The application of liquid and solid organic fertilizer from Tilapia fish waste for conservation of Central Sulawesi superior Jackfruit plant from Tulo and Beka

V M A Tiwow¹, Adrianton², P H Abram¹* and E A Simatupang²

¹Department of Science Education, Faculty of Training and Education, Tadulako University Palu, Indonesia
²Department of Agronomy, Faculty of Agriculture, Tadulako University, Palu, Indonesia

*Corresponding author: paulus_hengky@untad.ac.id

Abstract. In previous studies, there has been investigation about the levels of macro and microelements in liquid organic fertilizer and solid organic fertilizer made from Tilapia fish waste, indicated that the required standard of fertilizer could be met. Therefore, this research aims to study the application of Liquid Organic Fertilizer (LOF) and Solid Organic Fertilizer (SOF) from Tilapia fish waste to Central Sulawesi superior Jackfruit plants from Tulo and Beka areas. The factorial Block Random Design with two factors was used to analyze the growth of two kinds of Jackfruit plants and two kinds of fertilizer, with three times replications. The observation method was non-destructive measurement by using several parameters of growing plant standard. The result shows that all parameters measured among the combination of two kinds of Jackfruits, two kinds of fertilizers and three replications in terms of plant developing growth were no significant difference. The analyses of nutrient levels in the two kinds of fertilizers met the needs of Jackfruit plants.

1. Introduction

In the agro-ecological aspects, the Jackfruit plants are very suitable to be developed in Palu valley of Central Sulawesi, Indonesia. In terms of topology, Palu has a potential accessibility as a production center because it is easily accessible and near to the center of economic growth in Sulawesi island [1]. Jackfruit from Tulo and Beka areas are popular fruits from Central Sulawesi. It is considered as one of the local wisdom fruits. Because Jackfruit plants from this areas produce a crunchy and tastier fruit compared to normal Jackfruits from other places in Indonesia. Based on the previous study, it is found that this plant is resistant to drought [2, 3].

Another study shows that the test of organic growing media for Jackfruit seeds provide the best seed vigor results [4]. Therefore, organic fertilizer is needed for continuing growth of this seed. Liquid Organic Fertilizer (LOF) and Solid Organic Fertilizer (SOF) from waste of tilapia fish have been analyzed, with nutrients content as follow; for LOF are Zn (15.5 mg / L), Mn (18.8 mg / L), Cu (2 mg / L), Fe (17.7 mg / L), Ca (404.1 mg / L), Mg (77.2 mg / L), K (90.8 mg / L) [5]. And for SOF are Zn (15.5 mg / L), Mn (18.8 mg / L), Cu (2 mg / L), Fe (17.7 mg / L), Ca (404.1 mg / L), Mg (77.2 mg / L), K (90.8 mg / L) [6]. Some evidence shows that the fertilizer with fish raw materials can increase the yield of some types of fruit plants up to 60% [7]. Fish waste extract used for improving the growth, yield and quality of cucumber [8]. By-product of fish waste have been studied as plant bio stimulants [9].
Fish hydrolysed solutions possess macro and microelements contents compatible with theoretical data, that is suitable for foliar fertilizers [10]. Onion and garlic fertilized by Fish viscera (alcalase) showed highest total growing ratio (92.60% for onion and 105.55% for garlic) and plant height (38.50 cm for onion and 50.13 cm for garlic) [11]. To be able to grow and to develop, plants need a complete nutrition and form of macronutrients consisting of primary macros such as N-P-K, and secondary macros such as Ca (calcium), Mg (magnesium), and S (sulfur). While micronutrients consist of Fe (iron), Zn (zinc), Cu (copper), Mn (manganese), Cl (chlorine), Ba (barium), Mo (molybdenum), etc [12]. The purpose of this research is to apply liquid and solid organic fertilizer from Tilapia fish waste by fermentation process as a continued nursery fertilizer for the conservation of Central Sulawesi superior Jackfruits from Tulo and Beka areas.

2. Methods

The process of fermentation called “bakasang” produce liquid organic fertilizer (LOF) from fish waste (intestine, fins and scales) took 14 days. The production of solid organic fertilizer (SOF) is to mix between LOF and clay (b/b) by ratio of 1:1, and printed in a pellet machine. Nutrient analysis of LOF and SOF of Jackfruit plants has been done by certain equipment in the previous study [5, 6]. The method used is a split plot design with three factors and the type of nursery applied is the age of six months growth Jackfruit plants are in a small polybags (I) and moderate polybags (II). After the plants are placed in a new polybag, the LOF as a Group X is conducted as follows: dissolved 10 mL LOF into 1000 mL of water, then take 2-4 mL of that solution then apply it into the soil in polybags, repeated again after 14 days.

