Nutrients content and quality of liquid fertilizer made from goat manure

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Abstract. Quality of liquid fertilizer is determined by the content of nutrients and other chemical factors such as pH and EC. This research aimed to examine nutrient contents and dynamic of pH and EC of liquid fertilizer made from goat manure in combination with sugar and ammonium sulfate (ZA) and using Effective Microorganisms (EM) as the decomposer. This research was conducted by employing 3 x 3 factorial experiment with three replications. Each treatment combination was applied in 20 L of water. The first factor was the quantity of sugar which consisted of 3 levels: 12.5, 25, and 50 g L⁻¹ of water. The second factor was the quantity of ZA which consisted of 3 levels: 25, 37.5, and 50 g L⁻¹ of water. All combinations were added by 100 g of air dried goat manure L⁻¹ of water and EM solution 1 ml L⁻¹ of water, and incubated for five months. Results of the experiment indicated that the increasing concentration of ZA resulted in the significantly increase of N total and S total. Increasing concentration of sugar resulted in decreasing pH and increasing lactic acid; whereas, increasing concentration of ZA followed by increasing Electrical Conductivity (EC). There was no significantly change of pH and EC of the liquid fertilizer during five months incubation.

Key words: goat manure, liquid fertilizer, nutrients content, quality

1. Introduction
The availability of high quality fertilizers made of materials which are cheaper and easier found by farmers is very important. The quality of the liquid fertilizer is determined by the value of pH and EC, as well as the nutrient elements content of the fertilizer. Fertilizers as source of nutrients are very important for plant growth.

In geoponic cultivation, fertilizers are generally given to the soil as inorganic fertilizers so they can be absorbed quickly by plants. Nevertheless, the application of inorganic fertilizers can reduce the soil productivity. The soil productivity is determined by soil condition, previously fertilizing, organic matters addition, and kinds of plants cultivated [1]

Recently, many kinds of high quality of solid organic fertilizers are offered to the farmers, i.e. vermicomposting and fine compost, can result in higher yield of plants [2, 3]. Furthermore, now a
quantity of liquid organic fertilizers is made by either farmers or factories [4, 5, 6]. Organic matters used as raw materials to make liquid organic fertilizer are seaweeds [7, 8, 4, 5], Eichhornia crassipes, Symphytum officinale and Amaranthus retroflexus [9], and sludge [10]. Moreover, vermicomposting can also result in high quality of liquid organic fertilizer [6].

Organic farming, especially the use of organic fertilizers, in one hand it can result in lower quantity, but in another hand it can result in higher quality of plant yield. The lower yield quantity is due to the lower of macro nutrients content of the organic fertilizers [2, 3], so to get higher quantity of plant yield is necessary to fertilize the plant either by the high quality organic fertilizer or by higher dose organic fertilizer application.

To get the high quality organic fertilizer the use of effectiveness microorganisms (EM) during fermentation of raw materials is recommended. In order to give nutrients and energy sources for EM during fermentation, it can be added urea, NPK, as well as molasses in making liquid organic fertilizer [11]. EM is inoculant microorganisms used to ferment organic materials applied to increase the soil fertility, plant growth, and plant yield [12]. The quality of liquid fertilizer is determined by not only the pH but also nutrient elements content of the fertilizer. The quality of organic liquid fertilizer is also determined by content of another chemical substances such as growth regulator and organic acid [13, 14]. The production of high quality organic liquid fertilizer is very important to support the development of hydroponic cultivation in several countries. The liquid organic fertilizer can substitute inorganic chemical substances that more expensive and more difficult to be found in the market. This research was objected to examine nutrient contents (total of N, K2O, S, Fe, and Mn) and dynamic of pH and EC of liquid fertilizer made from goat manure in combination with sugar and ammonium sulfate (ZA) and using Effective Microorganisms (EM) as the decomposer.

2. Materials and Methods
2.1. Date and Place of The Experiment
The fermentation and incubation of the liquid fertilizers was conducted in the laboratory of University of Sarjanawiyata Tamansiswa in condition of air room temperature. The liquid fertilizer fermentation was carried out from the first week until the fourth week of February 2016. Whereas, the incubation of the liquid fertilizers was conducted from March until July 2016.

2.2. Preparation of The Materials
Goat manure used in this experiment was the feces of grass fed goat. The goat manure was in air dried condition, and it was grinded to become fine granules. Samples of the fine granules of goat manure were analyzed to get the data of pH and nutrient elements content based on Govere et al. [9].

2.3. Formulation of The Materials
Fertilizers were formulated by 3 x 3 factorial experiment with three replications. Each treatment combination was applied in 20 L of water. The first factor was the quantity amount of sugar consisted of 3 levels: 12.5, 25, and 50 g L⁻¹ of water noted as G1, G2, and G3 respectively. The second factor was the quantity of ZA which consisted of 3 levels: 25, 37.5, and 50 g L⁻¹ of water noted as Z1, Z2, and Z3 respectively. Nine treatment combinations were gained: G1Z1, G2Z1, G3Z1, G1Z2, G2Z2, G3Z2, G1Z3, G2Z3, and G3Z3. All combinations were added by 100 g air dried goat manure L⁻¹ of water and EM solution 1 ml L⁻¹ of water.

