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Research

Productivity of Lembah Palu Local Shallot (*Allium cepa* L. var. *Aggregatum*) from Organic Cultivation

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ABSTRACT

The local shallot variety of 'Lembah Palu' (*Allium cepa* L. var. *Aggregatum*) is a typical fried shallot plant in Palu City, Indonesia, and is a cooking spice or flavoring for various foods. The main objective of this research was to increase the productivity of the Palu local shallot of 'Lembah Palu' grown on liquefaction soils. This research was conducted from November 2019 to January 2020, in Kaleke Village, West Dolo Subdistrict, Sigi Regency, Central Sulawesi, Indonesia. This research used a Randomized Block Design with two factors. The first factor of Arbuscular Mycorrhiza Fungi (AMF) consisted of M0 (Control), M1 (10 g/polybag), M2 (15 g/polybag), and M3 (20 g/polybag). The second factor of bokashi fertilizer consisted of B0 (Control), B1 (312.5 g/polybag), and B2 (375 g/polybag). Each experimental unit consisted of 3 polybags and was grouped into 3 groups so that the total experimental unit was 108 plants or polybags. The results showed that the application of mycorrhiza 20 g/polybag and bokashi 375 g/polybag was able to produce the optimal number of tubers, the wet and dry weight of shallot tubers. Likewise, for the growth of Palu local shallot plants, the higher dose of mycorrhiza and bokashi resulted in better plant growth, i.e., plant height, number of leaves, and number of tillers.

Key words: Bokashi, morphology, mycorrhiza, productivity, shallots, tubers

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INTRODUCTION

Shallots of the Palu Valley variety (*Allium cepa* L. var. *Aggregatum*) are an excellent raw material for fried onions with a distinctive aroma, dense texture, and savory taste, and can withstand storage after frying. However, its productivity is still far compared to ordinary shallots, so farmers still do not obtain more profit. Therefore, to gain a higher profit, local fried shallots should be grown organically, so that it has a higher selling price. Furthermore, the shallot variety of 'Lembah Palu' or Palu Valley is a seasoning ingredient for several dishes, especially as a flavor enhancer. The cultivation of this local fried shallot plant using an organic cultivation system or without using inorganic fertilizers (chemical fertilizers) including in pest control. Palu local shallot is mainly planted in the Palu Valley area. The Palu Valley and its surroundings in 2018 had experienced earthquakes and liquefaction so the soils underwent structural changes.

Soil that experienced liquefaction is sand-type soil and contains a lot of sand, in which the soil is not cohesive (does not have or has very little adhesion between the grains). The application of bokashi fertilizer (organic matter) is expected to improve the soil structure, enhance soil absorption of water, increase the population of microorganisms in the soil, and as a source of nutrients for plants (Shin *et al*., 2017; Husen *et al*., 2022). The application of organic matter can increase the population and activity of beneficial microorganisms for plants such as rhizobium and mycorrhizae (Karimuna *et al*., 2016; Ortiz & Sansinenea, 2022). One of the organic fertilizers that can be applied is bokashi fertilizer. Organic farming enhances soil microbial abundance and activity (Lori *et al*., 2017). According to Caravaca *et al*. (2003), the organic matter can increase the N, P, K contents of the plant rhizosphere, where the nutrient concentration increases with the addition of bokashi.

The application of bokashi which can provide sufficient organic matter for the soil, a microbe is also needed to support the cultivation to increase crop yields (Karimuna *et al*., 2016). One of the soil microbes that can support increasing plant yields through its ability to be *symbiotic* with roots is Arbuscular Mycorrhiza Fungi (Samanhudi *et al*., 2017; Khaliq *et al*., 2022). Arbuscular Mycorrhiza Fungi (AMF) is a symbiosis between fungi and plant roots. AMF live around plant root areas which can increase host plant resistance to drought conditions by modifying soil and plant relationships and increasing water absorption capacity (Saleh *et al*., 2021).

