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The Combination of Biofertilizer and Organic Fertilizer to Improve Shallot (*Allium ascalonicum* L.) Production

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Abstract

Shallot is one of important horticultural crops in Indonesia; shallot consumption per capita is estimated to be 4.6 kg per year. The objective of this study was to evaluate the effect of combining biofertilizer and organic fertilizer on the production of shallot in Sukabanjar village, Pesawaran, Lampung, Indonesia. The study was set up using a randomized completely block design with two factors, biofertilizers and various organic fertilizers, i.e. cow manure, chicken manure, rice straw compost, oyster mushroom *baglog*. Our study demonstrated that combining biofertilizer and organic fertilizer significantly increased the number, diameter, and fresh and dry weight of tubers of "Bima Brebes" shallot. Shallots treated with biofertilizer combined with oyster mushroom *baglog* produced the highest tuber yield of 1788 g compared to 282 g in the control.

Keywords: chicken manure, cow manure, oyster mushroom *baglog*, rice straw compost, shallot tuber

Introduction

Shallot is one of the important horticulture commodities in Indonesia and worldwide. The major use of shallot is for spice, but it is also used as a component of traditional medicine (Sun et al., 2019). Shallot contains beneficial nutrients such as protein, fat, calcium, phosphorus and vitamin C (Rahayu and Berlian, 2006). Among several shallot varieties known, the "Bima Brebes" (*Allium ascalonicum* L. var "Bima Brebes"), which was produced in 1984, is now widely adopted in Brebes, Indonesia. Brebes is one of the largest shallot production centers in Indonesia (Basuki et al., 2017). "Bima Brebes" is known to have a good yield potential when grown in favorable environment (Gardner et al., 2013).

"Bima Brebes" yield could be up to 10 ton.ha^{-1} with a relatively short growing season; it is ready to harvest at 55–60 days after planting (DAP) compared to the other shallot cultivars, i.e. 60–90 DAP (Sumarno, 2019). "Bima Brebes" is also well adapted to rainy season; the tubers have medium to large tuber size, and pink to red maroon tuber color, making them highly sought in the market (Basuki et al., 2017).

The low productivity of shallots could be related to the low organic matter in its agro-ecosystem (Direktorat Pangan dan Pertanian, 2017), therefore it is important to maintain the level of organic matter in the soil. Excessive use of inorganic fertilizer for a long period can reduce the soil fertility, as indicated by the hardening of soil structure, reduction of soil aggregates and soil viability (Blanco-Canqui and Alan, 2013). The higher biological activities in soil, the higher soil fertility, the better the plant growth (Kemas, 2005). There is a need to compensate the negative effect of chemical fertilizer, and the use of biofertilizer and organic fertilizer are good candidates to minimize the negative impact of inorganic fertilizers. Biofertilizers contain active microorganisms that can be beneficial for plant growth (Damanik et al., 2011). A previous study also showed that organic fertilizers also improve soil health and fertility (Lin et al., 2020). This study aimed to evaluate the effect of combining biofertilizer and organic fertilizer on the production of "Bima Brebes" shallot.

Materials and Methods

The study was carried out in the village of Sukabanjar, subdistrict of Gedong Tataan, Pesawaran district, Lampung, Indonesia from September to December 2017. Pesawaran is categorized as low land (-5.4782102, 105.0086268, 174 m above sea levels), with average temperature of about 25.9^{0}C and rainfall intensity of about 2387 mm (En.climate-data, 2020). A total of 30 experimental plots representing 10 different treatments in three replicates were established. Thirty shallot seeds of the "Bima Brebes" variety were planted on each plot (2 m^2). The study was set up in a completely randomized block design involving two types of fertilizers, biofertilizer (Bio Max Grow ®) (B) and organic fertilizer (O). Biofertilizer treatment consists of B1 (without biofertilizer) and B2 (with biofertilizer administered on 3, 5, and 7 weeks after planting), whereas organic fertilizer treatment consists of O1 (without organic fertilizer), O2 (cow manure), O3 (chicken manure), O4 (rice straw compost) and O5 (oyster mushroom *baglog*), totalling 10 treatments. Each treatment was replicated three times. *Baglog* is a term that is generally used for the media for oyster mushroom cultivation.

