INTRODUCTION

Soybean (Glycine max (L.) Merill) is the third most important food crop after rice and corn (Wahyudin, 2017). Soybeans contain protein and other nutrients that are very important for the body and are raw materials for the industry for making tempeh, tofu, soy sauce, soy milk and various other preparations that are very popular with the community for nutritional improvement and the price is also relatively cheap (Rohman & Saputro, 2016; Mapegau, 2006). Thus, soybeans will always be sought after by the public and the need will always increase.

Indonesian soybean production fluctuated from 2014 to 2018, namely 955,000 tons, 963,000 tons, 860,000 tons, 539,000 tons, and 983,000 tons (Kementrian Pertanian, 2018). Indonesian soybean production has not been able to meet the needs, as evidenced by the existence of soybean imports from year to year. Soybean imports from 2014 to 2018 amounted to 1.965.811 tons, 2.256.932 tons, 2.261.803 tons, 2.671.914 tons and 2.585.809 tons (Badan Pusat Statistik, 2018).

One of the efforts that can be made to increase soybean crop production is land intensification and extensification. Intensification is an improvement in the cultivation system that can be carried out using organic fertilizers and biological fertilizers, while the extensification is carried out which is to utilize land that has low fertility such as Ultisol soil.

Ultisols are a soil order that is less fertile and has many limitations on its physical, chemical, and biological properties. Efforts that can be made include the use of liquid organic fertilizer (LOF) and arbuscular mycorrhizal fungi (AMF). This research was conducted from February to May 2020, in Beringin Raya, Muara Bangka Hulu District, Bengkulu City with an altitude of + 10 m above sea level. The purpose of this study was to explain the growth and yield of soybeans due to the application of liquid organic fertilizers and arbuscular mycorrhizal fungi in Ultisols. The research design used was a randomized complete block design (RCBD) with 2 factors with three replications. The first factor is the LOF dose which consists of four levels, namely: 0, 20, 40, and 60 mL L\(^{-1}\). The second factor is the AMF dose with three levels, namely: 0, 5, and 10 g plant\(^{-1}\). The results showed that there was no interaction between LOF and AMF. Giving a LOF concentration of 60 mL L\(^{-1}\) gave the highest yield on the growth and yield of soybeans, as well as the optimum concentration for seed/plant weight, which was 28.114 mL L\(^{-1}\), and the number of seeds was 37.589 mL L\(^{-1}\). AMF dosage of 10 g plant\(^{-1}\) gave the best growth and yield of soybean plants.

**Keywords**: soybean, Ultisol, liquid organic fertilizer, arbuscular mycorrhizal fungi
fertilizers because they contain nutrients in the form of a solution so that they are absorbed more easily and quickly by plants (Pasdori, 2014).

Liquid organic fertilizer (LOF) is a type of organic fertilizer that contains organic matter and essential macro and micronutrients (Taufika, 2011). Thus the use of LOF will be needed to improve soil properties. The results of the research by Tamba et al. (2017), showed that giving a POC dose of 40 mL L⁻¹ could increase the number of productive branches and the number of filled pods in soybeans. The application of organic fertilizers containing N, P, K can also increase and improve growth in the vegetative phase of plants (Sari et al., 2013).

Arbuscular mycorrhizal fungi (AMF) is a symbiotic microorganism and fungus that has mutually beneficial properties between the host plant and the fungus (Kuswandi & Sugiyato, 2015). Thus, the use of AMF can make high-yielding plants on land with low fertility such as ultisols. AMF can play a role in plant growth, namely, it can increase P elements and other elements in the soil, improve soil aggregation, protect plants from infection with root pathogens, increase drought resistance, increase soil microbes, and be used for remediating contaminated soil.

