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Performance of Shallots (*Allium Ascalonicum* L) in Peat Soil with Organic Fertilizer and Arbuscular Mycorrhizal Fungi (AMF)

Riki Warman[1]*, Putri Tria Santari[2], Nofrita Sandi[3]

[1] Horticulture and Plantation Research Center National Innovation Research Agency, Bogor 16915
[2] Food Crops Research Center National Innovation Research Agency, Bogor 16911
[3] Andalas University Faculty of Agriculture, Padang 25163

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Corresponding Author:
Riki Warman
rikiwarman@student.untan.ac.id

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Abstract: Peat soil has the potential and is widely available to be used for shallot cultivation with good and proper management, peat land is classified as marginal land for various types of plants because the soil condition is saturated with water, reacts acidic and contains toxic organic acids and low nutrient status so the condition of plant root media that is not conducive to root development so that it becomes a limiting factor in shallot cultivation. Efforts to increase peatland productivity for shallot cultivation can be carried out by adding organic fertilizers and using rhizosphere microorganisms such as Abuscular Mycorrhizal Fungi (AMF), this study aims to get a dose of organic fertilizer and AMF which can increase shallot production on peat soil. The research method used a separate experimental design (Split Plot) Completely Randomized Design which consisted of 2 factors, namely: AMF treatment (M) main plot consisting of 2 levels (without AMF application and AMF application), the second factor was the dose of organic fertilizer (O) child plot consisting of 6 levels (0 tons ha^{-1}, 3 tons ha^{-1}, 6 tons ha^{-1}, 9 tons ha^{-1}, 12 tons ha^{-1} and 15 tons ha^{-1}) there were 12 treatments each repeated 3 times, which was carried out in January-April 2021 in Pontianak City with the parameters of observing plant height, number of leaves, number of tillers, harvested dry tuber weight, harvested dry plant weight and tuber diameter. and the number of leaves, while the AMF treatment independently had a significant effect on the observation of the number of tillers, the weight of harvested dry tubers, the weight of harvested dry plants and the treatment of organic fertilizer with a dose of 3 tons h^{-1} showed good results because they were not significantly different from the required mines 15, 12 and 6 tons ha^{-1}.

Keywords: Red onion; Dose; Peat; Mycorrhiza; Organic fertilizer

Introduction

Shallots are a horticultural commodity belonging to the spice vegetables. Red onion is a commodity that is almost always needed as a cooking spice and has high economic value. In addition, the demand for shallots from year to year tends to increase. The demand for shallots has increased both in the form of consumption and as seeds. For this reason, efforts should be made to increase shallot production by expanding the planting area or using land that has not been cultivated intensively, such as marginal land, one of which is peatland. According to Najiyati et al., (2005) In general, peat soils have low fertility, availability of a number of macro nutrients (K, Ca, Mg, P) and micro (Cu, Zn, Mn, and Bo), and low PH. and contains toxic organic acids, and has a high Cation Exchange Capacity (CEC) but low Base Saturation (BS) so that it becomes a limiting factor in the practice of cultivating shallots on peat soils.

Efforts can be made to increase the productivity of peatlands in the cultivation of shallots by using the right technology such as the use of superior varieties, organic

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fertilizers, seed treatment and the use of microbiology. One of them is the utilization of Arbuscular Mycorrhizal Fungi (AMF), peat vegetation in West Kalimantan which is symbiotic with arbuscular mycorrhizae with a mutually beneficial relationship in which plants release root exudate which mycorrhizae can use as a food source (Buee et al., 2000) and the use of organic matter can provide a substrate for the reform process involving soil fauna and soil microflora (Saidy, 2018). According to Kivlin et al., (2011) that the existence of mycorrhizal fungal populations is strongly influenced by plant vegetation, geographical location and humidity and soil type. Peat had the highest number of spores and the percentage of root colonization in the application of 12 t ha^{-1} chicken manure. The available nutrient content in the soil can have a major impact due to the application of AMF colonization. However, the type or origin of peat and microbial composition can have a negative or positive impact on AMF (Abdullahi et al., 2015).

The application of mycorrhizae in plants is a form of effort to overcome the inhibition of plant growth both in the process of absorption of nutrients and the resistance of roots to stress by the surrounding environment, mycorrhizal fungi infect the host plant's root system, produce hyphae intensively so that the presence of mycorrhizae around plant roots can increase plant growth. plant growth performance in terms of leaf length, the number of shallot bulbs was higher when compared without using mycorrhiza (Fatkhurrahman et al., 2020). In line with the research of Rahman et al. (2019) The application of mycorrhiza and the use of 3 tons/ha-1 organic fertilizer with a dose of 250 kg P fertilizer, SP-36 ha^{-1} can increase plant dry weight and shallot bulb dry weight. This study aims to see the role of AMF and the use of organic fertilizer doses that can increase the production of shallots on peat soils.