Measurements and Data Analysis

Variables including plant height, number of leaves, number of tubers, diameter of shallots bulb, fresh and dry weights of tubers per plot were measured. Plant height and number of leaves were measured at 7 weeks after planting. Measurement of plant height at 7 weeks was conducted based on a previous study by Tambunan et., (2014) that the height of shallot would be significantly affected by the biofertilizer at 7 weeks after planting. The rest of the variables were measured on harvesting day (55–60 DAP). There were 10 plants selected randomly from each plot for measurement.

All data were analyzed by analysis of variance (ANOVA). If any significant variance was noted, the test was continued to the Least Significant Different (LSD) at α 5%. Statistical analysis was performed by using the statistical analysis software (SAS) version 9.1.3.

Result and Discussion

In general, the effects of biofertilizers and organic fertilizers were observed to be better when both fertilizers were combined in a plot as shown in the measurements of the different variables presented in Tables 1 and 2. At seven weeks after planting, plant height ranged from 30.30 to 42.7 cm (Table 1). Height differences were not significant in plants that were administered single fertilizers only, whereas, significant difference in height was observed in plants provided with combined fertilizers. The absence of biofertilizer in combination with various organic fertilizers caused no significant result on shallot height. The presence of biofertilizer in combination with chicken manure, rice straw compost and oyster mushroom baglog showed no significant result in terms of plant height compared to no organic fertilizer application. However, those results were significantly lower than the combination treatment of biofertilizer and cow manure. The tallest shallots were found in combination treatment of biofertilizer and cow manure, while the shortest shallots were in plot with chicken manure application with no biofertilizer. There was plant height improvement for about 24% as the presence of biofertilizer in combination treatment of cow manure (Table 2). Although, the main harvested part in shallot is its bulb, vegetative growth, as seen in plant height, is also important factor to assess (Biru et al., 2015).

The number of leaf in shallots is an essential vegetative growth variable to evaluate. Shallots in this study responded variably to fertilizers, with the greatest number of leaves found in plots treated

Table 1. The effect of biofertilizer (B), organic fertilizer (O), and combined biofertilizer and organic fertilizer (B*O) on the plant height, number of leaves, number of tubers, diameter of shallot bulb, and fresh and dry weight of tubers of "Bima Brebes"

Observed variables	Significance		
	B	O	B*O
Plant height (cm)	ns	ns	*
Number of leaves	*	ns	*
Number of tubers	*	*	*
Diameter of shallot bulb (cm)	*	ns	*
Tuber fresh weight per plot (g)	*	*	*
Tuber dry weight per plot (g)	*	*	*

Note: Significantly different based on LSD test at α 5%; ns = not significantly different.

Table 2. Plant height (cm) of “Bima Brebes” shallot treated with various combination of biofertilizers (B1-B2) and organic fertilizers (O1, O2, O3, O4, O5)

	Plant height (cm)				
	O1	O2	O3	O4	O5
B1	30.30Aa	34.50Ba	30.00Aa	41.33Aa	40.40Aa
B2	34.37Ab	42.7Aa	35.57Ab	34.67Ab	35.12Ab

Note: Mean value followed by different capital alphabet within the same column was significantly different, while mean value followed by different lowercase alphabet within the same row was significantly different based on LSD at α 5%. Without biofertilizer (B1), with the application of biofertilizer (B2), without organic fertilizer (O1), with the application of cow manure (O2), chicken manure (O3), rice straw compost (O4), and oyster mushroom baglog (O5)

with combined biofertilizer and cow manure (Table 3). On the other hand, the lowest number of leaves were found in the plot were no fertilizers administered and in the one with only chicken manure organic fertilizer was applied. The application of biofertilizer in combination with cow manure proved to be able to double the leaves number of shallot compared to the rest of the set-ups. The absence of biofertilizer in various organic fertilizer applied made no significant result in terms of leaf number. These findings support the enhanced effect of biofertilizer when combined with appropriate organic fertilizer (i.e. cow manure) to grow more leaves. The number of leaves influences the source capacity of plant, whereby increased number signifies a better potential for higher bulb yield. Higher number of leaves allows for more photosynthesis resulting in higher production of shallot tubers (Carora et al., 2014). Previous study by Biru et al. (2015) demonstrated that plants with more leaves had higher bulb yield.