AMF has hyphae that can accelerate the movement of phosphorus into plant roots, and are able to expand the nutrient uptake area in the soil (Hasanudin & Murcitro, 2004). Thus an increase in the availability of P in the soil will be followed by an increase in AMF provision. According to Malik et al. (2017), administering arbuscular mycorrhizal fungi (AMF) can increase soybean production on ultisol soils. According to the research results of Oktaviani et al. (2014), the provision of AMF biological fertilizer at a dose of 20 g plant⁻¹ and a consortium of microbes at a dose of 10 g kg⁻¹ of seed were able to increase soybean yield and production. While the research results of Suherman et al., (2012) showed that giving AMF at a dose of 8 g plant⁻¹ could increase growth in plant height, leaf number, and leaf area index and gave the best results on seed plant⁻¹ weight and 1000 soybean seed weight.

**MATERIALS AND METHODS**

This research was conducted from February to May 2020 in the Beringin Raya experimental garden, Muara Bangka Hulu District, Bengkulu City with an altitude of +10 masl.

Randomized Complete Block Design (RCBD) with 2 factors was used in this study. The first factor is the concentration of liquid organic fertilizer (LOF) which consists of 4 levels, namely: P₀: 0 mL L⁻¹, P¹: 20 mL L⁻¹, P₂: 40 mL L⁻¹, and P₃: 60 mL L⁻¹. The second factor was the dose of arbuscular mycorrhizal fungi (AMF) consisting of 3 levels, namely: M₀: 0 g plant⁻¹, M¹: 5 g plant⁻¹, and M₂: 10 g plant⁻¹. From these two factors, 12 treatment combinations were repeated 3 times so that there were 36 experimental units.

The stages carried out in this study were soil analysis, LOF analysis, land preparation, planting, fertilization, AMF application, LOF fertilizer application, sample determination, maintenance, and harvest. The variables observed were plant height (cm), number of leaves (strands), number of branches (branches), flowering age (wap), crown dry weight (g), root dry weight (g), number of pods (pods), number of empty pods (pods), number of seeds (seeds), weight of seeds plant⁻¹ (g), weight of 100 seeds (g), weight of seeds/plot (g), and P content of tissue (%).

Observation data were statistically analyzed using analysis of variance (ANOVA) at 5% level and Orthogonal Polynomial to determine the relationship between independent variables and dependent variables.

**RESULTS AND DISCUSSION**

The results of the analysis of variance showed that there was no interaction between giving LOF and the addition of AMF on the growth and yield of soybean plants. The concentration of LOF had a significant effect on the number of pods, and weight of seeds plot⁻¹, plant height, number of seeds, the weight of seeds plant⁻¹, and tissue P content. The administration of AMF dose significantly affected the number of seeds, and weight of seeds/plot, plant height, and tissue P content (Table 1).

| Variable                      | The source of diversity | LOF | AMF | Interaction |
|-------------------------------|-------------------------|-----|-----|-------------|
| Plant height                  | 13.55                   | 30.24 | * | 2.51 ns     |
| Number of leaves              | 0.42 ns                 | 0.12 ns | 0.40 ns |           |
| Number of branches            | 0.58 ns                 | 1.73 ns | 0.72 ns |           |
| Flowering age                 | 0.93 ns                 | 1.32 ns | 0.93 ns |           |
| Crown dry weight              | 0.53 ns                 | 0.22 ns | 0.43 ns |           |
| Root dry weight               | 0.58 ns                 | 0.24 ns | 0.50 ns |           |
| Number of pods                | 3.16 *                  | 1.15 ns | 1.41 ns |           |
| Number of empty pods          | 0.67 ns                 | 0.74 ns | 0.41 ns |           |
| Number of seeds               | 6.98 *                  | 5.71 ns | 2.33 ns |           |
| Weight seeds plant⁻¹          | 7.85 *                  | 0.83 ns | 1.66 ns |           |
| Weight of 100 seeds           | 0.29 ns                 | 1.27 ns | 1.92 ns |           |
| Weight seeds plot⁻¹           | 3.23 *                  | 3.62 * | 0.54 ns |           |
| Tissue P content              | 10.11 *                 | 7.63 * | 1.23 ns |           |

* significant at 5% level (P≤0.050) ; ns non significant (P>0.050)

The relationship between LOF concentration and soybean plant height forms a positive linear curve pattern,
Growth and Yield of Soybean

with the coefficient of determination ($R^2$) of 0.7331 or can be explained as 73.31%. Each addition of 1 mL L$^{-1}$ LOF will increase the height of soybean plants by an average of 0.1095 cm (Figure 1).