Mycorrhiza is a biological fertilizer and a type of fungus that can be transmitted through root infection. Mycorrhiza can be symbiotic with many types of plants, including shallots, and its symbiosis through plant roots. This symbiosis can produce mycorrhizal hyphae which can help plants obtain nutrients and water beyond the reach of plant roots. This was proven in this study that the roots of shallot plants had root infections, and the infected roots showed arbuscular and vesicles. Mycorrhiza makes mutualism symbiosis with plant roots through special structures called arbuscular and vesicles (Rich *et al*., 2014; Jia *et al*., 2020).

Mycorrhizae or arbuscular mycorrhiza fungi can help plants stimulate the growth of their roots so that it is more numerous and longer than plants that do not colonize with mycorrhizae. This is used to form phytoalexins to inhibit soil-borne pathogens that attack plants (Jeandet *et al*., 2013)**.** Mycorrhizae can play an important role in increasing plant growth in low fertility rates, and degraded land, and helping to expand nutrient uptake in the soil (Begum *et al*., 2019).

The concept of agricultural development should not only increase the productivity of the products, but also focus on natural balance, product quality, and safety (Khan *et al*., 2003; Yu & Wu, 2018.). The principles of future cultivation based on pest control, use of compost, use of beneficial microorganisms for plants, integrated resource management, and attention to environmental sustainability need to be applied in the concept of the agricultural sector development. It aims to make the development of the agricultural sector feasible economically, socially, and sustainably in the future. The cultivation concept is by the principles of organic farming which can be a solution to various potential long-term problems. This problem arises due to the application of conventional farming systems by relying on the excessive use of inorganic chemical fertilizers and pesticides (Baweja *et al*., 2020).

Problems that have the potential to arise include water pollution, decreased soil fertility, pest resistance to pesticides, and threats to human and animal health due to pesticide residues in food products consumed (Saha *et al*., 2014; Sihvonen *et al*., 2021). Changes in the lifestyle and perspective of the Indonesian people towards agricultural products that are increasingly concerned about nutritional value, taste, and product safety can increase the prospects for organic farming in the future. This is because organic farming systems can provide products that are free from inorganic chemical residues originating from the use of pesticides and chemical fertilizers. Therefore, a study was conducted on the response to the growth and yield of Palu local shallot plants by applying AMF and bokashi on liquefied soil media.

MATERIALS AND METHODS

Location and duration

This research was conducted in Kaleke Village, West Dolo Subdistrict, Sigi Regency, Central Sulawesi, Indonesia from November 2019 to January 2020. The seeds of this research come from the Sigi Bureaumaru area which is one of the development centers. Planting material for shallots comes from tubers that have been harvested for about 3 months, the plumule or forerunner of the shoots on the surface of the tubers. When planting tubers, cut the top of about 1/3 of the part to make it easier for the plumule or shoots to grow.

Research design

This research used a Randomized Block Design with two factors. The first factor of AMF consisted of four treatments: M_0 (Control), M_1 (10 g/polybag), M_2 (15 g/polybag), and M_3 (20 g/polybag). The second factor of bokashi fertilizer consisted of B_0 (Control), B_1 (312.5 g/polybag), and B_2 (375 g/polybag). Each experimental unit consisted of 3 polybags, and it was grouped/repeated into 3 groups so that the total experimental unit was 108 plants or polybags.

Table 1. Research design in productivity of lembah Palu local shallot (*Allium cepa* L. var. *Aggregatum*) from organic cultivation

Treatments	B0	B1	B2
M0	M0B0	M0B1	M0B2
M1	M1B0	M1B1	M1B2
M2	M2B0	M2B1	M2B2
M3	M3B0	M3B1	M3B2

The soil used went through the sterilization stage by steaming the soil. The sterilized soil was weighed according to the bokashi media ratio. Then, it was added in a 25 × 15 cm polybag. The seeds planting began with preparing the shallot seeds which were ready for planting (free from pests & diseases, pithy & rather bright in color). The seeds were cut at the end of the tuber about 1/3 part, and the seeds were then planted. Microfer biological fertilizer treatment was performed once at the time of planting and placed on the shallot seed tubers in the rhizosphere (root zone).

