Utilizing Organic Fertilizers on Two Types of Soil to Improve Growth and Yield of Bawang Dayak (Eleutherine americana Merr)

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**ABSTRACT**

Bawang dayak is a medicinal plant and can be grown as an economical crop with great potential value. It contains secondary metabolites with biological activities that are important for human health. The main problem related with the production of bawang dayak is the standard of cultivation. The goal of the experiment was to study the effects of organic fertilizers and growing media on the growth and yield of bawang dayak. The polybag experiment was performed with two factors, namely soil type and organic fertilizer by Factorial Completely Randomized Design and located in the greenhouse of University of Palangka Raya. The treatments were chicken manure, oil palm empty-fruit-bunch compost (OPEFBC), and NASA granule as organic fertilizers, while Histosol and Ultisol served as growing media treatment. The results showed that OPEFBC gave the highest in Ultisol and chicken manure in Histosol to improve plant height. The highest number of tubers were developed in Ultisol. Chicken manure improved P and Fe bulbs tissue whereas the content of N and K bulbs grown in Ultisol was higher than those in Histosol.

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Bawang dayak can be propagated vegetatively with tillers or tubers. The experiment to understand the breeding mechanism conducted by Manjula & Nair (2018) showed that in addition to vegetative propagation, the plant material can be multiplied by seeds, thereby increasing the development of this valuable medicinal plant. The suitable growing media is a mixture of fertile soil and compost with a ratio of 1:1. Maintenances needed during bawang dayak growth are weeding, daily watering, and fertilizing with NPK of 4.1 g/l and foliar fertilizer with a dose of 2 g/l (Naspiah, Iskandar, & Moelyono, 2014). In Kalimantan, the cultivation of bawang dayak has not been widely undertaken despite its potential health benefits because there is limited information about its cultivation techniques. The common cultural practice in bawang dayak that has been used is using the combined growing media with organic fertilizers to support plant growth and yield. The use of both Histosol and Ultisol is based on consideration that these two soil types were the most widespread in Central Kalimantan.

According to (Buschman, 1984), all soil types are suitable for the growth of gladiolus plants which members of Iridaceae family. The results of Atikah, Wardiyati, Nihayati, & Saputera (2017) reported that the use of sandy mineral soil produced the desirable growth and yields of bawang dayak compared to peat soils. Besides, Daniati, Budi, & Nurjani (2019) pointed out that the composition ratio of 1 alluvial : 1 manure : 1 sandy soil (w/w) provided the best average growth and yield of bawang dayak in alluvial soil. On peat soil, bawang dayak exhibited the optimum growth and yield responses when treated with chicken manure with a dose of 1,600 g per polybag (Sandra, Zulfita, & Surachman, 2019).

Another investigation of the effects of organic matter applications on the growth of a closely related species bawang sabrang (Eleutherine palmifolia) was reported by Anggraini, Haryati, & Irmansyah (2014). They applied rice straw compost and also investigated plant spacing to establish the optimum cultivation method. Other studies have investigated the timing and dosage of organic matter applications. Sitepu, Haryati, & Sitepu (2015) reported that time and dose of application of rice husk as a soil ameliorant led to significant positive differences in plant height, number of leaves, and number of sprouts. The influence of various growing media on growth and yields of bawang tiwai was also investigated by Sumarno, Mahdalena, & Hamidah (2019). They compared combinations of topsoil+sand, topsoil+rice husk, and topsoil+rice husk+sand against a control. Their results showed that planting media significantly affected the parameters of the number of leaves on the plants at 60 days after planting (DAP), with the combination of topsoil+sand resulting in the highest leaf number.