This is by the statement of Sampurno et al. (2016) which states that giving LOF with a concentration of 60 mL L$^{-1}$ tends to increase plant height compared to other treatments. Research results by Saputra et al. (2020) showed that increasing the concentration of LOF to 100 mL L$^{-1}$ tends to increase the fresh weight and dry weight of cat whiskers.

The addition of LOF concentrations is useful for meeting the macro and micronutrient needs of plants. Giving LOF can help metabolism in plants due to the water content in the LOF for nutrient solubility, so that nutrient transport from the roots to all parts of the plant will run well (Herawati et al., 2017). According to Sari et al. (2014), the provision of liquid organic fertilizers of 20 cc and 40 cc was able to increase the height of soybean plants when compared to those without LOF.

The provision of LOF concentration and number of pods of soybean crops form a positive linear pattern which means that each level of LOF concentration is up to 60 mL L$^{-1}$ followed by an increase in the number of pods (Figure 2).

![Figure 1. Relationship between LOF concentration and plant height.](image)

![Figure 2. Relationship between LOF concentration and number of pods.](image)

The coefficient of determination ($R^2$) is 0.2098 or can be explained by 20.98%. This means the addition of LOF concentration of 1 mL L$^{-1}$ can increase the number of soybean pods by 0.1339 pods. The increase in the number of pods plants$^{-1}$ is thought to be due to the content of N, P, K in LOF. According to Hamzah (2014), LOF administration gives real different results on a variable number of pods soybean plants, compared to without LOF administration. Meanwhile, according to Walid & Susyloswati (2016), NASA's organic fertilizer showed a very noticeable difference to the total number of pods plants$^{-1}$.

The relationship between LOF concentration and soybean seed count forms a quadratic pattern with a coefficient of determination ($R^2$) of 0.6624 or 66.24% (Figure 3).

The optimum concentration of LOF on the increase in the number of soybean seeds is 37,589 mL L$^{-1}$ with an average seed count of 115.89 seeds. Each addition of 1 mL L$^{-1}$ LOF will increase the number of soybean seeds by an average of 1.7291 seeds, while the addition of LOF concentration above the optimum concentration will decrease the number of soybean seeds by 0.023 seeds. When the enlargement of pods and the filling of soybean seeds requires a lot of elements K. Element K is required by plants for the formation of sugars and flour substances for the process of photosynthesis, and also helps in the formation of starch and proteins. Element P is also needed plants in the formation of seeds (Puspitasari & Elfarisna, 2017). This statement is also supported by Tamba et al. (2017) which states that the content of elements N, P, and K in LOF can improve vegetative growth of plants through the increase in the total leaf area and the amount of chlorophyll which in this case is related to the process of photosynthesis and increased production results.

The influence of LOF concentration on seed/plant weights forms a relationship with the quadratic curve pattern, with a coefficient of determination ($R^2$) of 0.4696 or 49.96% (Figure 4). It shows that the addition of LOF can increase the weight of seeds/plants up to optimum concentration, which is 28,114 mL L$^{-1}$ with a seed/plant weight of 18,313 g, while the provision of LOF above the optimum concentration will decrease the weight of soybean seeds/plants by 0.0035 g.

