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COMBINING BIOCHAR AND LIQUID ORGANIC FERTILIZER FOR IMPROVEMENT OF SHALLOT GROWTH AND YIELD

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ABSTRACT
This study aims to examine the response of shallots to applying biochar and liquid organic fertilizer combination, and to obtain the combination that gives the highest growth and yield of shallots. The research design used was a randomized block design (RBD) with one factor, namely the combination of biochar dosage and liquid organic fertilizer (LOF) concentration consisting of 0 tonha^{-1} biochar + 0 mL^{-1} LOF; 0 tons ha^{-1} biochar + 7.5 ml L^{-1} LOF;0tonha^{-1} biochar + 15 mLL^{-1} LOF; 10 tonha^{-1} biochar + 0 mLL^{-1} LOF; 10 tonha^{-1} biochar + 7.5 mLL^{-1} LOF; 10 tonha^{-1} biochar + 15 mLL^{-1} LOF; 20 tonha^{-1} biochar + 0 mLL^{-1} LOF; 20 tonha^{-1} biochar + 7.5 mLL^{-1} LOF; 20 tonha^{-1} biochar + 15 mLL^{-1} LOF. Each treatment was repeated 3 times. The results showed that the combination of biochar and liquid organic fertilizer increased the growth and yield of shallots. The best combination was obtained at 20 tonha^{-1} biochar + 7.5 mLL^{-1} LOF. The productivity of shallots in the form of dry tuber weight from this study (6.8 tonha^{-1}) is still low when compared to the national average (9 tonha^{-1}), and the yield potential of shallots of the Brebes variety (9.9 tonha^{-1}). When compared to shallots that were not given biochar and not given LOF, the yield of shallots in the form of tuber dry weight increased by 139.86% by administering a combination of biochar 20 tonha^{-1} + 7.5 mLL^{-1} LOF.

KEY WORDS
Allium ascalonicum, ameliorant organic, productivity.

Shallot (Allium ascalonicum L.) is one of the leading horticultural commodities and has good prospects as a source of income for farmers and foreign exchange. Shallots are not only used as a complement to cooking spices but also as a raw material for medicines and as an activator for various enzymes in the body.

The present shallot production is 2 million tons, with a productivity of 9-10 tons per hectare, according to BPS (2021). Although production and productivity are adequate, the annual growth rate of shallot usage (4.84%) remains higher than that of supply (2.93%). Furthermore, compared to the yield potential of shallots, the productivity of shallots is low. As a result, improving shallot production and productivity is a necessity that must be carried out to increase the supply growth rate and achieve potential results.

Increasing the production and productivity of shallots can be done by expanding the planting area. It is widely available in Indonesia, particularly in Jambi, are dry land dominated by ultisols. However, the ultisol dry land is suboptimal and has low fertility, characterized by its low organic matter content. Therefore, increasing the fertility of ultisols can be done by adding organic matter to the soil as a soil ameliorant.

Under an oxygen-limited environment, bio-agricultural wastes such as wood chips or crop straw are pyrolyzed to form biochar, an organic carbon-rich material. Application of biochar to agricultural land (dry and wetland) can improve soil friability, reduce water evaporation from the soil, suppress the development of certain plant diseases, and create a favorable environment for symbiotic microorganisms (Nurida et al., 2015). In addition to reducing the need for fertilizers and improving carbon absorption in marginal soils, the use of biochar also lessens the influence of elements that are toxic to plants, such as Zn, Pb, Cd, and Cr, whose availability in the soil decreases with the application of biochar (Knoblauch et al., 2021). Soil ameliorant with biochar has been proposed as a sustainable agricultural management technique to increase soil productivity and long-term carbon storage (Lehmann, 2007).

Rice husk is one of the organic materials used for biochar. Various studies have revealed that rice husk biochar can improve soil and increase crop productivity. Based on chemical analysis results, rice husk biochar contains: 3.72% C-organic, 0.5% N-total, 0.23% P_2O_5, 0.06% K_2O, 0.21% CaO, 0.13% MgO, 0.05% fulvic acid, 2.5% water content , and pH H_2O 8.3 (Nurida et al., 2013).