One of the organic fertilizers used in several studies is compost made from oil palm empty fruit bunches compost (OPEFBC). A study by Sembiring, Haryati, & Sipayung (2015) reported that OPEFBC had increased the relative growth of bawang dayak plants at 4 weeks after planting and the net assimilation rate after 5 weeks planting. In a separate study, Siregar, Haryati, & Simanungkalit (2014) showed that the use of OPEFBC combined with topsoil (topsoil, topsoil+compost 1:1, topsoil+compost 2:1, topsoil+compost 3:1) had a significant positive effect on the number of leaves, the number of bulbs per plant, and the weight of fresh bulbs per plot of bawang sabrang with the combination of topsoil+compost 1:1 and topsoil+compost 2:1. Chicken manure is another widely used source of organic matter induce better plant growth and soil fertility. In a study undertaken on a Ultisol, Karo, Lubis, & Fauzi (2017) showed that application of chicken manure with different times of incubation resulted in enhanced organic C, total N, total P, and exchangeable K of 1.05%; 0.35%; 0.060%, and 0.060 me/100 g, respectively. Combined application of chicken manure with OPEFBC (50% : 50%) (w/w) at different times of incubation produced more organic C 1.13%; total N 0.22%; total P 0.067% and exchangeable K 0.067 me/100 g. These values were considered lower than the study of Veeresh (2006) that reported in fresh chicken manure, plant nutrient status were 3.7-8.8% N; 0.4-1.1% ammonia; 1.2-2% phosphorus; 1.2-2.7% potassium. The objective of the study was to investigate differences in growth and yield of bawang dayak resulting from the application of a various combination of organic fertilizers (chicken manure, OPEFBC, and NASA granules) and two soil types (Ultisol and Histosol). The aim was to recommend optimal cultivation approaches of this medicinal plant on the two most widely occurring soil types in Central Kalimantan.
MATERIALS AND METHODS

This research was conducted under the greenhouse conditions from April to June 2016. Histosol material was taken from Kalampan Village, Sebangau District, Palangka Raya City, whereas, the Ultisol was collected from Pundu Village, Cempaga Hulu Sub District, Kotawaringin Timur District.

The bulk density of Histosol was 0.26 g/cm$^3$ and 1.62 g/cm$^3$ in Ultisol. The volume of soil used in a polybag was 520,000 kg/ha of Histosol and 3,240,000 kg/ha of Ultisol or equal to 9 kg of Histosol and 13 kg of Ultisol.

Based on the soil volume of each soil, the dose of chicken manure and OPEFBC was 20 t/ha equal to 346 g per polybag for Histosol and 80.246 g per polybag for Ultisol. The manures were mixed with the soil 7 days prior to planting. The NASA granule dose was 125 kg/ha equal to 2.16 g per polybag for Histosol and 0.50 g per polybag for Ultisol and was applied at the planting time.

The plant material in the form of bulbs were obtained from The Assessment Institute for Agricultural Technology (BPTP), Central Kalimantan, Indonesia. The research design was Factorial Completely Randomized Design with two factors. The first factor was soil type namely Histosol and Ultisol, while the second factor was the type of organic fertilizer, namely chicken manure, OPEFBC, and NASA granule. All of the combinations of the factors were replicated five times. Mature chicken manure was obtained from a chicken farm. OPEFBC was kindly donated by PT. Surya Inti Sawit Kahuripan oil palm plantation.

Soils were treated with 2 t/ha dolomite (34.6 g per polybag for Histosol and 80.24 g per polybag for Ultisol). Planting was done by immersing a bulb into the growing media. NPK fertilizer was applied 30 and 60 DAP (days after planting) at a rate of 41.6 kg/ha (1/3 recommended dosage in the amount of 125 kg/ha). The NPK dose was 0.72 g per polybag for Histosol and 0.17 g per polybag for Ultisol. Besides, furadan (carbofuran 3%) was applied at a rate of 15 kg/ha (Histosol 0.25 g per polybag, Ultisol 0.060 g per polybag) for pest and disease control.