AMF (arbuscular Mycorrizhae fungi) is a type of mycorrhiza that lives on the inside of plant root tissues also known as endo mycorrhiza, so this mycorrhiza can only be seen using a microscope. In contrast to the type of ectomycorrhizae, which can be seen with the eye because these mycorrhizae usually cover the roots of plants, so that the roots plants look bigger or fatter.

$$\text{Percentage of Root Infection} = \frac{\sum \text{Infected sample roots}}{\sum \text{All sample roots}} \times 100$$

Statistical analysis

To determine the effect of the treatment, observations were made on plant height, number of leaves, number of tillers, number of tubers per polybag, wet weight of tubers per polybag, dry weight per polybag, and percentage of roots infected with mycorrhiza. Data were analyzed using Analysis of Variance (ANOVA) using the Excel 17 program (2019). If there was a significant effect, then it was continued with the Honest Significant Difference test (HSD) at a level of 5%.

RESULTS AND DISCUSSION

Plant height

The ANOVA results showed that the treatment of mycorrhiza and bokashi doses had a very significant effect on plant height at plant ages 14, 21, 28, and 42 days after planting (DAP), while the interactions were not significantly different. The average plant heights of 14, 21, 28, and 42 DAP with different mycorrhiza and bokashi dose treatments are presented in Table 2. Table 2 shows that the higher dose of mycorrhiza (20 g/polybag) gave an increase in plant height, each of which was 140.9% higher than the control (at 14 DAP), 58.3% higher than the control (at 21 DAP), 32.9% higher than control (at 28 DAP), and 24.5% higher than control (at 42 DAP). Likewise with the dose of bokashi that the higher the dose of bokashi (375 g/polybag) increased the height of each plant by 37% higher than control (at 14 DAP), 20.7% higher than control (at 21 DAP), 13.1% higher than control (at 28 DAP), and 11.5% higher than control (at 42 DAP). The highest plant height was 24.27 cm (at 42 DAP).

Table 2. Average plant heights of 'Lembah Palu' shallot plants with different mycorrhiza and bokashi fertilizer doses

Fertilizer	Treatments	14 DAP	21 DAP	28 DAP	42 DAP
	Control (M_0)	2.20^{a}	6.57^{a}	14.67^{a}	19.5^{a}
AMF	10 g (M_1)	4.10^{b}	8.53^{b}	17.90$_{b}$	**22.3^{b}**
	15 g (M_2)	4.57^{bc}	9.27^{b}	18.27^{b}	23.27^{bc}
	20 g (M_3)	5.30^{c}	10.40^{c}	9.50^{c}	24.27^{c}
	HSD 5%	**0.82**	**0.97**	**1.08**	**1.37**
	Control (B_0)	3.38^{a}	7.73^{a}	16.43^{a}	20.9^{a}
Bokashi	312.5 g (B_1)	4.10^{b}	9.03^{b}	17.78^{b}	22.8^{b}
	375 g (B_2)	4.63^{b}	9.33^{b}	18.55^{b}	23.3^{b}
	HSD 5%	**0.61**	**0.75**	**0.81**	**1.03**

Note: The HSD level of 0.05

Number of leaves

The ANOVA results showed that the treatment of mycorrhiza and bokashi doses had a very significant effect on the number of leaves at plant ages 14 and 21 DAP. The average plant heights of 14 and 21 DAP with different mycorrhiza and bokashi dose treatments are presented in Figure 1.