The results of Akmal and Simanjuntak's research (2019) showed that administering 20 tons ha^{-1} of rice husk biochar increase the growth, and yield of mustard greens. Furthermore, the results of Rahayu et al. (2021) on corn plants showed that giving rice husk biochar was able to increase the growth of corn plants aged seven weeks after planting (WAP), and biochar at a dose of 15 $tons^{-1}$ gave better corn growth. The results of a study by Simiele et al. (2022) showed that the administration of biochar mixed with peat, bark humus, and quartz sand (1:1:1:2) was able to change the morphology of the roots, shoots, and leaves of tomato plants, especially during the vegetative phase, and conception. In addition, biochar was also able to increase the number of leaves and leaf area of plants compared to plants that were not biochar.

According to Nurida et al. (2015) biochar has low nutrients and CEC. Therefore, biochar application needs to be combined with fertilizers, which have a relatively high nutrient availability and are quickly available, especially when used for shallots, which have a relatively short lifespan. Fertilizers can be given in organic and inorganic forms, both solid and liquid, but the application of inorganic fertilizers harms plants and their growing environment, while organic fertilizers, apart from not damaging the environment, also contain soil microorganisms. One of the liquid organic fertilizers is LOF NASA. LOF NASA is a commercial LOF that contains macro and micronutrients, growth regulators, humic acid, and fulvic acid, with a 0.86 C/N (PT Natural Nusantara, 2021). LOF NASA can be given by pouring it or spraying it directly on the plants.

LOF NASA given to ground kale cultivated with a floating hydroponic system increased plant growth and yield, and a concentration of 2 mLL^{-1} gave the best plant height, number of leaves, and root length (Oktaviani et al, 2022). Furthermore, the results of research by Parayoga et al., (2018) on pakcoy plants showed that LOF NASA with a concentration of 2 mLL^{-1} gave the best growth and yield of pakcoy in Alluvial. Giving LOF NASA10 mLL^{-1} to corn was able to increase growth and yield compared to concentrations of 5 mLL^{-1} and 0 mLL^{-1} (Satria et al., 2021).

Based on the description above, it has been determined that utilizing biochar and LOF independently can improve crop growth and yield. Nevertheless, the combination of these techniques results in even more favorable outcomes and a considerable increase in plant productivity. Obtaining optimal yield for shallots and enhancing the fertility of ultisol soil requires precise determination of the accurate dosage for this integrated approach.

METHODS OF RESEARCH

The research was conducted at the Teaching and Research Farm, Faculty of Agriculture, University of Jambi, at 35 m above sea level. The study was conducted from August 2022 to October 2022. The experimental design used a Randomized Block Design with one factor, and three repetitions, namely a combination of rice husk biochar and NASA liquid organic fertilizer (LOF). The combinations tried consisted of: 0 $tonha^{-1}$ biochar + 0 mLL^{-1} LOF; 0 tons ha^{-1} biochar + 7.5 mLL^{-1} LOF; 0 $tonha^{-1}$ biochar + 15 mLL^{-1} LOF; 10 $tonha^{-1}$ biochar + 0 mLL^{-1} LOF; 10 $tonha^{-1}$ biochar + 7.5 mLL^{-1} LOF; 10 $tonha^{-1}$ biochar + 15 mLL^{-1} LOF; 20 $tonha^{-1}$ biochar + 0 mLL^{-1} LOF; 20 $tonha^{-1}$ biochar + 7.5 mLL^{-1} LOF; 20 $tonha^{-1}$ biochar + 15 mLL^{-1} LOF.

The biochar used is biochar derived from rice husks, made by simple pyrolysis (Center for Agricultural Research and Development, 2017). Biochar is given two weeks before planting by spreading it over the soil surface and stirring until evenly mixed. The dose given depends on the treatment being tried. Shallot bulbs that have had their ends cut off by 14 of the end of the bulb are planted by digging at a depth of approximately 5 cm. The shallot variety used is Bima Brebes, with a bulb size of 5–10 cm, which is old enough, free from pests and diseases, and has no defects. When the plants are 1 WAP old, they are given NPK fertilizer at a dose of 2 g per plant.