The bulbs were harvested at 90 DAP. Subsequent analysis of bulb tissue was performed in the Laboratory of Soil Physics, Chemistry and Biology, Faculty of Agriculture, Universitas Lambung Mangkurat, Banjarmasin, South Kalimantan, while, soil analysis was carried out in the Analytical Laboratory, Universitas Palangka Raya. Data of plant growth and yield were analyzed statistically using ANOVA, followed by Duncan’s Multiple Range Test (DMRT) with 5% significance levels, whereas the bulb tissue mineral content data was presented in average values.

RESULTS AND DISCUSSION

Plant Growth

There was no interaction between organic fertilizers and growing media nor did the two single factors on plant height (P>0.05) based on the ANOVA test. OPEFBC performed best in Ultisol in terms of plant height (53.22 cm) followed by NASA (52.66 cm) and chicken manure (50.16 cm) (Fig. 1). The highest plant height in Histosol was created by the application of 20 t/ha of chicken manure (52.88 cm) (Fig. 2).

The beneficial effect of OPEFBC on crop growth on acid soils was also reported by Mukhils et al. (2017), it showed that OPEFBC improved soil characteristics, plant growth, and disease suppression of tomato plants growing on this tropical acid soil. In particular, the study by Mukhils et al. (2017) showed that the application of OPEFBC increased plant height, leaf area, dry matter accumulation, and suppressed the development of bacterial wilt disease compared to the use of chicken manure. Significant improvement of soil chemical properties with OPEFBC was also reported by Ermadani & Arsyad (2013). They found that the application of 75 ml of OPEFB resulted in the highest increase in soil pH, organic C, cation exchange capacity, total N, available P, and exchangeable cations (K, Ca, Mg). Other research has reported that palm bunch ash (PBA) application can improve soil nutrient status and increase pH. Increased soil pH affects the increase in negative soil charge on both soil. The function of negative soil charge is to bind the cations present in the soil, thereby resulting in reduced leaching and enlarged storage capacity of nutrients in the soil (Shamshuddin & Anda, 2008). In this work, the use of various ameliorants (chicken manure, OPEFBC, NASA) induced the enhancement of pH, N, and K on two soil types (Table 1).

In terms of plant growth and development, Ogbuehi (2016) reported that PBA treated plots showed the best potential with the highest plant height, stem girth, number of leaves, and leaf area.
with PBA plots recording significantly different (P<0.05) values for these parameters and the highest (0.579) relative growth rate. The highest dry weight of root and shoots (11.97 g and 31.73 g respectively were obtained from PBA plots, and these results were also statistically significant compared with control. It was concluded that PBA application a rate of 100 g was optimal for improving vegetative growth of okra and the soil nutrient status and that a 300 g rate was optimal for improving the fruit yield of okra. It was recommended that smallholder farmers should adopt the PBA application as a soil amendment tool for increased productivity (Ogbuehi, 2016).

### Table 1. Chemical properties of Histosol and Ultisol before and after the experiment

| Soil type | pH H₂O (1:2.5) | N-total (%) | P-Bray (ppm) | K-exc (me/100 g) |
|-----------|---------------|-------------|--------------|-----------------|
| **Before** |               |             |              |                 |
| Histosol  | 3.35          | 0.64        | 165.67       | 0.63            |
| Ultisol   | 4.25          | 0.17        | 53.53        | 0.22            |
| **After** |               |             |              |                 |
| Histosol  | 3.82          | 0.28        | 13.41        | 3.06            |
| Ultisol   | 4.96          | 0.27        | 15.73        | 0.43            |

Remarks: Results of laboratory analysis from the Analytical Laboratory, University of Palangka Raya
Composting is one of the most suitable options amongst the agricultural waste management strategies taking into account both economic profit and environmental benefits. The composting process reduces the bulk volume of organic materials, eliminates the risk of spreading pathogens, weed seeds, or parasites associated with direct land application of manure, and leads to final stabilized products, which can improve and sustain soil fertility (Kavitha, Jothimani, & Rajannan, 2013). OPEFBC is composed of 45-50% cellulose and about equal amounts (25-35%) of hemicellulose and lignin (Deraman, 1993) and previous studies have shown the beneficial results of using this compost medium in agricultural trials. For example, significant improvement of plant growth and yield with OPEFBC was recorded by Ermadani & Arsyad (2013). They found that the application of 75 ml compost (equivalent to 15 t/ha) resulted in the highest increase in the dry weight of shoot, pod number, and seed dry weight of soybean. The highest dry weight of seed was 28 g (equivalent to 2.82 t/ha).

