The effectiveness of liquid organic fertilizer (LOF) Bio M2 on the growth and production of corn (Zea mays L.)

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Abstract. The organic fertilizers have more advantages to improve the quality of land. One of the organic fertilizers products is Liquid Organic Fertilizer (LOF) BIO M2. It can be used in food crops. However, the effectiveness test must be carried out for LOF so that it can be developed. The objective of this study is to examine the effectiveness of Liquid Organic Fertilizer (LOF) beside inorganic fertilizer on the growth and production of corn. The research was conducted in Bone, South Sulawesi, on August-December 2017. The experimental design used completely randomized design that consist of nine treatments which were the level of LOF combined dosage of inorganic fertilizer and replicated three times, so there were 27 experiment plots. The results of the study indicate that the use of organic fertilizer can improve land quality by increasing several elements in the soil and the shell of corn was highest in the treatment of LOF 100% and its recommended fertilizer 75%, for 7.17 tons/ha with RAE 233.33 %.

1. Introduction
Corn is an important food crop because it is the second source of carbohydrates after rice. As one source of food, corn has become the main commodity after rice. In some regions in Indonesia, corn is used as the main foodstuffs. Not only as food, corn is also known as one of the animal feed and industry.

Lately, market demands for corn was increase, but the high demand is not compensated with availability so this demand being unfulfilled. Thus, the efforts to improve the quality and quantity also to maintain environmental sustainability is a necessity [12]. Agricultural businesses using chemicals such as inorganic fertilizers and chemical pesticides that have been carried out in the past and continue to the present. They have a lot of negative effects, not only for humans but also for the environment and all living things. Another negative effects of the contamination of agricultural products by chemicals is adversely affecting for our health [7].

On the other hand, fertilization serves to add nutrients needed for plant growth and development to maintain the availability of nutrients for plants. In order for plants to absorb nutrients and grow properly, fertilization must pay attention for dosage, method, time and place. Using fertilizer for plants is generally done through the soil. This method become the most popular because it is more practical and able to save the time and energy. Using nutrients through the soil while the soil conditions was very low pH will not help much the availability of plant nutrients, because some elements can be fixed in the soil [4].
In addition, the weaknesses of fertilizer application through soil are easy to wash, evaporate, immobilize, compaction of soil, and the occurrence of nutrient extraction with other plant roots. The waste of energy is used which transfers nutrients absorbed by the roots that cooked on the leaves. Another impact that is no less important is that it can cause physical damage to the soil due to continuous and in excessive doses of inorganic fertilizer. If there is no effort to overcome this, it is feared that the plant nutrient no needs to fulfil [10].

For this reason, fertilizer application is needed which combines fertilizing through the soil and the leaves. Fertilization through leaves can provide nutrients for plants by entering directly into plants, so that the availability of nutrients for plants can be guaranteed. Nutrient absorption given through the leaves run faster, because nutrients enter through the stomata and enter the plant cells directly so that they can be directly utilized by plants. Thus the energy for translocation of nutrients from roots to leaves can be used for plant metabolism. Besides fertilizing through the leaves can reduce damage to the soil as well as when fertilizing through the soil.

One of the liquid organic fertilizers derived from animal manure or bio urine is BIO M2, but its effectiveness is unknown. For this reason, to study and to determine the effectiveness of the fertilizer, especially for corn. Considering that the number of alternative fertilizers in circulation (both registered and unregistered) is large, it is necessary to test the effectiveness. Before it is widely applied, it is required to determine the fertilizer content and the ability to increase farmers' production and income.

Based on this, the effectiveness of liquid organic fertilizer (LOF) BIO M2 was tested on the growth and the yield of corn for effort to use organic fertilizer widely. The objective of this study is to determine the effectiveness of the Liquid Organic Fertilizer (LOF) BIO M2 combined with inorganic fertilizer on the growth and production of corn.

2. Materials and Methods
The research was conducted for the experimental site in Bone, South Sulawesi. The study was done from August until December 2017. The land for this study was in the Ultisol soil type. Soil analysis was held at Laboratory ofAIAT South Sulawesi (BPTP). The materials in this research are corn cultivar Bima-19, LOF BIO M2, Urea, SP-36, KCl, pesticides, and insecticide. The experimental design completely randomized block design that consists of nine treatments: level of LOF BIO M2 combined dosage of inorganic fertilizer. Each treatment was replicated three times, so there were 27 experiment plots and each plot sizes 3 m x 4 m. The treatment arrangement is showed in Table 1.