Method

Time and place

The research was carried out on farmers' land in Pontianak city and the plant pest and disease laboratory, Faculty of Agriculture, University of Tanjungpura, which was carried out from January to April 2021.

Methodology

The study was conducted using the RAL Split Plot Experiment Design which consisted of 2 factors, namely: The first factor was the treatment of arbuscular mycorrhizal fungi (M), placed as the main plot consisting of 2 treatment levels (m0: Without Mikiriza Inoculum and m1: with Inoculum mycorrhiza) while the second factor was the dose of organic fertilizer from chicken manure (O) as child plots consisting of 6 levels (0 ton ha^{-1} , 3 ton ha^{-1}, 6 ton ha^{-1}, 9 ton ha^{-1}, 12 ton ha^{-1} and 15 tons ha^{-1}) consisted of 12 treatments, each treatment was repeated 3 times in each treatment unit consisting of 5 observation samples so that there were 180 units of observation.

Research Implementation

The planting medium used in this study was peat soil with hemist maturity level which had been dried and cleaned of coarse litter and then put into polybags measuring 35 x 35 cm. Each polybag was filled with ± 4.8 kg of soil, previously the peat soil used as a planting medium was mixed with dolomite 2 tons ha^{-1} or the equivalent of 10 g/polybag. Organic fertilizer was given 7 days before planting with doses of 0, 15, 30, 45, 60, 75 g/polybag, which is mixed into the planting medium, then incubated for 14 days.

The seeding process is carried out by means of seedling media with tubers measuring 5-6 g cut in ¼ of the previous portion, the seedling media consisting of sterile peat soil is put into the seedling basket. The onion bulbs that were used for the treatment of AMF inocula on the seedling media were mixed with AMF inocula with a ratio of 1:1 (w/w) for every 100 g of AMF inocula in the form of peat soil taken from pineapple rhizospheres, onion seeds which were not treated with AMF inocula. The media used is only peat soil that has been sterilized. Seeding lasts 7 days. Next, transplanting is carried out into the polybags that have been provided. Gain parameters in this study included plant height, number of leaves per clump, number of tillers per clump, dry harvested tuber weight per clump, dry harvested plant weight per clump and tuber diameter per clump and root infection by mycorrhizae, observations were made at 1, 2 , 3, 4, and 5 weeks after planting (MST), and observations of root infection were carried out using a microscope.

Data analysis

For data analysis, analysis of variance was used using Costat 6311Win software and if there was a significant effect it was continued with BNJ at a test level of 5%. The form of statistical analysis used is the RAL Split Plot Design, the statistical model is: $Yijk = \mu + \alpha i + \delta ik + \beta j + (\alpha\beta) ij + \square ijk$

Result and Discussion

Plant height

Data on the average height of shallot plants obtained were then analyzed for diversity to determine the effect of arbuscular mycorrhizal fungi and organic fertilizers which can be seen in Table 1.

Table 1. Analysis of Plant Height Diversity 7, 14, 21, 28 and 35 HST Due to Application of Organic Fertilizers and AMF.

SK	DB	F Count					F Table 5%
		7 HST	14 HST	21 HST	28 HST	35 HST	
Main Plot							
Mycorrhiza (m)	1	3.09tn	15.17tn	2.17tn	0.46tn	1.74tn	18.51
Square							
Organic fertilizer (o)	5	1.22tn	0.91tn	1.84tn	0.54tn	0.52tn	2.71
Interaction (mo)	5	0.68tn	0.59tn	0.49tn	0.73tn	0.78tn	2.71
Total	35						
KK (%)		4.51	20.02	13.51	12.91	11.65	

Note: * Real impact tn Unreal effect

The results of the analysis of diversity in Table 1. showed that mycorrhizal treatments, organic fertilizers and their interactions had no significant effect on all periods of plant height. Furthermore, the data on the average increase in plant height in each period is shown in Figure 1.

The increase in plant height and number of leaves at 7, 14, 21, 28 and 35 HST due to AMF and organic fertilizers showed no significant difference (Figures 1 and 2). While observing the root infection, it can be seen that the seedlings that were applied with AMF inolukula were infected (Figure 3). This is in accordance with what was reported by Rini et al. (2020) that the number of mycorrhizal infections in roots does not always have a significant effect on plant growth. In line with the research of Suryani et al. (2017) that the mycorrhizal treatment has not worked optimally on the growth of plant height and the number of shallot leaves, this has caused an increase in plant height and number of leaves due to the administration of AMF and organic fertilizers which have no significant effect.