LOF NASA is given from plants aged 2 WAP to 7 WAP, with an interval of once a week. Giving is done by spraying onto the surface of the leaves until the leaves are evenly wet, and stops when liquid fertilizer drips onto the soil surface. LOF concentration is given according to the treatment. Plant maintenance is adjusted to shallot cultivation standards in general.

After approximately 60 days from planting, the harvest process takes place. At this point, the leaves should have turned yellow by around 60-70%, become dry, and fallen to the ground. The tubers should have grown in size, and some may have emerged from the soil. They should be firm, shiny, and purplish-red in color.

Variables observed are plant height, number of leaves, number of tubers per hill, weight per tuber, fresh tuber weight per hill, dry tuber weight per hill, and tuber diameter. Plant height and number of leaves were observed at 7 WAP, while other variables were observed at harvest.

Data was analyzed using variance and continued with the Duncan Multiple Range Test at the level of $\alpha = 5\%$.

RESULTS OF STUDY

The plant height and number of leaves at 7 WAP was significantly influenced by the use of biochar and LOF. After conducting DMRT tests, it was found that the combination of 20 tonha^{-1} biochar + 7.5 mLL^{-1} LOF produced the highest plant height and number of leaves. This result was significantly different from the other combinations. On the other hand, the combination of 0 tonha^{-1} biochar + 0 mLL^{-1} LOF produced the lowest plant height. This result was similar to the combinations of 0 tonha^{-1} biochar + 7.5 mLL^{-1} LOF as well as 0 tonha^{-1} biochar +15 mLL^{-1} LOF, as shown in Table 1.

Table 1 – Average plant height and number of leaves at 7 WAP at various combinations of biochar and LOF

Biochar and LOF combination	Plant height (cm)	Number of Leaves
0 tonha^{-1} biochar + 0 mLL^{-1} LOF	22,04 e	7,50 f
0 tonha^{-1} biochar + 7,5 mLL^{-1} LOF	25,42 de	9,75 ef
0 tonha^{-1} biochar + 15 mLL^{-1} LOF	25,25 de	10,11 ef
10 tonha^{-1} biochar + 0 mLL^{-1} LOF	28,38 bcd	13,08 de
10 tonha^{-1} biochar + 7,5 mLL^{-1} LOF	27,67 cd	15,50 cd
10 tonha^{-1} biochar + 15 mLL^{-1} LOF	26,71 d	12,67 de
20 tonha^{-1} biochar + 0 mLL^{-1} LOF	30,58 bc	18,17 bc
20 tonha^{-1} biochar + 7,5 mLL^{-1} LOF	35,89 a	24,11 a
20 tonha^{-1} biochar + 15 mLL^{-1} LOF	31,30 b	19,28 b

Note: Numbers followed by the same letter are not significantly different according to DMRT α = 5%.

Table 2 – Average fresh weight and dry weight of bulbs per clump, and number of bulbs per clump of shallot at biochar and LOF combination

Biochar and LOF Combination	Fresh weight of bulbs per clump (g)	Dry weight of bulbs per clump (g)	Number of bulbs per clump
0 tonha^{-1} biochar + 0 mLL^{-1} LOF	13,50 e	9,08 e	4,00 f
0 tonha^{-1} biochar + 7,5 mLL^{-1} LOF	16,33 de	11,58 de	4,58 ef
0 tonha^{-1}biochar + 15 mLL^{-1} LOF	17,47 de	13,11 cde	4,89 ef
10 tonha^{-1} biochar + 0 mLL^{-1} LOF	22,28 cde	15,50 cd	5,78 cde
10 tonha^{-1} biochar + 7,5 mLL^{-1} LOF	23,83 bcd	17,00 bcd	6,33 bcd
10 tonha^{-1} biochar + 15 mLL^{-1} LOF	19,83 de	14,00 cde	5,50 def
20 tonha^{-1} biochar + 0 mLL^{-1} LOF	29,42 bc	18,72 bc	7,00 bc
20 tonha^{-1} biochar + 7,5 mLL^{-1} LOF	40,22 a	27,11 a	8,78 a
20 tonha^{-1} biochar + 15 mLL^{-1} LOF	31,67 b	21,78 b	7,55 ab

Note: Numbers followed by the same letter are not significantly different according to DMRT α = 5%.

