion using coffee ground and banana peels.

MATERIALS AND METHODS

The experiment was conducted in Central laboratory of Haramaya University. 6kg coffee ground was bought from local market, and 6kg banana peels will be used. Fermentation solution will be prepared by mixing one liter of molasses to three liter of groundwater or dechlorinated water following the procedure used by Unnisa (2015).

Experimental Procedure and Data Collection

The fermentation process was carried out under aerobic condition in two replications based on the method suggested by PCT (2013) as follow: clamps of coffee ground and chopped banana peels were formed in the open container covered with cotton cloth (the proportion of the coffee ground: 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). Finally quantitative analysis for composition of macronutrients in bioorganic fertilizer was determined as per procedures below.

Determination of Total Nitrogen Content

Nitrogen contents of fertilizer solution and compost tea (control solution) were determined by the Kjeldahl method consists of three steps: digestion, distillation, & titration.

Sample Digestion:

Sample solution was stirred into a beaker using a VELP magnetic stirrer for 60 sec. at 700 rpm, then 5 ml of sample was added into a 250 ml test tube, by using a pipette, For each sample: 2 catalyst tablet CM (3.5g K_2SO_4, 0.1g CuSO4, 5$H_2$0 Missouri); 20 ml concentrated sulphuric acid (96-98%); 5 ml of hydrogen peroxide (~ 30%) was added into test tube. Banks with all chemicals and without sample were prepared. The Digestion Unit was connected to a proper Aspiration Pump and a Fume Neutralization System to neutralize the acid fumes created during digestion phase. The samples was digested for 15 minutes at 150 °C, plus 15 minutes at 250 °C and 40 minutes at 420 °C.

Distillation and Titration:

The test tubes was cooled down to 50-60°C. The samples was distilled according to the following parameters (pre-defined method n°1): 50ml H_2O (dilution water); 0.1NH_2SO_4 as titrant solution;70ml NaOH (32 %); 6.38 Protein factor; 30ml H_3BO_3 (4 % with indicators). Distillation &Titration analysis time was 4 minutes for one test. 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.

Determination of Phosphorus Content

2.5g (accurate to 0.1 mg) liquid sample of biorganic liquid fertilizer and compost tea solutions were weighed, and put into a 125mL Erlenmeyer flask. Then, 10mL HNO_3 was added and heated on the electric hot plate. Samples were subjected to acid oxidation to make phosphorus react with vanadium ammonium molybdate and form yellow complex compound in nitric acid solution. After fully reacted, the flask was taken off the electric hot plate and left until it was cooled off. Then after, 10mL $HClO_3$ was added and the content of the flask was heated back on the electric hot plate. If the solution turns black, it was taken off and 5mL HNO_3 was added andl continued heating till the solution turns into colorless or amber and with white smoke. When there was 3-5mL left in the flask, it was cooled off and transferred into a 50mL volumetric flask and meter volume. Spectrophotometer was used to determine the absorbance at the wavelength of 440nm with an aim to quantitatively analyze the content of phosphorus. The blank experiment was carried out at the same time.

The preparation of the standard curve

The phosphorus concentration of the sample solution was obtained according to the standard curve. The content of phosphorus in the sample was calculated according to formula:

$$X = \frac{C \times V \times V_2}{m \times V_1 \times 1000} X100$$

Where X: content of phosphorus in the sample, mg/100 g; C: the concentration of phosphorus that is obtained from the standard curve,_mg/mL; V: the metered volume after the sample elixation, mL; V1: the volume of the sample solution that is taken, mL; V2: the metered volume of the coloration solution, mL; m: the mass of the sample, g.

Determination of Potassium content

The atomic absorption method was organized in such a way that the same diluted samples could be used for both sodium and potassium analyses, since these elements are often determined were ten times more concentrated than sodium standards. The standards was prepared in water and cesium was added at the concentration of 1000 mg/1. Cesium was also added to the diluted fertilizer solution samples. Easily ionized elements (such as the alkali metals) enhance the absorbance of other alkali metals because of ionization effects, the effects being greater at higher flame temperatures. Apparently, the atoms of another easily ionized element provide additional electrons that cause some of the atoms of the first element to return to the ground state, thus causing an increase in absorbance. For example, this enhancement of the absorbance of sodium metal in the presence of potassium (and vice versa) can be eliminated by the addition of a suitable amount of another alkali metal, such as cesium (Perkin and Elmer Corporation, 1973).

Sample preparation:

50ml of the samples was filtered and transferred in to the beaker and 5 drops of 1MHCl was added. The acidified sample was heated gently (not to evaporation) on hot plate for 7 minutes at 35^0C then cooled for 5 minutes and 3 drops of hydrochloric acid was added to dissolve deposited carbonates of metals and heated again for another 5 minutes to confirm the loss of organic constituents in the form of carbon dioxide and cooled for few minutes and ready for analysis. Since organic impurities were almost removed from the sample by heating.

Standard stock solution preparation:

stock solution was prepared from analytical reagent grade NaCl and KCl dried in oven at 105^0C for 1hour. 1.91 g of KCl was taken into 1000 ml flask and its volume was made up to the mark with the help of distilled H_2O. In this way a 1000 ppm of potassium solution was prepared. To make 10 ppm potassium solution, 10ml of 1000ppm solution was taken into 100 ml flask and its volume was made up to the mark with the help of distilled water. Similarly, to make 20 ppm potassium solution, 20 ml of 1000 ppm solution was taken into 100 ml flask and its volume up was made up to the mark with the help of distilled water. In the same way, standard solutions of 30 ppm, 50 ppm, 60 ppm and 70 ppm standards were prepared from stock solution.