The results of 14 dan 21 DAP showed that the administration of mycorrhiza with increasing doses given for each dose of bokashi fertilizer resulted in a higher number of plant leaves. Likewise, with the given doses of bokashi fertilizer, the higher dose of bokashi given resulted in a higher number of plant leaves. The ANOVA results showed that the treatment of mycorrhiza dose and bokashi dose had an interaction with a very significant effect on the number of leaves at 42 DAP.

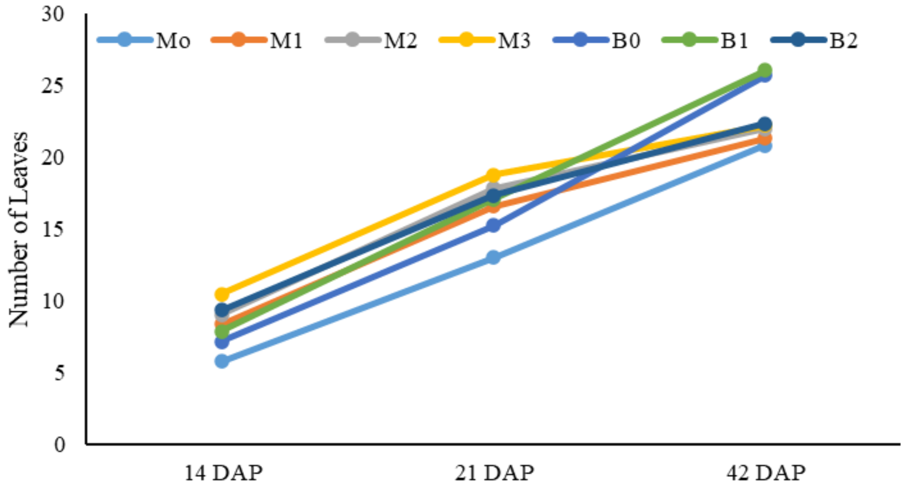


Fig. 1. Average number of leaves of 'Lembah Palu' shallot plants with different mycorrhiza and bokashi fertilizer doses leaves (Control (M0) 10 g (M1) 15 g (M2) 20 g (M3) Control (B0) 312.5 g (B1) 375 g (B2))

Number of tillers

The ANOVA results showed that the treatment of mycorrhiza and bokashi doses had a very significant effect on the number of tillers at plant ages 21, 28, 35, and 42 DAP. The average number of tillers at 21, 28, 35, and 42 DAP with different mycorrhiza and bokashi dose treatments are presented in Table 3.

The results of the HSD test (21, 28, 35, & 42 DAP) showed that the administration of mycorrhiza with increasing doses given for each dose of bokashi fertilizer resulted in a higher number of tillers. Likewise, with the given doses of bokashi fertilizer, the higher dose of bokashi given resulted in a higher number of tillers. HSD test results (at 21, 28, 35, & 42 DAP) showed that increasing the dose of mycorrhizae up to 20g/polybag can produce a higher number of tillers compared to the control. Each of these was 37.5% higher than the control (at 21 DAP), 18.3% higher than the control (at 28 DAP), 29.6% higher than the control (at 28 DAP), and 38.7% higher than the control (at 42 DAP). Likewise, increasing the dose of bokashi fertilizer up to 375 g/polybag increased the number of tillers, each of which was 18.3% higher than control (at 21 DAP), 13.9% higher than control (at 28 DAP), 20.8% higher than control (at 35 DAP), and 20.7% higher than control (at 42 DAP). The highest number of tillers was found in the treatment of 20 g/polybag mycorrhizal dose of 6.6 for shallot plants aged 42 DAP.