2.4. Fermentation of The Materials
Fermentation of the materials consisted of several steps. The steps were as follows: (1) goat manure, sugar, and ZA were mixed in ratio to 20 L of water. Sugar + ZA were diluted by 20 L of water in the
plastic bucket, then it was added by 20 ml EM and 2 kg goat manure. (2) The mixed materials were stirred manually around 5 minutes using wood stick. (3) All of mixed combination materials were fermented in the plastic bucket of 25 liter volume. All of the fermented plastic buckets were capped properly and they were put inside the room in condition of air room temperature. (4) Every day, in the morning and afternoon, all of the mixed fermented materials were stirred manually around 2 minutes using wood stick. (5) During 3 weeks while fermentation, the pH and EC of the solution were observed. The pH and EC were observed using portable pH/EC/TDS/ Temperature meter Hanna Instruments HI9811-5. In order to get the real value of EC and TDS, and due to the fertilizer solution which was very high concentrated, it was diluted by adding sterile water in ratio of 1:20 (v/v). (6) In the fourth week of fermentation, both macro and micro elements, and organic acids content of the fertilizer solution were observed [9, 15, 16]. The acid organics observed were citric, acetic, and lactic acid on formulation of G1Z1, G3Z1, G1Z3, and G3Z3 using HPLC method [15, 16].

Each formula of treatment combinations of the liquid fertilizers was taken 5 liters to put inside plastic containers which were capped properly. Those plastic containers were incubated in the room for five months. Every month the pH and EC of the solution were observed.

3. Results and Discussions

Results of the analysis listed in the Table 1 indicated that the nutrient content of the goat manure was in the range of standard as recommended by the Regulation Minister of Agriculture Republic Indonesia [17]. The Regulation states that the solid organic fertilizer must have the content of macro element (N + K₂O + P₂O₅) ≥ 4 %, Fe total ≤ 9000 ppm, and Mn total ≤ 5000 ppm, and Zn total ≤ 5000 ppm. The results were also appropriate with the research by Karim et al. [18] stating that N content of goat manure is 1.02 %. The nutrient element content of animal husbandry manures is depended on their food and animal species [19]. The results of macro and micro elements analysis of the goat manure are listed in Table 1.

Results of the experiment (Figure 1) indicated that there was no interaction between the quantity of sugar (G) and ZA (Z) on the pH value of liquid fertilizers. The highest quantity of sugar (G3) could result in the lowest pH (the three lowest lines) and the lowest quantity of sugar (G1) could result in the highest pH (three upper lines). There was no effect of ZA on pH of the liquid fertilizers.

Figure 2 indicates that there is no interaction between the quantity of sugar (G) and ZA (Z) on the EC value of liquid fertilizers. The highest quantity amount of ZA (Z3) could result in the highest EC (three upper lines) and the lowest quantity of ZA (Z1) could result the lowest EC (the three lowest lines). There was no effect of sugar on EC of the liquid fertilizers. The neutral pH and the highest EC could be resulted in the formulation of G1Z3.

| No. | Nutrient elements | Unit | Content       |
|-----|-------------------|------|---------------|
| 1   | N total           | %    | 1.15 ± 0.11   |
| 2   | P₂O₅ total       | %    | 1.10 ± 0.14   |
| 3   | K₂O total        | %    | 2.79 ± 0.16   |
| 4   | Ca total         | %    | 1.56 ± 0.09   |
| 5   | Mg total         | %    | 0.42 ± 0.06   |
| 6   | S total          | Ppm  | 2050 ± 16.09  |
| 7   | Fe total         | Ppm  | 7214 ± 29.46  |
| 8   | Mn total         | Ppm  | 512 ± 13.45   |
| 9   | Zn total         | Ppm  | 924 ± 15.87   |

± indicates the value of standard deviation of mean (n = 3)
**Figure 1.** Effect of Sugar and ZA Levels on pH of Liquid Fertilizer during Fermentation. Error Bars Represent The Standard Deviations.

**Figure 2.** Effect of Sugar and ZA Levels on EC of Liquid Fertilizer during Fermentation. Error Bars Represent Standard Deviations.
Results indicated that there was interaction between sugar (G) and ZA (Z) on the content of N, K, S, Fe, and Mn of the liquid fertilizers. The increasing of ZA could result the increasing of N total content as well as S total content of the liquid fertilizers (Table 2). Both macro and micro element content of the liquid fertilizers is lower than the macro and micro element content of the liquid organic fertilizer as stated in the Regulation Minister of Agriculture Republic Indonesia [17].

