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Research Article

Hydroponic Growing of Lettuce (*Lactuca sativa L.*) Using Bioorganic Liquid Fertilizer from Groundnut Husk and Onion Bulbs

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Abstract

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 groundnut husk and onion bulbs through aerobic fermentation in open containers. The result indicated that bioorganic liquid fertilizer solution from groundnut husk and banana peels through aerobic fermentation in open containers. Phosphorus (P), Potassium (K), and calcium (Ca) were found to be significant between bioorganic liquid fertilizer and compost tea (used as a control) solution. The quality of bioorganic liquid fertilizer solution produced in the present study was indicated that all measured parameters including PH, Electrical Conductivity (EC), Carbon(C), Nitrogen (N), and C:N ratio was found to be significant between compost tea and bioorganic fertilizer solutions. The performance of lettuce irrigated with bioorganic fertilizer solution in both soil and hydroponic medium (sawdust) was performing better than compost tea solution. It was found 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 bioorganic fertilizer solutions, for all soil grown lettuce and hydroponic growth using sawdust. However, there was no significance difference observed for Number of Leaves per Plant (NLP). Further evaluation of fertilizer should have to be done by conducting field experiments for various crop plants.

Keywords: Compost tea; Electrical conductivity; Lettuce; Organic fertilizers; Plant macronutrients

Introduction

Organic agriculture refers to agriculture in which synthetic fertilizers and pesticides are not used, and in which various environmental issues are considered [1]. Organic hydroponics is defined as soilless cultivation in which an organic waste stream is used as nutrient solution [2]. Because of environmental concerns regarding production of synthetic fertilizer and waste management, it is of interest to develop efficient food production systems, in which the advantages of hydroponic cultivation is combined with the large organic waste resources available, not least in urban areas with high population density and lack of cultivable land [3]. Lettuce (*Lactuca sativa L.*) is one of the most popular leafy vegetables for fresh consumption around the world, and is considered a good source of health-promoting compounds such as vitamins A, C, calcium, iron, antioxidants like quercetin, caffeic acid and lactupicrin which is anti-carcinogenic [4,5]. Lettuce has excellent potential as a year-round indoor crop. Lettuce grows rapidly, even in situations of relatively low light and temperatures. Lettuce was ready to harvest 4-6 weeks after being transplanted into the hydroponic system–with the rate of growth and size of plants harvested being highly dependent on cultivar grown and the amount of light provided to the crop [6,7]. This system also contributes to sustainable production of vegetables through adoption of most efficient growing conditions about plant requirements in terms of nutrient elements, water supply, climatic conditions as well as modern managerial practices [8]. Waste generation and subsequent accumulation generated by unabating increase in human populations is one of the major problems confronting future generations. This is aggravated by improper waste disposal that often causes greater problems in terms of environmental pollution and disease occurrence not only to human beings but also to animals [9]. 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). Considering such justifications, the present study has planned to produce bioorganic fertilizer through aerobic method using groundnut husks and onion bulbs.

Materials and Methods

The experiment will be conducted in General laboratory of Haramaya University. 6kg groundnut husk and 6kg onion bulbs were bought from Haramaya town. Fermentation solution will be prepared by mixing one liter of sorghum flour three liter of groundwater or dechlorinated water 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 groundnut husk and chopped onion bulbs were formed in the open container covered with cotton cloth (the proportion of the husk: bulb=1:1). The starting clamp components were successively arranged in layers with a height of 0.4m 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 were 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 50 days. 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:

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

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 [10] as follow:

Calibration Standard Preparation: Two buffers were 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 30mL of pH 7.00 buffer into a 50mL beaker.

Sample Preparation: 40mL of the sample liquid bioorganic fertilizer was measured by using a graduated cylinder into a 50mL 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. Source: [14].

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

Electrical conductivity (EC) measure: A 2:1 by volume method was used to measure EC based on modified procedure used by [11]. 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/Rs=K/R.

Procedure for conductivity: 0.746g KCl was dissolved (previously dried at 105 °C for 2 hours) and the volume was made to 1L with CO_2 free deionized water. This solution has an electrical conductivity of 1.413dS/m at 25 °C. Then 1:2 bioorganic fertilizer solution: water suspension was prepared by weighing 10g air-dry bioorganic fertilizer solution (<2mm) into a bottle. 50mL deionized water will be added, and mechanically shaken at 15rpm 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 [12]: TDS (ppm)=0.64×EC(μS/cm) =6.4×ECmS/cm=640×EC (dS/m).

Table 2: Rating of bioorganic fertilizer solution based on Electrical Conductivity (EC). Source: [14].

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

Hydroponic experiment for testing bioorganic fertilizer solution

The fertilizer solution was tested by growing lettuce (*Lactuca sativa*) 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 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 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. The standard for macronutrient composition was indicated in Table 3. 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 in open container