Histosol is a marginal soil due to low nutrient availability and low inorganic fertilization efficiency under acidic conditions. The nutrients of this soil are not able to be released quickly (Priyadi et al., 2005). The addition of ameliorant is indispensable to escalate the productivity of Histosol. The growth pattern of bawang dayak on Histosol was worse when compared to those on Ultisol (Atikah, Wardiyati, Nihayati, & Saputera, 2017). At 8, 12, 16, 20, 24 weeks after planting (WAP), the Histosol plant height only reached 3.0, 6.3, 9.5, 13.5, and 14.25 cm, respectively, meanwhile, the Ultisol plant height attained at 33.4, 40.7, 47.7, 52.6, and 52.8 cm, respectively.

### Plant Yields

Organic fertilizers significantly increased the number of bulbs per clump and fresh weight of bulbs per clump (P<0.05). Chicken manure produced the both highest number of bulbs per clump (11.6) and the bulb fresh weight per clump (50.65 g). The results were significantly different from those for the OPEFBC treatment (7.8 and 26.3 g, respectively) and NASA fertilizer (5.7 and 26.8 g, respectively) (Table 2). Whalen, Chang, & Clayton (2002) found that crop production on acid soils can be best improved by the application of animal manure in order to increase the pH of the soil. The effects of increasing the soil pH included those related to micronutrient uptake. There have been many studies on the effects of organic fertilizers on the growth of economic plant species with below-ground storage organs. For example, the performance of gladiolus (*Gladiolus hybridus*) cv. White Prosperity (Iridaceae family) was studied by Dongardive, Golliwar, & Bhongle (2007). This is a small herbaceous annual flower that belongs to the same family as bawang dayak (Iridaceae). They found that NPK application resulted in the lowest number of days to corn sprouting (8.56), number of days to 50% spike initiation (64.90) and number of days to the opening of the first 2 florets (69.12 days), and greatest plant height (88.26 cm), leaf length (74.33 cm), number of leaves per plant (7.50), spike length (95.57 cm), number of spikes per plant (1.41), number of florets per spike (13.92) and floret diameter (8.78 cm), NPK application performed somewhat better than the application of vermicompost + Azotobacter + PSB [phosphate-solubilizing bacteria] (8.91, 67.12, 71.69, 85.22, 69.92, 6.84, 90.10, 40.96, 12.87 and 7.91 cm, respectively).

Soil media i.e. Ultisol and Histosol had a significant effect on the number and fresh weight of bulbs per clump (P<0.05), but not on bulb diameter (Table 3). These results are not in line with Sumarno, Mahdalena, & Hamidah (2019) that showed the application of various planting media did not significantly affect the number of bulbs, tubers, and the bulb weight of bawang dayak. Growing bawang dayak on Ultisol, Yunindanova, Agusta, & Asmono (2013) reported that an application of OPEFBC at 8 weeks and a fiber mulch provided the highest harvest weight and the highest number of fruit (436.56 g and 16 fruits). The number of fruit and fruit weight were lower than found in general tomato cultivation owing to the high acidity of the Ultisol growing medium. In addition, the lower CEC level of this soil led to lower nutrient uptake. Application of OPEFBC at 8 weeks increased the harvest weight by 52.59% compared to the control and also increased the number of fruit by 82.53% compared to the control. Atikah, Wardiyati, Nihayati, & Saputera (2017) work on two soil types Histosol and sandy mineral soil delivered that the number of bawang dayak tillers as much as 1.8, 5.3, 7.8, 12, and 12 at 8, 12, 16, 20, and 24 WAP in mineral soil, successively. In Histosol, there were fewer results of tillers in the amount of 0, 0.3, 0.6, 0.8, and 2.0 at 8, 12, 16, 20, and 24 WAP, respectively. The same pattern also occurred in the bulb fresh weight per clumps. The top-level of fresh
weight of bawang dayak tubers was achieved due to the application of mineral soil of 26.4 g and Histosol of 8.1 g at 20 WAP.