Preparation of working standards:

Five 100ml volumetric flasks were prepared and labeled as 2ppm, 4ppm, 6ppm, 8ppm and 10ppm. The assigned concentrations were prepared by adding 2ml, 4ml, 6ml, 8ml and 10ml of 100ppm stock solution in to 2ppm, 4ppm, 6ppm, 8ppm and 10ppm flasks respectively and filled to the mark.

The blank solution was prepared from 2ml of 1MHCl and deionized water. The instrument was then calibrated by aspirating the working solution in the order of blank then standard analyte solution. After the calibration curve (appendix fig 3) is established, and the samples were aspirated into the flame photometry through nebulizer from sample 1 to sample 6. In between each measurement there was aspiration of blank solution to avoid the effect of contamination or error in concentration reading. The concentration of each metal ion is determined selectively at specific wavelength. The maximum wavelength at which Na^{+1} determined is 589nm and K^{+1} is at 766nm.

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.

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).

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 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. The conductivity meter was calibrated according to the manufacturer's instructions using the KCl reference solution to obtain the cell constant. The cell was rinsed thoroughly. The electrical conductivity of the 0.01M KCl was measured at the same temperature as the soil suspensions. The conductivity cell was rinsed with the sample biorganic fertilizer suspension. The conductivity cell was refilled without disturbing the settled solute. The value indicated on the conductivity meter was recorded.

The cell was rinsed with deionised water between samples. For EC, researchers adopted the term “mho”-“ohm” written backwards. 1dS/m = 1mmho/cm = 1000µmho/cm. Units used for measuring electrical conductivity of water are MicroSiemens per centimeter µS/cm, millisiemens per centimeter (mS/cm) and DeciSiemens per meter dS/m. 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×EC (µS/cm) = 6.4×ECmS/cm = 640×EC (dS/m).

Pot experiment for testing bioorganic fertilizer solution

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

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).

group. That is totally one liter of fertilizer solution was used.

Data analysis

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

Three kilograms of both coffee ground and chopped banana peels were co-fermented in open container covered with cotton cloth (so as to prevent entry of insects) for 60 days at ambient temperature. It was found that 4 liters of bioorganic liquid fertilizer solution were produced from 6kgs of co-fermented substrates. This finding was in accordance with PCT (2013) who recommended aerobic fermentation of organic wastes as an efficient process of bioorganic solution fertilizer production.

Determination of Plant Macronutrient Composition of biorganic Liquid fertilizer solution

Macronutrient composition of bioorganic fertilizer and compost tea solutions was shown in Table 3.

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

Treatment	P	K	Ca	Mg	Na
Compost tea	1.44±0.33b	2.11±0.08b	2.72±0.02b	1.01±0.01b	1.19±0.08b
Biorganic	2.51±0.19a	3.74±0.88a	4.15±0.01a	2.35±0.50a	2.67±0.11a

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).

Phosphorus (P), Potassium (K), calcium (Ca), Magnesium (Mg) 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 sodium (Na) 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 Monisha and Rameshaiah (2016) who produced liquid fertilizer from vegetable waste.

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 range between 6.0 to 8.0 which is optimum for most crop plants.

The carbon content of fertilizer solution in the present study, was found to be 53.85% (Table 4). 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

The bioorganic liquid fertilizer produced was evaluated by growing Ethiopian lettuce in pot experiment in two

Table 4: Quality of liquid fertilizer solutions

Treatment	PH	EC	C	N	CN
compost tea	8.95±0.35a	0.65±0.06b	21.37±3.49b	2.61±0.02b	8.20±1.41b
Bioorganic	7.00±0.28a	1.11±0.16a	49.45±1.63a	3.25±0.07a	15.21±0.17a

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.

Table 5: Performance of lettuce in pot

Medium	Treatment	ABM	NLP	HWP	DM
Soil	compost tea	56.11±2.70b	6.50±0.71a	43.40±1.84b	76.50±2.12a
	Bioorganic	70.71±0.58a	8.50±0.71a	56.25±1.20a	65.00±1.41b
Sawdust	compost tea	71.95±1.87b	7.50±0.71a	49.50±2.83b	81.00±1.41a
	Bioorganic	86.35±2.62a	10.50±0.71a	73.85±1.91a	71.00±2.12b

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). BMW: biomass weight per plant (gm); NLP: number of leaves per plant; DM: days to maturity; HWP: head weight per plant.

replications. It was indicated in Table 5 that the performance of lettuce irrigated with bioorganic fertilizer solution was performing better than compost tea solution and soil grown plant. It was indicated that most of the measured parameters including above ground biomass per plant (BMW), days to maturity (DM), and head weight per plant(HWP) were found to be significant, between compost tea and biorganic fertilizer solutions, for all soil grown plant and hydroponic growth using sawdust and water solution.

However, there were no significance difference observed for number of leaves per plant (NLP). Similar study was conducted 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. The resulting benefits are very likely to fertilize crops, to maintain the stability of nutrient elements in the soil and reducing the bad impacts of chemical fertilizers. In addition to a liquid fertilizer that can be sold in the market, liquid fertilizer can be used for agriculture purpose or in the premises for plantation.

CONCLUSIONS

The present study has produced bioorganic liquid fertilizer solution from oil cake and banana peels through aerobic fermentation in open containers. The result indicated that . Phosphorus (P), Potassium (K), calcium (Ca), Magnesium (Mg) 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), and Nitrogen (N) contents of the solutions. Both compost tea and bioorganic liquid fertilizer solutions fulfills the basic requirements of plant macronutrients with respect to electrical conductivity and C:N ratio as a quality standard for organic fertilizers. It can also be concluded from the present study that biogranic liquid fertilizer can be produced from locally available substrates. Small holder farmers can get economic relief, because by using this technology, they can minimize the use of chemical fertilizer which is being expensive and not environmentally friendly.

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