Seed planting was done with the spacing of 70 x 20 cm. The urea fertilizer was applied on 7 and 30 day after planting (DAP) according to the treatment while SP-36 and KCl were applied once at 7 DAP. Additional BIO M2 was applied at 9 and 28 DAP. It drained from the root to the organic fertilizer treatment plot. Weeding was removed manually. The soil was analyzed before corn planting. The analysis included soil pH data, N-total, P-available, K-total, K-add, and C-organic. Measurement of soil pH using pH meter, N-total using Kjeldahl, P-available and K-dd method using Olsen, and C-organic using Spectrophotometer.

Parameters observed in this research were plant height and number of leaves aged 2, 3, 4, 5, and 6 weeks after planting, length of cob, diameter of cob, weight of cob, weight of 100 grain dry seeds, weight dry per plant, shelled corn, and RAE. Data were analyzed by analysis of variance (ANOVA) to compare the effect of the treatments. If there was a significant difference, the Highest Significant Difference (HSD) test 5 % would be conducted. This test is used to determine the difference between each treatment that is tried. Next to compare the effectiveness of agronomy LOF BIO M2 was determined by the relative agronomic effectiveness (RAE) method of each standard fertilizer (recommendation) [5].
Table 1. Treatment of giving LOF BIO M2 and its combination with inorganic fertilizer at corn in Bone, South Sulawesi, 2017

| No. | Treatment | Urea (kg ha⁻¹) | SP-36 (kg ha⁻¹) | KCl (kg ha⁻¹) | POC BIO M2 (ml ha⁻¹) |
|-----|-----------|----------------|-----------------|---------------|----------------------|
| 1.  | P1= No fertilization (control) | 0 | 0 | 0 | 0 |
| 2.  | P2= Based on 100% recommendation (Urea+SP-36+KCl) | 300 | 100 | 75 | 0 |
| 3.  | P3= 100% recommendation + 100% POC BIO M2 | 300 | 100 | 75 | 3000 |
| 4.  | P4= 75% recommendation | 200 | 75 | 56.25 | 0 |
| 5.  | P5= 75% recommendation + 100% POC BIO M2 | 200 | 75 | 56.25 | 3000 |
| 6.  | P6= 75% recommendation + 75% POC BIO M2 | 200 | 75 | 56.25 | 2000 |
| 7.  | P7= 75% recommendation + 75% POC BIO M2 | 200 | 75 | 56.25 | 4500 |
| 8.  | P8= 100% recommendation + 75% POC BIO M2 | 300 | 100 | 75 | 2000 |
| 9.  | P9= 100% recommendation + 150% POC BIO M2 | 300 | 100 | 75 | 4500 |

3. Results and Discussion

3.1. Soil Chemical Analysis

The results of soil analysis based on the criteria for assessing the chemical and physical properties of Ultisol soil from Bone, South Sulawesi can be categorized as acid soil, because it has a low pH (H₂O) of 4.30 and KCl 3.90, Organic C is low at 1.49, low N-total is 0.15, low P-total and K-total is very low. Based on the results of initial soil analysis showed that fertilization needs to be done to improve soil fertility. The results of soil analysis can be seen in Table 2.

Table 2. Land characteristics of Bone, 2017

| Parameter                      | Determination | Result | Criteria |
|-------------------------------|---------------|--------|----------|
| Soil Characteristics          |               |        |          |
| pH (H₂O)                      |               | 4.30   | acid     |
| pH (KCl)                      |               | 3.90   |          |
| C-organic (%)                 |               | 1.49   | low      |
| N-total (%)                   |               | 0.15   | low      |
| C/N (%)                       |               | 13     |          |
| Chemical properties of soil   |               |        |          |
| P-Bray (ppm)                  |               | 16     | low      |
| K-Bray (ppm)                  |               | 2.05   | very low |
| Ca (me/100 g)                 |               | 6.07   | low      |
| Mg (me/100 g)                 |               | 0.81   | low      |
| K (me/100 g)                  |               | 0.05   | very low |
| Na (me/100 g)                 |               | 8.11   | high     |
| KTK                           |               | 27.72  | high     |
| KB                            |               | 23     | low      |
| physical properties of soil   |               |        |          |
| sand (%)                      |               | 53     |          |
| dust (%)                      |               | 26     |          |
| see (%)                       |               | 30     |          |

