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Full length Research paper

Production of Bioorganic Liquid Fertilizer from Khat Leaves and Onion Bulbs

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Microbial formulations for producing bioorganic liquid fertilizers are promising technology in the future. Thus, the present study was aimed to produce bioorganic liquid fertilizer from khat leaves and onion bulbs through aerobic fermentation in open containers. Macronutrient composition of bioorganic fertilizer and compost tea solutions 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. 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. The test for bioorganic liquid fertilizer produced indicated that the performance of lettuce irrigated with bioorganic fertilizer solution was performing better than compost tea solution. 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. The present study has produced bioorganic liquid fertilizer from domestic wastes. Using such technology will enhance waste disposal and reuse mechanisms at small and large scales. Further studies are required to be conducted on nutritional quality of vegetables grown by using such fertilizers.

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

INTRODUCTION

Organic farming helps in maintaining environmental health by reducing the level of pollution, reduces human and animal hazards by reducing the level of residue in the product. helps in keeping agricultural production at a higher level and makes it sustainable, reduces the cost of agricultural production and also improves the soil health, sustainable agricultural production, reduces the cost of agricultural production and also improves the soil health, ensures optimum utilization of natural resources for short-term benefit and helps in conserving them for future generation, saves energy for both animal and machine, and reduces risk of crop failure. Besides these, it has been demonstrated extensively that plant products produced from organic farming are substantially better in quality like, bigger in size, look, flavor and aroma. Even animal products like milk, meat etc. have been observed to be of better quality when they are fed with feed and fodder produced organically (Chandra, 2005).

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 Ethiopia, 85-90% of Khat (*cata adulis* F.) produced is exported and makes a very significant contribution to the country's foreign earning. khat waste generates several facets which is understood by its quality and generated across all phases of khat production and consumption sites. Majority of the stake holders are concerned about the impact of khat waste. The left over khat waste attract rodents and insect significant impact on public health. East and west Hararghe topographic areas are potential regions to produce large quantity of Khat in Ethiopia. Since earlier times the root, steam and leaves of khat

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plant have been used for medical purpose to cure various diseases, for soil protection and economic value chain. Khat is providing huge income and job opportunities to the population of those regions (Dechasa, 2001).

The basis of sustainable agriculture is the use of locally produced and new cast bio mass resources to re build and maintain the soil productivity. Proper producing and recycling of organic waste for agriculture can greatly reduce the environmental pollution of resource are the additional benefit of the organic liquid fertilizer (Kurdali and Shammaa, 2010).

In light of such justifications the present study has planned to produce bioorganic fertilizer through aerobic digestion using khat leaves and onion bulbs.

MATERIALS AND METHODS

The laboratory experiment was conducted at Haramaya University Central Laboratory. 6kg khat leaves was collected from Awaday town, and 6kg onion was bought from local market at Haramaya town. Fermentation solution was prepared by mixing 1kg of sorghum flour to 2 liters 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 powdered khat leaves and chopped onion bulbs were formed in the open container covered with cotton cloth (the proportion of the khat: bulb = 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:

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

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.

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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).

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).

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

Pot experiment for testing the effect 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 Rare 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 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

Organic Fertilizers plant nutrients derived solely from the remains or by-products of a once-living organism (Virginia Cooperative extension, 2015). Bioorganic fertilizers are organic fertilizers produced by micorbial formulations (PCT, 2013). Fertilizer is said to be complete

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

Treatment	P	K	Ca	Mg	Na
Compost tea	0.77±0.13b	1.72±0.19b	1.36±0.12b	1.05±0.02a	1.74±0.11b
Bioorganic	1.34±0.04a	3.65±0.40a	4.05±0.75a	2.35±0.56a	2.83±0.22a

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 solutions

Treatment	PH	EC	C	N	C:N
compost tea	6.45±0.36a	0.35±0.06b	25.87±1.46b	2.61±0.02b	9.92±0.47b
Bioorganic	4.45±0.35b	0.78±0.02a	52.95±1.91a	3.25±0.07a	16.30±0.94a

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.

when it contains nitrogen, phosphorus, and potassium (10-10-10, 5-10-10, 5-30- 5, etc.). An incomplete fertilizer contain one or two of the major components. Accordingly, in the present study, bioorganic liquid fertilizer solution was produced from aerobic co-fermentation of khat leaves and onion bulbs. Three kilograms of both substrates (powdered khat leaves and chopped onion bulbs) were co-fermented in open container (as biodigester) 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.

Macronutrient composition of bioorganic fertilizer and compost tea solutions was shown in Table 3. 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 Magnesium (Mg) content of the solutions.

It also indicated that percentage macronutrient compositions of biorganic 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 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 52.95% (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 on soil

The test for bioorganic liquid fertilizer produced as in Table 5 indicated that the performance of lettuce irrigated with bioorganic fertilizer solution was performing better than compost tea solution. 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.

However, there was 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.

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Table 5: Mean Performance of lettuce in pot

Treatment	ABM	NLP	HWP	DM
Compost tea	36.11±2.70b	4.50±0.71a	23.40±1.84b	56.50±2.12a
Bioorganic	54.21±1.29a	5.50±0.71a	36.25±1.20a	43.00±1.41b

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.

CONCLUSIONS

Macronutrient composition of bioorganic fertilizer and compost tea solutions 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. 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. The test for bioorganic liquid fertilizer produced as in Table 8 indicated that the performance of lettuce irrigated with bioorganic fertilizer solution was performing better than compost tea solution. 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.

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