Table 3. The average number of tillers of 'Lembah Palu' shallot plants with different mycorrhiza and bokashi fertilizer doses

Fertilizer	Treatments	Number of Tillers			
		21 DAP	28 DAP	35 DAP	42 DAP
AMF	Control (M_0)	2.67[a]	3.94[a]	4.63[a]	4.76[a]
	10 g (M_1)	3.13[ab]	4.31[ab]	5.20[ab]	5.54[b]
	15 g (M_2)	3.40[b]	4.48[b]	5.57[b]	6.06[bc]
	20 g (M_3)	3.67[b]	4.66[b]	6.00[b]	6.60[c]
	HSD 5%	**0.57**	**0.53**	**0.81**	**0.61**
Bokashi	Control (B_0)	2.90[a]	4.02[a]	4.80[a]	5.16[a]
	312.5 g (B_1)	3.33[a]	4.44[ab]	5.45[ab]	5.83[b]
	375 g (B_2)	3.43[b]	4.58[b]	5.80[b]	6.23[b]
	HSD 5%	**0.51**	**0.48**	**0.72**	**0.55**

Note: The HSD level of 0.05

Number of tubers

The ANOVA results showed that the administration of mycorrhiza doses, bokashi doses, and their interactions had a significant effect on the number of tubers in Palu local shallots. The average number of tubers with different mycorrhiza and bokashi dose treatments and their interaction are presented in Figure 2.

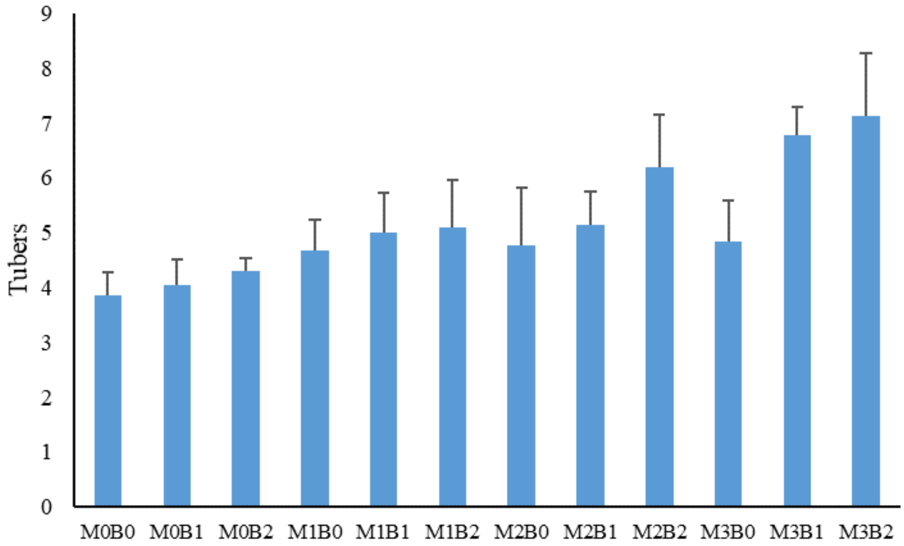


Fig. 2. Average number of tubers of 'Lembah Palu' shallot plants with different mycorrhiza and bokashi fertilizer doses leaves (Control (M0) 10 g (M1) 15 g (M2) 20 g (M3) Control (B0) 312.5 g (B1) 375 g (B2)).

The results of the HSD test showed that the administration of mycorrhiza with increasing doses given for each dose of bokashi fertilizer resulted in a higher number of plant tubers. Likewise, with the given doses of bokashi fertilizer, the higher dose of bokashi given for each dose of mycorrhiza showed a higher number of plant tubers. The highest number of tubers 7.1 was found in plants that were given a mycorrhizal dose of 20 g/polybag and added with bokashi fertilizer at a dose of 375 g/polybag.

Wet weight of tubers and dry weight of tubers

The ANOVA results showed that the treatment of mycorrhiza and bokashi doses had a very significant effect on the wet weight of tubers, while the interactions were not significantly different. The average wet weight of tubers with different mycorrhiza and bokashi dose treatments is presented in Table 4. The results of the HSD test showed that the administration of mycorrhiza with increasing doses given for each dose of bokashi fertilizer resulted in a higher wet weight of tubers. Likewise, with the given doses of bokashi fertilizer, the higher dose of bokashi given resulted in a higher wet weight of tubers.