The economic value of shallots relies on the yield of the tuber. Combining biofertilizer and organic fertilizer was proven to significantly increase the number of tubers per plot. The addition of biofertilizer combined with the application of oyster mushroom *baglog* produced the highest number of tubers, i.e. 5 times higher than control (Table 4). In general, organic fertilizer application significantly improved the tuber number by 85% to 276%, irrespective of the biofertilizer types. The number of tubers in shallots is more related to the number of leaves than to plant height. The more leaves the plant has, the stronger is its capability to supply needed nutrients to other organs, such as tubers. This finding also agrees with previous study that reported the improvement of tuber number as the effect of biofertilizer application in shallot (Sukmadi et al., 2016).

The diameter of shallot tubers was also significantly improved when biofertilizer and organic fertilizer were combined. The treatment of biofertilizer only (without organic fertilizer) could improve the tuber diameter for about 13% as compared to not using fertilizer (control set up) (Table 5). Moreover, the widest diameter in tubers was from combination treatment of biofertilizer and straw compost increased by 107% compared to the control. Hence, combining biofertilizer and organic fertilizer clearly shows the opportunity to boost the yield of shallot since there was an increase of size/diameter of harvested tuber as yield component.

The fresh and dry weights of shallot tubers per plot were also greater when fertilizers were combined (Table 6). The highest fresh weight was found in combination treatment between biofertilizer and oyster mushroom *baglog*, while the lowest fresh weight was found in control plots. Improvement rate in fresh weight when fertilizers were combined was at about 534%. Similar response was seen in dry weight, with improvement rate of about 623% when biofertilizer and oyster mushroom *baglog* were combined, as compared to control. For all organic fertilizer types used, the addition of biofertilizer as

Table 3. Number of leaves of “Bima Brebes” shallot treated with various combination of biofertilizers (B1-B2) and organic fertilizers (O1, O2, O3, O4, O5)

	Leaf number				
	O1	O2	O3	O4	O5
B1	11.67Aa	17.20Ba	11.67Ba	14.80Ba	17.40Ba
B2	15.33Ab	26.27Aa	18.33Ab	24.03Aab	24.03Aab

Note: Mean values followed by different capital alphabet within the same column was significantly different, while mean value followed by different lowercase alphabet within the same row was significantly different based on LSD at α 5%. Without biofertilizer (B1), with the application of biofertilizer (B2), without organic fertilizer (O1), with the application of cow manure (O2), chicken manure (O3), rice straw compost (O4), and oyster mushroom baglog (O5).

Table 4. Number of tubers of "Bima Brebes" shallot treated with various combination of biofertilizers (B1-B2) and organic fertilizers (O1, O2, O3, O4, O5)

	Number of tubers per plot				
	O1	O2	O3	O4	O5
B1	56.00Ac	213.33Aa	103.67Bb	220.67Aa	202.00Ba
B2	77.33Ac	175.00Ab	168.00Ab	254.00Aa	290.67Aa

Note: Mean values followed by different capital alphabet within the same column was significantly different, while mean value followed by different lowercase alphabet within the same row was significantly different based on LSD at α 5%. Without biofertilizer (B1), with the application of biofertilizer (B2), without organic fertilizer (O1), with the application of cow manure (O2), chicken manure (O3), rice straw compost (O4), and oyster mushroom baglog (O5).

Table 5. Tuber diameter of "Bima Brebes" shallot treated with various combination of biofertilizers (B1-B2) and organic fertilizers (O1, O2, O3, O4, O5)

	Diameter of tuber (cm)				
	O1	O2	O3	O4	O5
B1	1.12Bc	1.73Ab	1.92Bab	1.87Bab	2.14Aa
B2	1.27Ac	2.06Aab	1.86Ab	2.32Aa	2.18Aab

Notes: Mean values followed by different capital alphabet within the same column was significantly different, while mean value followed by different lowercase alphabet within the same row was significantly different based on LSD at α 5%. Without biofertilizer (B1), with the application of biofertilizer (B2), without organic fertilizer (O1), with the application of cow manure (O2), chicken manure (O3), rice straw compost (O4), and oyster mushroom baglog (O5).