In Group Z, the same pre-treatment, after the plants were placed on a new polybag, solid fertilizer was applied by sowing 5 grams of pellets repeated in every 14 days. There are two ways to measure the plants growth, first non-destructive method, by measuring leaf length, leaf width growth and plant height growth, second, by measuring plants growth parameters; Leaf Area Index (LAI), Plant Growth Rate (PGR) or Crop Growth Rate (CGR), Net Assimilation Rate (NAR), Leaf Area Ratio (LAR), and Relative Growth Rate (LTR) [13].

3. Results and Discussions

LOF and SOF have been made based on the procedure of previous studies and the analysis on their macro and micronutrients was conducted. The raw materials of these fertilizers are local tilapia fish waste. The fish are taken from Lindu Lake in Central Sulawesi and the process to manufacture fertilizer using “bakasang” fermentation method. It is adopted from Traditional Fermentation Technology procedure as a local wisdom from North Sulawesi [8, 10].

Applying of LOF and SOF may have a good effect to growing plants as studied before, that using organic waste as fertilizer has improved soil structure, water retention capacity, microbial biomass, and nutrient availability and can reduce health and environmental hazards, and do not contain toxins or carcinogenic substances [5, 6].

The results of experiment knowing the nutrients levels of given fertilizer which applied to LOF and SOF from tilapia fish waste of Tulo and Beka Jackfruit seeds shown in table 1. The quantities LOF and SOF are used as standard which could applied from commercial liquid fertilizers, 10 ml LOF / L water samples and 5 mg SOF / L samples. The analysis of the elements content in both samples can be seen in Table 1.
### Table 1. Nutrient levels in liquid and solid organic fertilizers

| Nutrient levels | LOF | SOF |
|-----------------|-----|-----|
| Zn (mg/L)       | 0.01 | 0.106 |
| Mn (mg/L)       | 0.015 | 1.093 |
| Cu (mg/L)       | 0.01 | 0.013 |
| Fe (mg/L)       | 0.064 | 2.0122 |
| Ca (mg/L)       | 13.548 | 49.395 |
| Mg (mg/L)       | 4.384 | 6.447 |
| K (mg/L)        | 0.505 | 1.516 |
| N (%)           | 0.052 | 0.016 |
| P (%) or mg/L   | 0.063/630 | 0.055 |
| Co (mg/L)       | - | - |
| Ni (mg/L)       | - | - |

From measurements of each variations in table 2, on three-factor split plot data after 2 and 4 weeks applying fertilizer are leaf length growth were in the range of 3.5-18%, leaf width are in range of 5.0-16.7% and plant height are between 0.3-6.8%. This growth is at the medium level growth as similar to the previous studied by Susilo [14]. After applying fertilizer for 30 days, it is the result show that the dose of LOF and SOF are not significantly different. It shows that for Jackfruit plants in the two different polybags, large and small which has leaf width 0.05-0.34 cm, leaf length 0.3-0.8 cm and plant height from 0.2 to 4.4 cm.

The experiment by Muray and Andeson reported that to gain high production crop of tomato or pepper transplants, fertilizers should be applied 4 to 8 times during the life of a 8-9 weeks [9]. In terms of amount of fertilizer, some evidences from scholars found that the concentration of liquid organic fertilizer of 10 ml / L that mustard plants respond with good growth [15].

In liquid or solid organic fertilizer will affect the vegetative growth of plants by using tea pulp containing 0.32% Nitrogen, and it can increase the production of sweet corn from 939 g / m² to 1116 g / m² [16]. Using the certified organic fruit set and yield increase from 15 to 74% by the organic fertilizer in comparison to the conventional synthetic nutrients for melon plants grown [17].

Substance content has effect for both growing and transporting nutrients positively or negatively for the whole plant. Fahmi (2011) states that the Nitrogen content of organic fertilizer if it is excessive can react negatively to other nutrients such as potassium and silicon, and it affects the transport of photosynthesis to plants [18]. Moreover, the results of lettuce study showed that treatments significantly affected the growth and chemical characteristics of lettuce. The best results in regard to plant growth and yield were obtained from 100 and 150 kg kg/ha nitrogen dozes of the combination of fish manure and commercial fertilizer [19].