This is not following the results of Sinuraya et al. (2015) research which showed that the provision of LOF
The concentration of 40 mL L\(^{-1}\) gave the highest results to seed/plant weight. The addition of LOF concentration is very influential on the weight of seeds. This is suspected because the role of P and K contained in LOF can supply soybean plant nutrients until the generative phase. Element P can accelerate and strengthen the growth of young plants into mature plants accelerate seeding, and can also increase grain production (Puspitasari & Elfarisna, 2017). According to Wicaksono (2015), LOF concentrations showed noticeable different results. The best result of LOF administration is produced by a concentration of 120 mL L\(^{-1}\).

Concentration LOF 0-60 mL L\(^{-1}\) affects weight seeds plot\(^{1}\) by forming a positive linear curve pattern. This indicates that each addition of LOF 1 mL L\(^{-1}\) can increase the weight of seeds/plot on average by 1,895 g (Figure 5).

The administration of LOF containing N, P and K can improve the vegetative growth of plants that can affect the process of photosynthesis of plants. A good process of photosynthesis will increase the carbohydrates produced as food reserves in the form of pods and will accumulate in the form of seeds (Sari et al., 2014). This is in contrast to the opinion of Walid & Susylowati (2016) stated that the provision of LOF concentration has a real effect and tends to give the highest results on variable dry weight seeds plots\(^{1}\).

The relationship of POC concentration and P levels of soybean plant tissue forms a positive linear curve pattern (Figure 6). Each addition of 1 mL L\(^{-1}\) LOF will increase the P level of soybean tissue by an average of 0.0015%. The coefficient of determination (R\(^2\)) is 0.4744. The coefficient of determination (R\(^2\)) is the increase in LOF concentration is directly proportional to the increase in tissue P levels in soybean crops. P nutrient content in the soil ultisol is also classified as very low to moderate so that the nutrient is not enough for plant growth. Good plant growth can be achieved if the nutrients needed for plant growth and development are in the form of available, balanced and in optimum concentrations and supported by environmental factors that are good for plant growth and development (Walid & Susylowati, 2016).

The relationship between AMF and high soy plants forms a positive linear curve pattern. This means, each addition of 1 g plant\(^{-1}\) AMF will increase the average height of soybean crops by 0.7797 cm, with a coefficient of determination (R\(^2\)) of 0.8221 or equivalent to 82.21% (Figure 7).

The provision of AMF serves to help the absorption process of nutrients, especially N, P, and K by expanding the root system through the formation of lateral hyphae. The provision of AMF is proven to increase P absorption and plant growth (Fahmissidqi, 2016).

According to Oktaviani et al. (2014), the optimum dose of mycoriza (AMF) for soybean crops is 26.35 g, while according to Charisma et al. (2012) the administration of AMF 20 g plant\(^{-1}\) has a noticeable effect on the high variable of plants and is the optimum dose of soybean crops.
AMF dosing with the number of soy seeds forms a positive linear curve pattern. This means, each addition of 1 g plant\(^{-1}\) AMF will increase the number of soybean seeds by an average of 2,1367 seeds (Figure 8). The coefficient of determination \(R^2\) is 0.747. The coefficient value of determination indicates that the relationship between AMF dose and the number of soybean seeds can be explained by 74.7%.

AMF application can increase soybean crop production by increasing the number of seeds. This happens because P nutrients are important in seed filling, seed seeding, and increasing grain production (Malik et al., 2017). AMF dosing has a noticeable effect with the distance of increasing the number of seeds at each given dose. This is by the opinion of Dinata (2019) which states that the administration of a dose of AMF 10 g plant\(^{-1}\) can increase the maximum number of seeds in soybean crops. According to Malik et al. (2017), AMF administration has a real influence on the number of soybean seeds and increases crop production compared to without AMF administration.

AMF dosing forms a positive linear curve pattern in the weight of soybean seeds plots\(^{-1}\) which means that each increase in AMF dose is followed by the equation. (Figure 9).

![Figure 8. Relationship between AMF dose and number of seeds](image)

This means that each addition of 1 g plant\(^{-1}\) will increase the variable weight of soybean seeds plots\(^{-1}\) by an average of 11.825 g, with a determination coefficient value \(R^2\) of 0.6028 or can be explained by 60.28%.