Bioorganic liquid fertilizer solution was produced from mixture of groundnut husk. Three kilograms of both groundnut husk and chopped onion bulbs were co-fermented in open container covered with cotton cloth (to prevent entry of insects) for 50 days at ambient temperature. It was found that 4 liters of bioorganic liquid fertilizer solution were produced from 6kgs of co-fermented substrates. The present fertilizer was produced as 4L per 6kgs of substrate (4L/6kgs). Further dilution can be conducted depending on the economy of the user and performance evaluation. Similar study was reported by [13,14] who produced liquid organic fertilizer using distillery slop, molasses, and sugarcane leaves as substrates. While hydroponics is an excellent technique for the cultivation of vegetable crops and other plants, organic fertilizers cannot be used in conventional hydroponic systems, which generally utilize only inorganic fertilizers. These chemical fertilizers are a major constituent in hydroponics but using high concentrations of chemical fertilizer may pose a risk to consumers due to the accumulation of toxic chemicals in vegetables. NH_4^+ and NO_3^- are beneficial nutrients for plant growth, yet when chemical fertilizers are used, long-term nitrate accumulation occurs. Nitrates are a naturally occurring form of nitrogen and an integral part of the nitrogen cycle in the environment. The mineral composition of bioorganic liquid fertilizer solution and compost tea solutions Table 4 was compared with the standard for major macronutrients requirement of hydroponic lettuce plant Table 3. It was found that the composition of both fertilizer solutions in the present study satisfies the standard with bioorganic liquid fertilizer being higher in mean values for all the studied parameters. Even though the bioorganic fertilizer produced in the present study fulfills those minimum requirements. However, further evaluation of fertilizer should have to be done by conducting field experiments for various crop plants. Since fertilizer requirement depends on nature of the soil, crop plant types and other environmental factors. As a result of fertilizer use, nitrates tend to accumulate in vegetable leaves, and this is true of lettuce [15].

Table 2: Recommended nutrient ranges for lettuce[1].

Nutrient	Range	Target level
N	2.5-4.0%	3.50%
P	0.4-0.6%	0.45%
K	4.0%-7.5%	5%
Ca	0.9-2.0%	1.00%
Mg	0.3-0.7%	0.35%
S	0.1-0.3%	0.10%
Fe	50-150ppm	130ppm
Zn	25-50ppm	40ppm
Mn	30-55ppm	50ppm
Cu	5-10ppm	8ppm
B	15-30ppm	20ppm
Mo	NA	0.03ppm

[1]young mature wrapper leaf sampled prior to heading. higher N (4-5%) concentrations will be found if young matured leaves are sampled in the early growing stages (6-8 leaf stages). Source: Maggio et al. (2012).

Table 4: Macronutrient composition of bioorganic fertilizer solution and compost tea.

Treatment	P	K	Ca	Mg	Na
Compost tea	1.19±0.02b	1.57±0.03b	1.37±0.01b	1.01±0.02a	0.91±0.05a
Bioorganic	2.20±0.19a	4.43±0.35a	4.97±1.09a	2.58±0.55a	1.69±0.39a

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).

Determination of plant macronutrient composition of bioorganic liquid fertilizer solution

Plant macronutrient composition Table 4 of bioorganic fertilizer and compost tea solutions indicated that Phosphorus (P), Potassium (K), and calcium (Ca) were found to be significant between bioorganic liquid fertilizer and compost tea (used as a control) solution. However, there were no significance differences with respect to magnesium (Mg) and sodium (Na). It also indicated that percentage macronutrient compositions of bioorganic fertilizer solution were found to be greater than those of compost tea solution in all studied macronutrients. This finding was in accordance with [16] who produced liquid fertilizer from vegetable waste.

Determination of the quality of bioorganic liquid fertilizer

Table 5: Quality of liquid fertilizer solutions.

Treatment	PH	EC	C	N	CN
Compost tea	8.45±0.36a	0.45±0.06b	28.37±0.76b	2.61±0.02b	10.88±0.19b
Bioorganic	5.50±0.43b	0.83±0.09a	56.45±2.62a	3.25±0.07a	17.38±1.18a

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.

The quality of bioorganic liquid fertilizer solution produced in the present study was measured with respect to PH, EC, and C:N ratio as in Table 5. All measured parameters including PH, Electrical Conductivity (EC), Carbon(C), Nitrogen (N), and C:N ratio was found to be significant between compost tea and bioorganic fertilizer solutions. The present study was shown that Both compost tea and bioorganic liquid fertilizer solutions fulfilled the basic requirements of plant macronutrient medium 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 56.45% Table 5. 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% [16].

Hydroponic growth of lettuce on sawdust as an inert material

Table 6: Performance of lettuce in pot.

Medium	Treatment	ABM	NLP	HWP	DM
Soil	Compost tea	36.11±2.70b	4.50±0.71a	23.40±1.84b	56.50±2.12a
		54.21±1.29a	5.50±0.71a	36.25±1.20a	43.00±1.41b
Sawdust	Bioorganic	51.95±1.87b	6.50±0.71a	34.00±2.12b	50.50±2.12a
		67.85±0.49a	9.50±0.71a	51.85±0.92a	41.00±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.

The bioorganic liquid fertilizer produced was evaluated by growing lettuce in pot experiment in two replications. Two fertilizer solutions namely compost tea and bioorganic liquid fertilizer solutions were evaluated by growing lettuce on soil and sawdust (hydroponic inert material). It was indicated in Table 6 that the performance of lettuce irrigated with bioorganic fertilizer solution in both soil and hydroponic medium (sawdust) was performing better than compost tea solution. It was found 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 bioorganic fertilizer solutions, for all soil grown lettuce and hydroponic growth using sawdust. However, there were no significance difference observed for Number of Leaves Per Plant (NLP). Similar study was conducted by [17] 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 [18]. 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.

Conclusion

It was indicated that percentage macronutrient compositions of bioorganic fertilizer solution were found to be greater than those of compost tea solution in all studied macronutrients. The performance of lettuce irrigated with bioorganic fertilizer solution in both soil and hydroponic medium (sawdust) was performing better than compost tea solution. It was found 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 bioorganic fertilizer solutions, for all soil grown lettuce and hydroponic growth using sawdust. However, there was no significance difference observed for Number of Leaves Per Plant (NLP). In present study that bio organic 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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