The number of bulbs and bulb fresh weight per clumps were higher in Ultisol. Generally, the chemical properties of Ultisol are better than Histosol in term of macronutrient content. Before an experiment, the chemical properties of Ultisol used were pH 4.25, N-total 0.17%, C-org 2.65%, available P 53.53 ppm, exchangeable cations of K 0.22 me/100 g, Ca 0.93 me/100 g, CEC 14.27 me/100 g and base saturation 9.60%, while, Histosol had 3.35 pH, N-total 0.64%, C-organic 57.01%, available P 165.67 ppm, exchangeable K 0.63 me/100 g, exchangeable Ca 2.11 me/100 g, CEC 34.34 me/100 g and 13.09% of base saturation (Table 1). Ichriani, Syehfani, Nuraini, & Handayanto (2018) suggested that Ultisol from Kalimantan had a pH of 4.3, C-org 0.52%, available P 2.13 ppm, and available K 15.25 ppm. Exchangeable cations of Ca, Mg, K, Na were in the amount of 1.80, 0.45, 0.06, 0.21 me/100 g, CEC 5.64 me/100 g, and 45% base saturation, respectively. Peat soil has a pH 4.07, C-org 56.24%, N-total 0.57%, available P 14.32 ppm, exchangeable cations of Ca, Mg, K, Na of 3.38, 5.33, 0.68, 1.16 me/100 g, 165.65 me/100 g CEC and 6.12% base saturation (Salampak, 1999).

**Bulb Tissues Analysis**

Based on the results of the tissue analysis of the bulbs of bawang dayak (Table 4), the average content of nitrogen, phosphorus, potassium, magnesium as well as iron from plants grown in the Ultisol soil media was 0.57%; 0.12%; 0.11%; 0.49%; 418.18 ppm meanwhile in Histosol they were 0.53%; 0.48%; 0.10%; 0.49%; 460.60 ppm, respectively.

**Table 2.** Diameter, the number, and fresh weight of bulbs per clump on some organic fertilizers at 16 WAP

| Organic Fertilizers | Diameter of bulbs per clump (cm) | Number of bulbs per clump | Fresh weight of bulbs per clump (g) |
|---------------------|----------------------------------|---------------------------|-------------------------------------|
| Chicken Manure      | 1.43 a                           | 11.6 b                    | 50.65 b                             |
| OPEFBC              | 1.32 a                           | 7.8 a                     | 26.3 a                              |
| NASA                | 1.46 a                           | 5.7 a                     | 26.8 a                              |

Remarks: Values followed by different letters in the same column differed significantly under DMRT (α ≤ 0.05)

**Table 3.** Diameter, the number, and fresh weight of bulbs per clump on two soil types at 16 WAP

| Soil Media Type | Diameter of bulbs per clump (cm) | Number of bulbs per clump | Fresh weight of bulbs per clump (g) |
|-----------------|----------------------------------|---------------------------|-------------------------------------|
| Ultisol         | 1.36 a                           | 9.8 b                     | 39.6 b                              |
| Histosol        | 1.45 a                           | 7.1 a                     | 29.56 a                             |

Remarks: Values followed by different letters in the same column differed significantly under DMRT (α ≤ 0.05)