Table 3 – Average bulb diameter and weight per bulb of shallot at biochar and LOF combination

Biochar and LOF combination	Bulb diameter (mm)	Weight per bulb (g)
0 $tonha^{-1}$ biochar + 0 mLL^{-1} LOF	13,59 f	2,54 e
0 $tonha^{-1}$ biochar + 7,5 mLL^{-1} LOF	14,11 ef	2,70 de
0 $tonha^{-1}$ biochar + 15 mLL^{-1} LOF	14,79 de	3,15 de
10 $tonha^{-1}$ biochar + 0 mLL^{-1} LOF	15,53 cd	3,54 cde
10 $tonha^{-1}$ biochar + 7,5 mLL^{-1} LOF	16,15 c	3,83 cd
10 $tonha^{-1}$ biochar + 15 mLL^{-1} LOF	14,52 def	3,34 cde
20 $tonha^{-1}$ biochar + 0 mLL^{-1} LOF	16,24 bc	4,53 bc
20 $tonha^{-1}$ biochar + 7,5 mLL^{-1} LOF	19,15 a	5,96 a
20 $tonha^{-1}$ biochar + 15 mLL^{-1} LOF	17,23 b	5,38 ab

Note: Numbers followed by the same letter are not significantly different according to DMRT α = 5%.

Table 1 show that plants do not respond positively when using only liquid organic fertilizer (without biochar). If biochar is added to the planting medium, and accompanied by liquid organic fertilizer that is sprayed on the plants, it will produce greater height and number of leaves, both at a dose of 10 $tonha^{-1}$ biochar and at a dose of 20 $tonha^{-1}$ biochar.

The combination of biochar and liquid organic fertilizer has a significant effect on the fresh weight, dry weight of tubers per clump, and the number of tubers per clump. The best results were obtained with the combination of 20 $tonha^{-1}$ biochar + 7.5 mLL^{-1} LOF (Table 2). Tuber diameter and weight per tuber were also significantly influenced by the combination of biochar and LOF, and the best combination was obtained at 20 $tonha^{-1}$ biochar + 7.5 mLL^{-1} LOF (Table 3).

DISCUSSION OF RESULTS

Based on the data collected from observing different variables related to shallot growth and yield (Tables 1, 2, and 3), it is clear that combining LOF administration with biochar results in high yields. However, when LOF is given without biochar, the growth and yield of shallots remain low. Conversely, giving biochar without LOF leads to better results.

Studies have demonstrated that incorporating biochar into soil can enhance its chemical, physical, and biological properties, thereby improving soil quality that has been depleted (Nurida et al., 2015). Biochar's high pH and total soil carbon content account for the enhancement in soil chemical properties. Adding biochar to soil can raise both soil pH and organic carbon levels. An analysis of rice husk biochar revealed that it has a pH of 7.37 and an organic carbon content of 41.84%, as well as 0.54% total nitrogen, 0.24% total phosphorus, and 0.41% total potassium (Research Institute for Industrial and Refreshing Plants, 2022).

The study revealed that shallots that were treated with biochar or a combination of biochar and LOF showed an increase in growth and yield. This finding is consistent with the research conducted by Akmal et al. (2019) on pakcoy plants, where the application of biochar ranging from 5 $tonha^{-1}$ to 30 $tonha^{-1}$ resulted in improved growth and yield compared to those without biochar. This increase was attributed to the rise in soil pH, soil CEC, total N, total P, total K, and soil available K. Furthermore, Turpiano et al. (2015) and Smiele et al. (2022) have also reported similar results in their studies on lettuce and tomato plants, respectively.

The results of research by Sadzli et al. (2019) on green bean plants showed that biochar was able to improve the physical properties of the soil by reducing the bulk weight of the soil compared to that which was not treated with biochar. According to Saputra et al. (2018) adding organic matter to the soil can increase the amount of soil pore space and form a crumbly soil structure thereby reducing the bulk weight of the soil. Soil with a small bulk weight will make it easier for plant roots to penetrate the soil, thus improving the plant root system. The research results of Sutono and Nurida (2012) prove that biochar is able to improve the soil's ability to hold water by increasing the number of aeration pores and the amount of available water. In addition, a study conducted by Ichwan et al. (2020) demonstrated that the use of biochar on corn plants at rates ranging from 3 $tonha^{-1}$ to 15 tonha^{-1} resulted in an increase in crop yield (measured by seed weight per plant) of 36% to 69%. Additionally, soil weight per volume decreased while total pore space and soil water content increased. This suggests that the application of rice husk biochar can enhance the physical properties of soil, leading to improved growth and yield of shallots.