Table 6. Fresh and dry weights of tubers of "Bima Brebes" shallot treated with various combination of biofertilizers (B1-B2) and organic fertilizers (O1, O2, O3, O4, O5)

	O1	O2	O3	O4	O5
	Fresh weight of tuber (g)				
B1	282Ab	1196Aa	1073Aa	1092Ba	1262Ba
B2	437Ac	1288Ab	1266Ab	1427Ac	1788Aa
	Dry weight of tuber (g)				
B1	7.41Ab	36.13Aa	30.82Aa	31.83Ba	36.99Ba
B2	11.62Ac	37.20Ab	38.12Ab	43.35Ab	53.59Aa

Notes: Mean values followed by different capital alphabet within the same column was significantly different, while mean value followed by different lowercase alphabet within the same row was significantly different based on LSD at *α* 5%. Without biofertilizer (B1), with the application of biofertilizer (B2), without organic fertilizer (O1), with the application of cow manure (O2), chicken manure (O3), rice straw compost (O4), and oyster mushroom *baglog* (O5).

companion fertilizer improved the fresh and dry weights of shallot tuber per plot. However, significant results were only observed in rice straw compost (O4) and oyster mushroom *baglog* (O5). Biofertilizer alone can result in fresh and dry weight increase in Bima shallot tuber by about 18% to 22% as compared to those without fertilizer (Saharuddin et al., 2018). It was also previously shown that biofertilizer application increases production rate to about 55.71% compared to those without biofertilizer (Sukmadi et al., 2016).

This present study demonstrates the positive effect of adding biofertilizer for shallot growth and yield. Biofertilizer is a microorganism-containing fertilizer that is usually helpful when there is low plant yield due to low soil fertility (Amutha et al., 2014; Mohammadi and Sohrabi, 2012). Liquid biofertilizers prove to be successful in improving the growth and yield of shallots (Purba et al., 2020). Biofertilizers are usually composed of several beneficial microbes for supporting plant growth (Bhattacharjee and Dey, 2014; Mezuen et al., 2002). Biofertilizer used in present experiment (Biomaxgrow®) were consisted of *Azospirillum*, *Azotobacter*, *Pseudomonas*, cellulotic microbes, nutrient solubilization microbes, arbuscular mycorrhizal fungi, indole acetic acid hormone, alkaline phosphatase enzymes and active phosphatase enzymes (Gunarto, 2013). Purba et al. (2019) reported that *Azotobacter*, *Bacillus*, *Pseudomonas* and *Serratia* are four groups of beneficial bacteria that are frequently found in biofertilizers and work as plant growth promoting rhyzobacteria (PGPR) that could produce phytohormone to help plant growth. Microbes in biofertilizers, such as *Azotobacter*, *Azospirillum*, phosphate solubilizing bacteria and *Rhizobium* support nutrient fixation, solubilization, organic matter decomposition and mineralization (Prasad et al., 2019; Biswas et al., 2000). *Azotobacter* is known to produce several hormones such as auxin, gibberellin and indole-acetate acid to regulate the plant growth. Azotobacter is also known to produce anti-fungal compounds that aid in seed germination (Yuwono, 2008). *Azospirillum* and *Azotobacter* are able to fix nitrogen and can boost plant growth and soil fertility (Dermiyati, 2015).

The addition of biofertilizer not only increases plant nutrient availability but also soil organic matter (Wu et al., 2005). Thus, the use of organic matter as the companion of biofertilizer doubles the positive effect for the plant. In addition to soil biological fertility, organic fertilizers make soil more porous resulting in better root penetration, leading to the formation of more and larger tubers (Sudiarso, 2007). Among several organic fertilizers currently being used, shallot production rate (dry basis) is at 9.37 $tons.ha^{-1}$ using oyster mushroom *baglog*, 7.60 $tons.ha^{-1}$ with rice straw compost, 6.67 $tons.ha^{-1}$ with chicken manure, and 6.51 $tons.ha^{-1}$ with cow manure (Purnawanto and Nugroho, 2015). Oyster mushroom *baglog* contains mycelium protein that could be a good nitrogen source and helps to make more porous soil (Peniwiratri, 2007). The compost of oyster mushroom *baglog* contains 22.95% C-organic, 1.39% N, 1.31% P_2O_5, 1.78% K_2O and has a C/N ratio of about 16.51 (Rahmah et al., 2016).

Conclusion

Combining biofertilizer and organic fertilizers cow manure, chicken manure, rice straw compost, or oyster mushroom *baglog* significantly increased plant height, tuber number and diameter, tuber fresh and dry weights of "Bima Brebes" shallot. The best fertilizer treatment, as indicated by the highest fresh tuber yield of 1788 g per plant, was the combination of biofertilizer and oyster mushroom *baglog*, as compared to control that only produced 282 g per plant.

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