**Table 4.** Nutrient contents of bawang dayak bulbs tissue on the different soil type

| Organic fertilizer Treatment | N   | P    | K    | Mg  | Fe  |
|------------------------------|-----|------|------|-----|-----|
|                              | %   | ppm  | ppm  | ppm | ppm |
| Ultisol*Chicken manure       | 0.59| 0.12 | 0.12 | 0.49| 418.18|
| Ultisol* OPEFBC              | 0.71| 0.13 | 0.12 | 0.49| 400.00|
| Ultisol*NASA                 | 0.42| 0.12 | 0.10 | 0.49| 436.36|
| Average                      | 0.57| 0.12 | 0.11 | 0.49| 418.18|
| Histosol* Chicken manure     | 0.50| 0.22 | 0.10 | 0.49| 527.27|
| Histosol* OPEFBC             | 0.51| 0.13 | 0.09 | 0.49| 490.91|
| Histosol*NASA                | 0.60| 0.13 | 0.12 | 0.49| 363.64|
| Average                      | 0.53| 0.48 | 0.10 | 0.49| 460.60|

Remarks: Results of laboratory analysis from Laboratory of Chemical, Physical and Biological Soil, University of Lambung Mangkurat, Banjarbaru, Banjarmasin, South Kalimantan.
Table 5 shows the nutrient content of bawang dayak bulbs that increased with organic fertilizers application. The application of chicken manure resulted in nitrogen, phosphorus, potassium, magnesium and iron contents of 0.54%; 0.17%; 0.11%; 0.49% and 472.72 ppm, respectively. Application of OPEFBC produced nitrogen, phosphor, potassium, magnesium and iron contents of 0.61%; 0.13%; 0.10%; 0.49% and 445.45 ppm while NASA fertilizer application led to nitrogen, phosphor, potassium, magnesium as well as iron contents of 0.51%; 0.12%; 0.11%; 0.49%; 400 ppm, respectively. There is no report related with mineral content found in bawang dayak bulbs.

Some literatures on bawang dayak refer more to the content of secondary metabolites and their pharmacological activities. Koocheki & Seyyedi (2020) recorded that N, P, K content of saffron corm as 1.41%, 0.28%, and 0.92%, respectively, on a dry weight basis. The N and P might be remobilized and stored in the corm at the same time with leaves senescence. The higher corms might be due to more carbohydrate storage which results in expansion of the root system, thus increasing mineral uptake including macro-and micronutrients.

An effect of organic fertilizer application on the nutrient contents of the leaves and corms of hybrid *Gladiolus* sp. was found by Sönmez, Çığ, Güler, & Başdoğan (2013) who used three organic fertilizers treatments (chicken manure, farmyard manure, peat, and waste mushroom compost). The application of organic fertilizers increased both the macro and micronutrient contents of the in leaves and corms of hybrid *Gladiolus* sp. The highest content of nitrogen (1.97%), iron (160 ppm), and manganese (128 ppm) in the leaves was obtained from the chicken manure application. The highest contents of iron (17.6 ppm) and magnesium (0.20%) in corms were obtained from the application of peat and waste mushroom compost. In our study, the Fe uptake of bulbs was 418.18 ppm in Ultisol and 460.60 ppm in Histosol. The organic fertilizer improved on P and Fe uptake of bulbs was chicken manure at a rate of 0.17% and 472.72 ppm (Table 4 and Table 5).

### CONCLUSION AND SUGGESTION

Since there was no interaction between fertilizers and media, the influence of a single factor also had no significant effect. OPEFBC was the best ameliorant for improving plant height in Ultisol (53.22 cm), while chicken manure induced highest plant height (52.88 cm) in Histosol. The highest number and bulb fresh weight were produced by bawang dayak with Ultisol media (9.8 and 39.6 g) and chicken manure application (11.6 and 50.65 g). Chicken manure also improved the P and Fe bulb tissues at a rate of 0.17% and 472.72 ppm respectively, whereas the content of N and K bulbs grown in Ultisol was higher than those in Histosol.
(0.57% and 0.11%). These results indicate that the application of organic fertilizers can improve the performance and yield of bawang dayak when grown on acidic tropical soils.

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