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area and dry weight, net assimilation rate can be measured properly.

Comparing the weight of dry matter and leaf area of only one was fertilizer by LOF (XBII,11). It part was, most of growing shoot on stem were at plants that fertilizer by SOF (ZTI,20, ZBI,20, ZTII,19). The interesting part was, most of growing shoot on stem were at plants that fertilizer by SOF (ZTI,17,18, ZBI,20), only one was fertilizer by LOF (XBII,11). It is possible the concentration of nutrients in SOF more than in LOF, as representing in Table 1. It is because of consisting of clay in SOF.

Table 2 shows also the direct measurement of plants growth base on leaf length and width and plants height. The amount of a given nutrient affected to the growth in Table 1. From the presentation growth, each plant was growing depend on each condition. Leaf length growth was from 3.5 to 25%, the young leaf was growing faster than the older one. The trend was happened as well as to leaf width growth and plant height. Each plant has adjusting capacity with their ecology condition surround. The interesting part was, most of growing shoot on stem were at plants that fertilizer by SOF (ZTI,17,18, ZBI,20), only one was fertilizer by LOF (XBII,11). It is possible the concentration of nutrients in SOF more than in LOF, as representing in Table 1. It is because of consisting of clay in SOF.

Table 3 shows the measurement data of leaf growth rate according to Leopold and Kriederman by comparing the weight of dry matter and leaf area of plants from one time to another. By observing leaf area and dry weight, net assimilation rate can be measured properly.

### Table 2. Measurement data according to the three factor split plot

| No. | Code | Leaf Length (Cm) | Leaf width (Cm) | Plant Height (Cm) | Other Remarks |
|-----|------|------------------|-----------------|-------------------|--------------|
|     |      | W2 | W4 | % | W2 | W4 | % | W2 | W4 | % | W2=week 2,W4=week4 |
| 1   | XTI  | 2.2 | 2.5 | 12 | 0.35 | 0.4 | 12.5 | 53.9 | 54.2 | 0.6 |
| 2   | XTI  | 3.3 | 3.6 | 8.3 | 0.54 | 0.59 | 8.5 | 66.7 | 68 | 1.9 |
| 3   | XTI  | 1.9 | 2.2 | 13.6 | 0.28 | 0.33 | 15.2 | 66.9 | 67.1 | 0.3 |
| 4   | XTI  | 1.6 | 1.9 | 15.8 | 0.27 | 0.32 | 15.6 | 67.1 | 69.4 | 3.3 |
| 5   | XTI  | 0.9 | 1.2 | 25 | 0.43 | 0.48 | 10.4 | 53.8 | 58.2 | 7.6 |
| 6   | XTI  | 2.8 | 3.1 | 9.7 | 0.47 | 0.52 | 9.6 | 80.4 | 80.9 | 0.6 |
| 7   | XBI  | 3.2 | 3.5 | 8.6 | 0.95 | 1 | 5.0 | 66.3 | 71.1 | 6.8 |
| 8   | XBI  | 1.9 | 2.2 | 13.6 | 0.65 | 0.7 | 7.1 | 55.2 | 57.3 | 3.7 |
| 9   | XBI  | 2.2 | 2.5 | 12 | 0.42 | 0.47 | 10.6 | 59.8 | 62.6 | 4.5 |
| 10  | XBI  | 1.8 | 2.1 | 14.3 | 0.48 | 0.53 | 9.4 | 86.6 | 88.7 | 2.4 |
| 11  | XBI  | 1.3 | 1.6 | 18.8 | 0.25 | 0.3 | 16.7 | 84.4 | 85.2 | 0.9 |
| 12  | XBI  | 2.6 | 2.9 | 10.3 | 1.25 | 1.3 | 3.8 | 65.9 | 69.7 | 5.5 |
| 13  | ZTI  | 4.5 | 4.8 | 6.3 | 1.14 | 1.19 | 4.2 | 67.1 | 67.8 | 1.0 |
| 14  | ZTI  | 6.7 | 7 | 4.3 | 2.78 | 2.83 | 1.8 | 75.2 | 78.8 | 4.6 |
| 15  | ZTI  | 2.2 | 2.5 | 12 | 0.55 | 0.6 | 8.3 | 55.4 | 57.7 | 4.0 |
| 16  | ZTI  | 1.6 | 1.9 | 15.8 | 0.44 | 0.49 | 10.2 | 69.4 | 72.6 | 4.4 |
| 17  | ZTI  | 1.3 | 1.6 | 18.8 | 0.34 | 0.39 | 12.8 | 55.3 | 56.9 | 2.8 |
| 18  | ZTI  | 8.2 | 8.5 | 3.5 | 2.75 | 2.8 | 1.8 | 84.2 | 85.6 | 1.6 |
| 19  | ZTI  | 4.8 | 5.1 | 5.9 | 1.18 | 1.23 | 4.1 | 56.4 | 57.1 | 1.2 |
| 20  | ZTI  | 2.9 | 3.2 | 9.4 | 0.14 | 0.19 | 26.3 | 88.9 | 89.6 | 0.8 |
| 21  | ZTI  | 1.6 | 1.9 | 15.8 | 0.25 | 0.3 | 16.7 | 61.2 | 61.6 | 0.6 |
| 22  | ZTI  | 4.4 | 4.7 | 6.4 | 0.81 | 0.86 | 5.8 | 80.9 | 82.6 | 2.1 |
| 23  | ZTI  | 1.8 | 2.1 | 14.3 | 0.31 | 0.36 | 13.9 | 80.6 | 81.2 | 0.7 |
| 24  | ZTI  | 4.4 | 4.7 | 6.4 | 1.52 | 1.57 | 3.2 | 66.6 | 68.9 | 3.3 |