Note: Soil samples are analyzed in the Soil laboratory, AIAT South Sulawesi
3.2. Soil Condition after Assessment

The results of the soil analysis after the assessment showed that the application of liquid organic fertilizer increased soil pH. The increase in pH is due to the addition of OH- or organic cations from the decomposition of organic matter resulting in the release of H+ and OH-. According to Patola [8] that if a lot of cations are absorbed by the root (NH4+), a lot of H+ ions will come out from the roots into the soil so that the soil becomes more acidic. If a lot of anions are absorbed by the root (NO3-), then a lot of HCO3- is released by the root into the soil so that the soil becomes more alkaline. The application of organic fertilizer into the soil can stimulate the activity of soil and microbial enzymes, the activity of total soil enzymes depends on extracellular enzymes and the amount of enzymes in dead and living microbial cells [13].

The addition of organic fertilizer can increase the content of C-organic, total N, P, and K, although it does not change the content status of these elements. Although the soil P and K values have not changed, the availability of P and K elements increase with the treatment of organic fertilizer. The increase in element K is thought to be due to the decomposition of organic matter which produces organic acids and nutrients such as fulvic acid and humic acid. According to Wu, et al [18] the presence of humic acid and fulvic acid in the soil accelerates the release of K+ ions which are bound between mineral lattices. The increase in element P with the treatment of organic fertilizer caused by the nature of the element P from organic fertilizer is easily available than the element P from inorganic fertilizer.

Table 3. Soil Nutrient Content After Assessment

| Parameter         | Treatment | Initial | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 |
|-------------------|-----------|---------|----|----|----|----|----|----|----|----|----|
| pH                | 4.30      | 4.30\(a\) | 4.51\(d\) | 5.50\(e\) | 4.29\(a\) | 5.75\(d\) | 5.10\(c\) | 4.97\(b\) | 5.15\(c\) | 5.71\(d\) |
| C Organik (%)     | 1.39      | 1.39\(a\) | 1.70\(b\) | 2.54\(d\) | 1.53\(a\) | 2.53\(d\) | 2.10\(c\) | 2.09\(c\) | 1.72\(b\) | 2.00\(c\) |
| N Total (%)       | 0.15      | 0.15\(ns\) | 0.17 | 0.20 | 0.15 | 0.20 | 0.21 | 0.18 | 0.17 | 0.19 |
| P Bray-1 (ppm)    | 16        | 16\(a\) | 19\(b\) | 20\(e\) | 17\(a\) | 21\(c\) | 20\(d\) | 19\(b\) | 18\(b\) | 21\(c\) |
| K (me/100 gram)   | 2.05      | 2.05\(a\) | 2.35\(b\) | 2.78\(c\) | 2.11\(a\) | 3.20\(d\) | 2.89\(c\) | 2.80\(c\) | 2.31\(b\) | 3.11\(d\) |

Remarks: Numbers followed by different letters in each column are significantly different at \(p = 0.05\)

P1 = without fertilizer as control
P2 = Based on 100% recommendation (Urea+SP-36+KCl)
P3=100% recommendation + 100% POC BIO M2
P4=75% recommendation
P5=75% recommendation + 100% POC BIO M2
P6=75% recommendation + 75% POC BIO M2
P7=75% recommendation + 150% POC BIO M2
P8=100% recommendation + 75% POC BIO M2
P9=100% recommendation + 150% POC BIO M2

From Table 3 it can be seen that the results of the analysis of soil nutrient content after the assessment are the pH, total N, organic C, P, and K of the soil increased after application of all treatments except in the treatment of fertilizer recommendation of 75% which decreased the pH value even though C-organic, P, and K also increased. The results of the final soil analysis showed that the application of organic fertilizers produced higher pH, total N, organic C, P, and K values compared to fertilizer treatment based on recommendations.