The Seed weight results are influenced by photosynthesis, element N plays an important role as a constituent of proteins that will be used by plants to increase the contents of pods. Element P plays a role in the supply and transfer of energy in all plant physiological processes such as helping to accelerate the process of pod development and eating.

Plant response due to AMF administration has a real effect on the number of seeds/plants, seed weight plot\(^{-1}\) and weight of 100 seeds with the best dose indicated by the treatment of 5 and 10 g AMF planting\(^{-1}\) hole (Sukmasari et al., 2018). Meanwhile, according to Alfandi (2015), the administration of P fertilizer with a dose of 45 kg SP-36 ha\(^{-1}\) and CMA with a dose of 7.5 g planting\(^{-1}\) hole shows the best influence.

There is a positive linear relationship between AMF dose and P content in the tissue (Figure 10).

![Figure 9. Relationship between AMF dose and weight of seeds plot\(^{-1}\)](image)

This means each addition of AMF will increase the P level of soybean crop tissue by an average of 0.007%. The coefficient of determination \(R^2\) is 0.596 or can be explained by 59.6%.

P levels of plant tissue indicate the large content of P nutrients stored in plant tissues, this element is needed in generative phases to support photosynthesis translocation of plant organs. Hara P obtained plants through the absorption of inorganic P by the roots (Malik et al., 2017). Based on the results of Oktaviani et al. (2014) research, plants associated with AMF can increase P absorption compared to those without AMF administration. This happens because AMF can provide element P available in the ground. According to Wardhani et al. (2019), the provision of AMF can increase the P element available to plants.

The results of the variant analysis showed that AMF doses had an unreal effect on variable amounts, the number of branches, flowering age, dry weight of headers, and dry root weights. AMF dose independently with the administration of 10 g plant\(^{-1}\) gives the highest result in the variable number of leaves, dry weight of header, dry root weight, and fastest flowering age, while the highest number of branches at the dose of 5 g plant\(^{-1}\).

![Figure 10. Relationship between AMF dose and tissue P content](image)

This is alleged because environmental factors such as air temperature are needed in the vegetative and generative phases of plants. It is supported by Indriani et al. (2011), who states that AMF in plants increases at a temperature of 30 °C. Factors that influence AMF infection in plant roots are light, temperature, soil fertility, and soil pH. The best air temperature for arbuscular development is about 30 °C, for colonization of mycelium on the root surface between 24-34 °C, as well as sporulation and development of vesicles at a
temperature of 35 °C. The elements in the soil that have the most effect on mycorrhiza are P, where the high P content in the soil will inhibit colonization. High soil N content also negatively affects the growth and development of mycorrhiza. The effect of element N on mycorrhiza is also influenced by the availability of element P in the soil (Padri et al., 2015). This is supported by the opinion of Yusrinawati & Sudantha, (2016) which states that mycorrhiza will support plant growth in nutrient deficient plant conditions such as P and N, as well as colonization of roots by AMF can benefit growth in acidic soils and poor nutrients.

The AMF dose exerts an unreal influence on the variable number of pods, the number of hollow pods, and the weight of 100 soybean seeds. The content of N, P, K on research land is classified as very low to medium and the addition of AMF dose in growth variables or the administration of AMF has no effect on the number of pods plants but the administration of AMF dose of 10 g plant showed the highest yield, namun has not received optimum dose for soy plant growth and yield.

**CONCLUSION**

There is no interaction between LOF concentration and the addition of AMF dose in growth variables or soybean crop yields. LOF concentration of 60 mL L\(^{-1}\) showed the highest results but has not yet reached the optimum dose for variable plant height, number of pods, seed weight plot, and tissue P content. The optimum concentration for seed plant weight is 28.114 mL L\(^{-1}\) and the number of seeds is 37.589 mL L\(^{-1}\). AMF dose of 10 g plant showed the highest yield, namun has not received optimum dose for soy plant growth and yield.

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