Note: X=LOF, Z=SOF, B=Jackfruit-Beka, T=Jackfruit-Tulo, I= small Polybag, and II=big polybag.
Plant growth analysis is used to obtain quantitative measurements in following and comparing crop growth such as Area of Leaf (A), Area of Soil (S), Leaf Area Index (LAI), Crop Growth Rate (CGR), Net Assimilation Rate (NAR), Leaf Area Ratio (LAR), and Relative Growth Rate (RGR) [20]. The values obtained that LAI ranging from 0.30-7.37 cm / day, CGR 0.29-1.30 cm2 / day, LTR ranging from 0.55-1.49 g / g / day, LAN is around 0.095 -0607 g / cm2 / day, and the NLD ranges from 0.58 to 0.75 cm2 / g. The RGR value is in medium growth range. These values are similar to measurements as a standard by Yao et al. [13]. Generally, all of application organic fertilizer will be increase growing of any plant because of nutrient content in it. [21-24].

4. Conclusion
It can be concluded that the application of LOF and SOF from fermentation of Tilapia fish waste have a good effect in growing plant of Jackfruit Tulo and Beka with a certain given amount that can apply in every month. Based on measurement of leaf wide and length, the plant growths were increases. It has been proven as well by measurement of several parameters of crops growth as ILD, LAN, NLD and LTR that the growth of Jackfruit Beka and Tulo have in medium growth range. The results showed that required N, P, and K accumulation in the plant biomass for 1 t grain yield was 23.1, 3.5, and 28.5 kg, respectively. Suggesting by Ji et al said," the successful application of liquid organic fertilizers in our study suggested a rational way to reuse agricultural wastes and was effective in sustaining plant growth and the health of the soil system" [25].

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**Table 3. Measurement of leaf growth rate**

| Jackfruit Type | Leaf length (cm) | Leaf width (cm) | dry weigh (g) | A Cm² | LAI Cm²/day | CGR Cm²/day | NAR g/g/day | RGR g/g |
|----------------|------------------|-----------------|--------------|-------|-------------|-------------|-------------|--------|
| Beka           | 0.36             | 7               | 3.3          | 0.07  | 15.5        | 0.35        | 20.0        | 0.71   | 14.29  |
|                | 0.44             | 9.1             | 3.9          | 0.12  | 23.8        | 0.54        | 14.29       | 0.58   | 8.33   |
|                | 0.48             | 10.3            | 4            | 0.13  | 27.7        | 0.63        | 12.5        | 0.62   | 7.69   |
| Tulo           | 0.28             | 5.2             | 2.4          | 0.05  | 8.4         | 0.19        | 33.33       | 0.60   | 20.0   |
|                | 0.29             | 6.8             | 2.7          | 0.07  | 12.3        | 0.28        | 20.0        | 0.71   | 14.29  |
|                | 0.36             | 8.2             | 3.6          | 0.08  | 19.8        | 0.45        | 16.67       | 0.75   | 12.5   |
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