The assessment has a significant effect on soil pH, organic C, P and K content, and has no significant effect on the total N content of the soil for each treatment. The highest pH increase was obtained in the treatment of 75% + 100% recommendation of liquid organic fertilizer BIO M4 and significantly different from other treatments. Likewise, the highest increase in C-organic content was obtained in the treatment of fertilizer recommendation 75% + 100% liquid organic fertilizer BIO M4,
the highest increase in total N content was obtained in the treatment of fertilizer recommendation 75% + 75% liquid organic fertilizer BIO M4, P and the highest K was obtained for each treatment giving 75% recommended fertilizer + 100% liquid organic fertilizer BIO M4 and recommended fertilizer 75% + 75% liquid organic fertilizer BIO M4.

The pH, C-Organic, total N, P, and K values at the end of the experiment increased. Difference in soil pH enhancement ranged from 0.21 to 1.45, total N ranged between 0.02-0.06%, organic C ranged from 0.7-0.61%, P ranged from 1-5 ppm, and K increases ranged from 0,3-1,15 me /100g (Table 4). These results are in line with the research of [3] where P solvent microbial inoculation significantly affected soil P availability and uptake of P. Wu et al [20] added that the use of biological fertilizers not only increased nutrient levels in plants such as N, P and K, but also increases the content of organic compounds and total N in the soil. The application of biological fertilizer in compost can increase the total N content, soil P and soil K except Ca and Mg contents.

### Table 4. Difference in Soil Nutrient Content at the Beginning and End of Experiment

| Treatment | pH (H2O) | C-Organik (%) | N-Total (%) | P Bray I (ppm) | K (me/100 g) |
|-----------|----------|---------------|-------------|----------------|--------------|
| PI(without fertilizer) | 0 | 0 | 0 | 0 | 0 |
| P2(100% recommendation) | 0,21 (+) | 0,31 (+) | 0,02 (+) | 3 (+) | 0,3 (+) |
| P3(100% recommendation+100% LOF BIO M2) | 1,2 (+) | 1,15 (+) | 0,05 (+) | 4 (+) | 0,73 (+) |
| P4(75% recommendation) | -0,01 (-) | 0,14 (+) | 0 | 1 (+) | 0,06 (+) |
| P5(75% recommendation+100% LOF BIO M2) | 1,45 (+) | 1,14 (+) | 0,05 (+) | 5 (+) | 1,15 (+) |
| P6(75% recommendation+75% LOF BIO M2) | 0,8 (+) | 0,71 (+) | 0,06 (+) | 4 (+) | 0,84 (+) |
| P7(75% recommendation+150% LOF BIO M2) | 0,67 (+) | 0,7 (+) | 0,03 (+) | 3 (+) | 0,75 (+) |
| P8(100% recommendation+75% LOF BIO M2) | 0,85 (+) | 0,33 (+) | 0,02 (+) | 2 (+) | 0,26 (+) |
| P9(100% recommendation+150% LOF BIO M2) | 1,41 (+) | 0,61 (+) | 0,04 (+) | 5 (+) | 1,06 (+) |

(-) : Reduction of nutrient content
(+): Adds nutrients

### 3.3. Plant Growth and Yield

Plant growth is one of indicator in recognizing much far about the characteristic of plant and plant height, the number of leaves are growth factors that are used as parameters in the effectiveness test of inorganic fertilizer treatment and LOF BIO M2 at various doses. Observation of plant height is measured from the ground surface until it reaches the highest leaf top [14]. From the results of the analysis of the influence of inorganic fertilizers combined with LOF BIO M2 on plant height and number of leaves can be seen in Figures 1 and 2.

The results showed that in general fertilization treatments did not significantly affect the vegetative growth (plant height and number of leaves of corn). In Figure 1 shows that plant growth has not shown a significant difference, it is suspected that this because until age 6 weeks after planting, the plant needs is still relatively low and plants still enough to make organic element of the soil, so the addition of LOF BIO M2 combined with inorganic fertilizers at various doses have not had an impact or influence on plant growth. Likewise with Figure 2, with the number of leaves at 2,3,4, and 5 weeks after plant also have not shown significant differences, then 6 weeks after plant there was significant differences. It is suspected that it caused by the nutrient contained in macro and micro LOF BIO M2 and inorganic fertilizer can be used by the plant to forming leaves. The treatment of 75%
recommendation + 100% LOF BIO M2, tend to have the highest plant height and number of leaves. According to [1], plant growth is a combination of genetic content and its environment, so that a low response to the environment can reduce growth, consequently the plant grows low.