Table 4. Average wet weight of tubers of 'Lembah Palu' shallot plants with different mycorrhiza and bokashi fertilizer doses.

Fertilizer	Treatment	Tubers Wet Weight	Tubers Dry Weight
AMF	Control (M_0)	12.78[a]	8.78[a]
	10 g (M_1)	21.33[b]	15.22[b]
	15 g (M_2)	22.33[b]	17.26[b]
	20 g (M_3)	27.00[c]	21.56[c]
	HSD 5%	3.89	3.12
Bokashi	Control (B_0)	12.75[a]	12.75[a]
	312.5 g (B_1)	22.33[b]	16.50[b]
	375 g (B_2)	23.58[b]	18.08[b]
	HSD 5%	3.50	2.81

Note: HSD level of 0.05

The ANOVA results showed that the treatment of mycorrhiza and bokashi doses had a very significant effect on the dry weight of tubers, while the interactions were not significantly different. The average dry weight of tubers with different mycorrhiza and bokashi dose treatments is presented in Table 4.

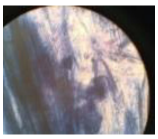
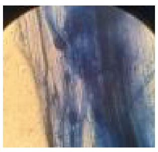
HSD test results showed that the increasing dose of mycorrhiza had an effect on the wet weight of tubers which also increased. When compared to the control, there was an increase of 66.9% (10 g/polybag), 74.7% (15 g/polybag), and 111.3% (20 g/polybag), respectively. Likewise, the higher doses of bokashi fertilizer had an effect of increasing the wet weight of the tubers. When compared to the control, there was an increase of 33.9% (312.5 g/polybag) and 41.6% (375 g/polybag), respectively. The heaviest wet weight of tubers was 27.00 g (Table 3).

The HSD test results showed that the increasing dose of mycorrhiza had an effect on the dry weight of tubers which also increased. When compared to the control, there was an increase of 73.4% (10 g/polybag), 99.7% (15 g/polybag), and 145.6% (20 g/polybag), respectively. The same response was also found with the administration of bokashi fertilizer that the higher dose of bokashi gave the effect of increasing the dry weight of tubers. When compared to the control, there was an increase of 29.4% (312.5 g/polybag) and 41.8% (375 g/polybag), respectively. The heaviest dry weight of tubers was 21.56 g (see Table 4).

Percentage of roots infected with mycorrhiza

The percentage of mycorrhiza-infected roots found in the roots of local hammer shallots is presented in Table 5. The percentage of mycorrhiza-infected roots showed Mo (0%), M1(20%), M2(40%) and M3 (80%), respectively.

Table 5. Percentage of roots infected with mycorrhiza in local hammer shallot roots

Treatment	Image	∑ All observed sample roots	∑ Infected sample roots	Percentage of infected roots (%)
M0 (control)		10	0	0
M1 (10 g/polybag)		10	2	20
M2 (15 g/polybag)		10	4	40
M3 (20 g/polybag)		10	8	80

Interaction of amf and bokashi fertilizer doses on the plant growth and yield

The research showed that in the parameters of plant height aged 35 DAP, number of leaves aged 28, 35, and 42 DAP, and number of tubers at the end of the study, there was an interaction between the dose of mycorrhiza spores and the dose of bokashi fertilizer. The results showed that the higher doses of mycorrhizal spores at each dose of bokashi had a better effect on growth parameters, i.e., plant height at 35 DAP; and number of leaves at 28, 35, 42 DAP; and yield (number of tubers) of Palu local shallot plants. This was because the increasing number of mycorrhiza spores in the plant root area is beneficial for the plant in nutrient and water absorption. The administration of mycorrhiza to the root area of plants resulting in plant roots could be symbiosis well with mycorrhiza, and this will significantly help plants to absorb nutrients and water (Bárzana *et al*., 2012),. The optimal nutrients and water are used by the 'Lembah Palu' shallot plants to form carbohydrates and will combine with inorganic materials to create protoplasm at the growing point of plant stem (meristem tissue). Therefore, plants grow higher, and the number of leaves and tubers is also increased.