Table 2. The Average Content of N, K, S, Fe, and Mn of The Liquid Fertilizers

| Formula | N total (%) | K2O total (%) | S total (%) | Fe total (ppm) | Mn total (ppm) |
|---------|-------------|---------------|-------------|----------------|----------------|
| G1Z1    | 0.44 d      | 0.17 b        | 0.06 e      | 26.71 g        | 21.34 e        |
| G1Z2    | 0.66 c      | 0.13 cd      | 0.19 b      | 31.80 f        | 24.50 d        |
| G1Z3    | 0.85 a      | 0.11 d       | 0.26 a      | 30.28 f        | 23.71 d        |
| G2Z1    | 0.39 d      | 0.14 c       | 0.09 d      | 47.94 c        | 30.49 b        |
| G2Z2    | 0.79 b      | 0.12 cd      | 0.24 a      | 45.85 d        | 37.54 a        |
| G2Z3    | 0.81 ab     | 0.12 cd      | 0.20 b      | 39.31 e        | 27.95 c        |
| G3Z1    | 0.44 d      | 0.19 a       | 0.06 e      | 82.47 a        | 29.55 cb       |
| G3Z2    | 0.66 c      | 0.19 ab      | 0.15 c      | 82.33 a        | 38.03 a        |
| G3Z3    | 0.85 a      | 0.21 a       | 0.20 b      | 76.68 b        | 29.44 cb       |

G * Z (\(\rho > F\)) <.0001 0.0103 <.0001 <.0001 <.0001

Numbers in columns followed by same letter are not significantly different at the 5% level of significance by DMRT

Table 3. The Average Content of Organic Acid of Liquid Fertilizers

| No. | Treatment | Citric acid (mg L\(^{-1}\)) | Lactic acid (mg L\(^{-1}\)) | Acetic acid (mg L\(^{-1}\)) |
|-----|-----------|-----------------------------|-----------------------------|-----------------------------|
| 1   | G1Z1      | 41.09 a                     | 49.37 d                     | 2,512.17 a                  |
| 2   | G3Z1      | 35.80 b                     | 7,582.52 a                  | 373.89 d                    |
| 3   | G1Z3      | 29.39 c                     | 17.2 d                      | 915.38 b                    |
| 4   | G3Z3      | 30.02 c                     | 7,270.21 b                  | 439.55 c                    |

G * Z (\(\rho > F\)) 0.0012 < 0.0001 < 0.0001

Numbers in columns followed by same letter are not significantly different at the 5% level of significance by DMRT

Results of the experiment indicated that there was interaction between sugar (G) and ZA (Z) on the content of organic acid of liquid fertilizers. Results indicated that the highest of quantity amount of sugar (G3) could result the highest of lactic acid content in combination with both the lowest ZA (Z1) and the highest ZA (Z3): 7,582mg L\(^{-1}\) and 7,270mg L\(^{-1}\) respectively. The highest acetic acid content could be resulted from the combination of G1 and Z1: 2,512 mg L\(^{-1}\) (Table 3).

The higher content of lactic acid due to the higher amount of sugar could result in the lower pH of the liquid fertilizer while reducing the quality of liquid fertilizer. Nevertheless, several studies show that lactic acid can accelerate the plant growth. L-lactic acid can stimulate the growth of duckweed plant (\(Lemna minor\) L.) and corn (\(Zea mays\) L.) as it was indicated at increasing plant biomass [20]. L-(d)-lactic acid can exhibit typical growth promoter activity at very low concentrations and dosage application [21].
Acetic acid as well lactic acid can make plants healthy. These organic acids can decrease the number of seeds infected by fungi, however at the highest concentration it negatively affected germination parameters and declined the seed vigor of Zinnia seeds [22]. Compared to the content of lactic acid as well acetic acid, the content of citric acid was very low. Citric acid can accelerate the plant growth. Talebi et al. [23] report that citric acid environmentally sounds chemical, in concentration 300 mg L$^{-1}$, is effective on the various aspects of growth and development of Gazania plants.

Results of the experiment indicated that the combination of 100 g goat manure + 12.5 g sugar + 50 g ZA had the normal pH (around 6.0 - 6.5), the higher EC (around 3200 - 3400 µS cm$^{-1}$, after diluted by the water in ratio 1:20), and the higher content of N total and S total. Otherwise, it had the lowest lactic acid content.

Results of the experiments indicated that there was no significantly change of pH (Figure 3) and EC (Figure 4) of the liquid fertilizers during five months incubation. These results indicated that the storage during five months did not change the quality of the liquid fertilizers.

![Figure 3](image.png)

**Figure 3.** The pH Dynamic of Liquid Fertilizers During Storage. Error Bars Represent Standard Deviations
Figure 4. The EC Dynamic of Liquid Fertilizers During Storage. Error Bars Represent Standard Deviations

4. References
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