Figure 1. Effect of fertilization on corn plant height: A (◊) without fertilization, B (□) 100% recommendation, C (△) 100% recommendation + 100% POC BIO M2, D (X) 75% recommendation, E (+) 75% recommendation + 100% POC BIO M2, F (●) 75% recommendation + 75% POC BIO M2, G (_inactive) 75% Recommendation + 150% POC BIO M2, H (-) 100% Recommendation + 75% POC BIO M2, I (¥) 100% Recommended + 150% POC BIO M2.

Figure 2. Effect of fertilization on the number of leaves: A (◊) without fertilization, B (□) 100% recommendation, C (△) 100% recommendation + 100% POC BIO M2, D (X) 75% recommendation, E (+) 75% recommendation + 100% POC BIO M2, F (●) 75% recommendation + 75% POC BIO M2, G (inactive) 75% Recommendation + 150% POC BIO M2, H (-) 100% Recommendation + 75% POC BIO M2, I (¥) 100% Recommended + 150% POC BIO M2.
Various combinations of inorganic fertilizer with LOF BIO M2 have significant differences on the length of cob, diameter of cob, and weight of cob. This shows that corn responds differently to different combinations of inorganic fertilizer with LOF BIO M2. The results showed that the combination of inorganic fertilizer + LOF BIO M2 significantly increased the production of corn including the cob length, diameter of the cob, and cob weight (Table 3). The highest length of cob was obtained in treatment 75% of recommendations combined with 100% LOF BIO M2 fertilizer, which is 5.8 gr. Likewise, the diameter and weight of cobs, the treatment which is the 75% recommendation combined with the 100% LOF BIO M2 fertilizer, give the highest yield compared to other treatments. In the table, it showed that all treatments for LOF BIO M2 combined with inorganic fertilizers obtained higher yields than treatments that were not given LOF BIO M2 or fertilizer based on recommendations. These nutrients play a big role in the growth and yield of plants. This can be known from the function of each of these nutrients. Micro nutrients function as enzyme activator systems or in the process of plant growth, such as photosynthesis and respiration.

Organic fertilizer provides nutrients in a form that is not available to plants, besides organic fertilizers contain more organic matter than nutrients [15]. Giving 75% recommendation combined with 100% LOF BIO M2 get the best results, allegedly because the element N contained in biourine (BIO M2) with different inorganic fertilizers, and at that dose can meet the needs of plants. [9] added that the excess of liquid biourine fertilizer is able to provide nutrients for plants without damaging nutrients in the soil and more easily absorbed by plants. [8] stated that biourine is beneficial because it does not damage the soil and plants even if used as often as possible. In addition, biourine has a binding material, so that fertilizer solutions that are given to the soil surface can be directly used by plants.

### Table 5. Length, diameter, and weight of cob as a result of using various combination inorganic fertilizer with LOF BIO M2

| Combination inorganic fertilizer with LOF BIO M2 | Length of Cob (cm) | Diameter of Cob (mm) | Weight of Cob (g) |
|------------------------------------------------|-------------------|---------------------|------------------|
| P1(without fertilizer)                          | 13,00 a           | 40,00 a             | 4,02 a           |
| P2(100% recommendation)                         | 15,53 ab          | 43,26 c             | 4,32 b           |
| P3(100% recommendation+100% LOF BIO M2)        | 16,07 b           | 43,92 c             | 5,10 c           |
| P4(75% recommendation)                         | 14,70 a           | 44,16 d             | 4,11 b           |
| P5(75% recommendation+100% LOF BIO M2)         | 17,27 c           | 45,79e              | 5,54 c           |
| P6(75% recommendation+75% LOF BIO M2)          | 17,53 c           | 44,29 d             | 4,32 b           |
| P7(75% recommendation+150% LOF BIO M2)         | 15,43 ab          | 45,01e              | 5,09 c           |
| P8(100% recommendation+75% LOF BIO M2)         | 16,54 b           | 44,31 d             | 5,13 c           |
| P9(100% recommendation+150% LOF BIO M2)        | 16,11 b           | 42,51 b             | 4,75 bc          |