The results of this research in Tables 2, 4, and 6 showed that the interaction of mycorrhiza spore and bokashi fertilizer doses significantly affected growth (plant height at 35 DAP & number of leaves at 28, 35, 42 DAP), as well as the number of shallot tubers at the end of the study. The mycorrhiza doses of 20 g/polybag and 375 g/polybag resulted in the highest plant height of 25.53 cm (at 35 DAP), while the number of leaves were 28.4, 28.9 and 28.0, respectively (at 28, 35 and 42 DAP). The highest average number of tubers was 7.13 tubers. The increasing growth and yield of the plants was due to the availability of macro-micro nutrients from bokashi fertilizer which can be maximized by mycorrhiza. This can enhance plant height and increase the yield of Palu local shallot tubers. The application of cow manure bokashi can increase the biological activity of the soil and also the availability of nutrients, so that it can help plant growth and yields (Fajeriana *et al*., 2022). In addition, El-sherbeny *et al*. (2022) mentioned that a symbiotic plant with mycorrhizae can grow better due to the greater surface area of the roots to absorb nutrients and water. Mycorrhizae which can adapt well to the growing environment and can adapt to their host plants, can be relied upon to assist plants in absorbing nutrients and water so that it can support plant growth. In addition, the addition of mycorrhizae to plants will stimulate the plants to form growth hormones such as cytokines and auxins (Foo *et al*., 2013; Mukherjee *et al*., 2022)**.**

Plants when in their growth experience nutrient or water stress, which is due to the presence of nutrients and water beyond the reach of the roots, and mycorrhiza will stimulate the plant to produce more and longer plant roots (Dhiman *et al*., 2022)**.** Furthermore, Begum *et al*. (2019) stated that the roots of plants infected with mycorrhiza can make the volume and length of the roots wider and longer to obtain nutrients and water for the host plant.

The results in Table 6 showed that the interaction between mycorrhiza and bokashi fertilizer doses significantly affected the number of tubers. The mycorrhiza treatments of 20 g/polybag and 375 g/polybag doses of bokashi fertilizer produced a higher number of tubers. This was because mycorrhiza can increase nutrient absorption, especially the P element which is available in the soil and bokashi fertilizers. In addition, the increase in the number of tubers is influenced by bokashi fertilizer which also contains soil microorganisms. The microorganisms are effective as decomposers which accelerate the decomposition process of organic matter so that the availability of macro-micro nutrients in organic matter can be available for plants. Bokashi contains soil microorganisms that can increase the availability of nutrients in organic matter (Luo *et al*., 2022).

Mycorrhiza biological fertilizers

This was observed in this study, where in almost all growth variables (plant height & number of tillers) and yield variables (wet weight & dry weight of tubers), the results of plants given mycorrhizae were always higher compared to those not given mycorrhiza (control). In particular, plants given mycorrhiza of 20 g/polybag resulted in a height increase of about 24.5 - 140.9% better than plants that were not given mycorrhizae (control) during growth from 14 to 42 DAP. Likewise, the variable number of tillers aged 21-42 DAP showed that giving mycorrhizal doses of 20 g/polybag increased the number of tillers by around 18.3% -38.7% compared to plants that were not given mycorrhiza (control). The yield variable was even affected in that giving higher mycorrhizal doses increased the wet weight of tubers compared to those not given mycorrhizae (control), which was 66.9% (10 g/polybag), 74.7% (15 g/polybag), and 111.3% (20 g/polybag), respectively. Likewise, the dry weight of the tubers also increased when compared to the control of 73.4% (10 g/polybag), 99.7% (15 g/polybag), and 145.6% (20 g/polybag), respectively.