The more biochar given, the higher the plant height, number of leaves, fresh and dry weight, and diameter of shallot bulbs. This indicates that biochar can boost plant growth and yield by enhancing the soil's physical, chemical, and biological properties. Antonius et al. (2018) found that shallot plants grown in pots with biochar had a greater total population of soil bacteria than those without. Even though bacteria don't consume biochar, it offers a place for soil microorganisms to thrive (Gani, 2009). Giving LOF was apparently not able to increase plant growth and yield if it was not combined with biochar, even though the concentration given was up to 15 mLL^{-1}. These results show that plant nutrient needs cannot be met only by LOF, which means that LOF in this case is a supplement, so to get better growth and yields in shallots, biochar must still be added to the soil. However, there was an increase in wet bulb weight, dry bulb weight, and number of bulbs in shallots treated with LOF compared to those without LOF. The increase in wet bulb weight of shallots ranged from 20.96% -29.41%; dry tubers 27.53% - 44.38%; and the number of tubers 14.50% - 21.00%. The research results of Yusniati et al. (2019) showed that there was an increase in the growth of shallots treated with LOF, but did not provide a significant difference between plants given LOF and without LOF on tuber fresh weight and tuber dry weight.

The most successful growth and yield of shallots were achieved with the use of both biochar and LOF. By enhancing the planting medium through soil amandements and providing LOF to the plant, necessary nutrients for growth and development become more available. This finding aligns with a study by Zaitun et al. (2014) on dragon fruit plants, which found that a combination of biochar (10 tonha^{-1} and LOF (1 L per 10 L of water) enhanced soil properties (pH, C-organic, N-total, available P, K dd, and CEC) and improved plant growth.

The dose of biochar 20 tonha^{-1} + LOF 7.5 mLL^{-1} was the combination that gave the highest shallot growth and yield. If the LOF concentration is increased to 15 mLL^{-1}, growth and yield will decrease. It is suspected that this is due to the sufficient amount of nutrients obtained by plants from the soil and from the leaves for their growth. If the amount of nutrients absorbed by plants is excessive, it can cause ion antagonism between nutrients, thereby affecting their effectiveness. The research results of Ichwan et al. (2021) showed that if the levels of one of the nutrients in the plant are excessive, it will reduce the levels of other nutrients. This can be seen from the decrease in leaf Ca and Mg levels in red chili plants that were given foliar fertilizers with increasing leaf K levels.

The productivity of shallots in the form of dry weight of bulbs from this study (6.8 tons ha^{-1}) is still low when compared to the national shallots (9 tonsha^{-1}), and the potential yield of the Brebes variety of shallots (9.9 tonha^{-1}). A supportive climate, especially during tuber enlargement, is needed in order to obtain maximum results. During the study, the ambient temperature ranged from 25^{0}C - 28^{0}C, which is the ideal temperature for shallot growth. However, high enough humidity (more than 80%) can interfere with the growth of shallots, which only require a RH of around 50-70%. Apart from that, uneven rainfall during the research was also one of the factors that influenced the development of shallot bulbs. Therefore, to obtain maximum shallot yields in Jambi, in addition to soil conditions that are not optimal, it is also necessary to consider the environmental conditions for plant growth. Erratic climate changes due to global warming also greatly influence the success of crop cultivation.

CONCLUSION

The combination of rice husk biochar and NASA liquid organic fertilizer (LOF) can increase the growth and yield of shallots. The combination that gives the best growth and yield of shallots is 20 tonha^{-1} biochar + 7.5mLL^{-1} LOF NASA. When compared with no biochar and no liquid organic fertilizer, the combination of 20 $tonha^{-1}$ biochar + 7.5 mlL^{-1} LOF NASA was able to increase the dry weight of shallot bulbs by 139.87%.

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