Remarks: Numbers followed by different letters in each column are significantly different at p = 0.05

At Table 6 showed that fertilizer treatment significantly affected weight of 100 grains dry seed, dry seed weight per plant, and grain yield. The highest weight of 100 grains dry seed, dry seed weight per plant, and the shelled corn obtained on the treatment of 75% recommendation fertilizer combined with 100% LOF BIO M2, as well as the highest shelled corn obtained in the treatment. This is in line with research [21] which states that the application of chemical fertilizers with organic fertilizers can significantly increase soybean production (weight of 100 grains and crop yields per hectare).
Table 6. Weight of 100 grain dry seed, dry seed weight per plant, and shelled corn as a result of using various combination inorganic fertilizer with LOF BIO M2

| Combination inorganic fertilizer with LOF BIO M2 | Weight of 100 grain dry seed (g) | Dry seed weight per plant (g) | Grain yield (t ha\(^{-1}\)) | RAE (%) |
|-----------------------------------------------|---------------------------------|-------------------------------|-----------------------------|--------|
| P1(without fertilizer)                        | 31.36 a                         | 162.51 a                      | 3.81a                       | -      |
| P2(100% recommendation)                       | 33.12b                         | 162.98 ab                     | 5.25 b                      | 100    |
| P3(100% recommendation+100% LOF BIO M2)       | 33.61 b                         | 162.78 ab                     | 4.60 ab                     | 54.86  |
| P4(75% recommendation)                        | 32.89ab                        | 162.52 a                      | 4.29 ab                     | 33.33  |
| P5(75% recommendation+100% LOF BIO M2)        | 35.02 c                         | 164.32 c                      | 7.17 c                      | 233.33 |
| P6(75% recommendation+75% LOF BIO M2)         | 33.90 b                         | 163.20 b                      | 5.25 bc                     | 100    |
| P7(75% recommendation+150% LOF BIO M2)        | 33.21 b                         | 163.54 b                      | 4.46 ab                     | 45.14  |
| P8(100% recommendation+75% LOF BIO M2)        | 33.30 b                         | 164.07 bc                     | 5.27 b                      | 101.39 |
| P9(100% recommendation+150% LOF BIO M2)       | 34.38 bc                        | 162.93 ab                     | 5.28 b                      | 102.08 |

Remarks: Numbers followed by different letters in each column are significantly different at \(p = 0.05\)

By looking at the results of these combinations, it can be said that the LOF BIO M2 fertilizer can substitute the use of inorganic fertilizers. High yields obtained LOF BIO M2 which given with various levels are thought to be caused because the fertilizer has a process of absorption rate that can be directly absorbed by plants after it is given [6]. The development of better corn results was suspected because the provision of nutrients has been available in optimal and balanced amounts so that the provision of inorganic fertilizers at a dosage of 75% recommendation combined with PO BIO M2 100% was able to provide a balance between macro and micro nutrients in plants. Plants will not give maximum results if the required nutrients are not available [11]. Meanwhile, according to [2], fertilization can increase growth and yields both qualitatively and quantitatively.

RAE calculation is carried out on the yield of shelled corn to see the effect of fertilization on corn production. The effect of applying inorganic fertilizer combined with LOF BIO M2 organic fertilizer shows an RAE value greater than the recommended fertilizer. It showed that the addition of LOF BIO M2 resulted in higher effectiveness than the use of fertilizer recommendations alone in producing corn production, which is indicated by the highest RAE value (233.33%), namely in the treatment of giving the provision of inorganic fertilizer 75% of the recommendations combined with giving 100% LOF BIO M2.

4. Conclusion
1. The Application of organic fertilizer combined with LOF BIO M2 can increase corn growth and shelled corn by 50%.
2. The highest yield of shelled corn is obtained in the treatment of giving 75% fertilizer based on recommendation + 100% LOF BIO M2 which is 7.17 t ha\(^{-1}\)
3. LOF BIO M2 fertilizer with a dose of 100% combined with inorganic fertilizers based on recommendations about 75% has the highest RAE value of 233.33% compared to other treatments.
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