The process of nutrients entering the plant by Arbuscular Mycorrhiza Fungi (AMF) occurs through three stages, i.e., 1) Absorption of nutrients from the soil by external hyphae, 2) Translocation of nutrients from external hyphae to internal mycelium in plant roots, and 3) Release of nutrients from internal mycelium to root cells which can be reached by plant root hairs.

Bokashi fertilizer

This study showed that the use of bokashi fertilizer in this study had a significant effect on vegetative growth of plant height, number of leaves, number of tillers, as well as shallot plant yield of tubers wet weight and tubers dry weight. The treatment with the highest dose of bokashi at 375 g/polybag resulted in the highest growth and yield. These results indicated that the best treatment for bokashi fertilizer application is 375 g/polybag. This was presumably because organic matter can increase the concentration of nutrients in the soil, especially N, P, and K, as well as other elements. Pramono (2004) stated that organic matter including bokashi from a mixture of cow dung, rice husk, and bran can improve the physical, biological, and chemical properties of the soil. Organic matter can increase both macro and micronutrients, reduce plasticity, and increase the number and types of microbes that are important for plants (Pan *et al*., 2012; Sharma *et al*., 2014). Furthermore, Yu *et al*., (2013) emphasized that the influence of organic matter on soil chemical properties includes increasing the availability of phosphorus elements bound in organic form to avoid leaching. Organic compounds derived from plant residues contain the element phosphorus (Muliana *et al*., 2018; Jantamenchai *et al*., 2022) so it will increase phosphorus in the soil when applied.

This bokashi fertilizer is a mixture of cow manure, rice husk, and bran, all of which are organic materials. According to Purwaningsih *et al*. (2022), the amount of nutrients in manure can affect the growth and development of shallot plants. In addition, the administration of bokashi can improve soil quality, and as a result, it can improve soil texture, and soil fertility, increase humus levels, and promote the role of soil microorganisms (Xiaohou *et al*., 2008). Furthermore, Lasmini *et al*. (2018) reported that the addition of organic matter in the form of bokashi can increase the contents of organic matter and nutrients in the soil.

The bokashi fertilizer in this study was a mixture of cow manure, rice husk, and rice bran, and added with EM4, then fermented for 14 days. The bokashi fertilizer contains all organic matter, which is very beneficial for the growth and yield of Palu local shallots. Bokashi fertilizer is an organic fertilizer that can be made independently from a mixture of several fermented organic materials (Gashua *et al*., 2022) such as straw, husk, rice bran, corn bran, wheat bran, tofu dregs, coconut dregs, grass, and animal manure.

The results showed the higher dose of bokashi fertilizer given can produce good growth and yield of Palu local shallot plants, especially in plant height at plant age 14, 21, 28, 42 DAP (4.63, 9.33, 18.55 & 23.3 cm, respectively), number of leaves at plant age 14 and 21 DAP (9.33 & 17.35 leaves, respectively), number of tillers at plant age 21, 28, 42 DAP (3.42, 4.58, 6.23 tillers, respectively), wet weight of tubers (23.58 g), and dry weight of tubers (18.08 g). This was because the higher dose of bokashi fertilizer resulted in greater amounts of macro and micronutrients for shallot plants. In addition, bokashi fertilizer can provide water for plants in better quantities and for a longer time, compared to without bokashi fertilizer.

CONCLUSION

The interaction between AMF at a dose of 20 g/polybag and 375 g/polybag achieved the best growth and yield of Palu local shallot plants. The application of bokashi fertilizer at a dose of 375 g/polybag resulted in the best growth and yield of Palu local shallot plants. Meanwhile, the administration of mycorrhiza at a dose of 20 g/polybag resulted in the best growth and yield of Palu local shallot plants. This research is carried out in polybags, it is better to use bokashi organic fertilizer because of the limitations of mycorrhizal hypha to take up nutrients and water. Suggestion, the research is conducted in the field, it is better to use mycorrhiza and organic matter

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ETHICAL STATEMENT

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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