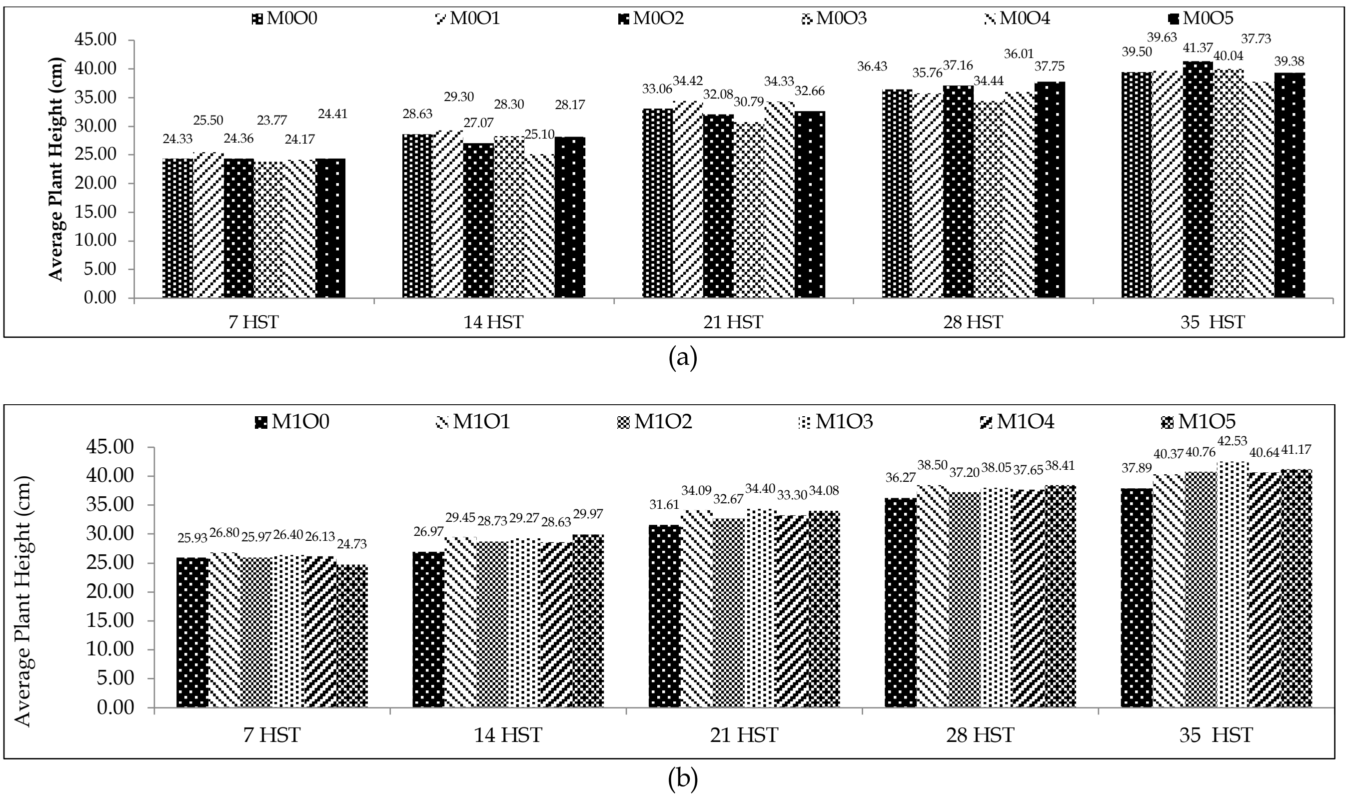


Figure 1. (a) Average plant height in the combination without mycorrhiza and doses of organic fertilizer, and (b) Combination of mycorrhiza and organic fertilizer dosage

Figure 1 shows that the height of shallot plants in the combination without mycorrhiza and various doses of organic fertilizer ranged from: 7 HST, namely 23.77 to 25.50 cm, 14 HST, namely 25.10 to 29.30 cm, 21 HST, namely 30, 79 to 34.42 cm, 28 HST which is 34.44 to 37.75 cm, and 35 HST which is 37.73 to 41.37 cm. It can be seen that the use of chicken manure on peat soil should be given up to a dose of 6 tons/ha with increasing doses not increasing shallot plant height, Elinda et al. (2022) reported that the application of quail organic fertilizer at a dose of 30 g/polybag could increase plant height to 31.96 cm and was not significantly different from giving up to a dose of 150 g/polybag for up to 8 weeks after planting.

Shallot plant height in a combination of mycorrhiza and various doses of organic fertilizers ranged from: 7 HST, namely 24.73 to 26.80 cm, 14 HST, namely 26.97 to 29.97 cm, 21 HST, namely 31.61 to 34.40 cm , 28 HST, namely 36.27 to 38.41 cm, and 35 HST, namely 37.89 to 42.53 cm. Ryan et al. (2002) reported that mycorrhizal fungi did not make a significant contribution in increasing nutrition and plant growth.

Number of Leaves Per Clump

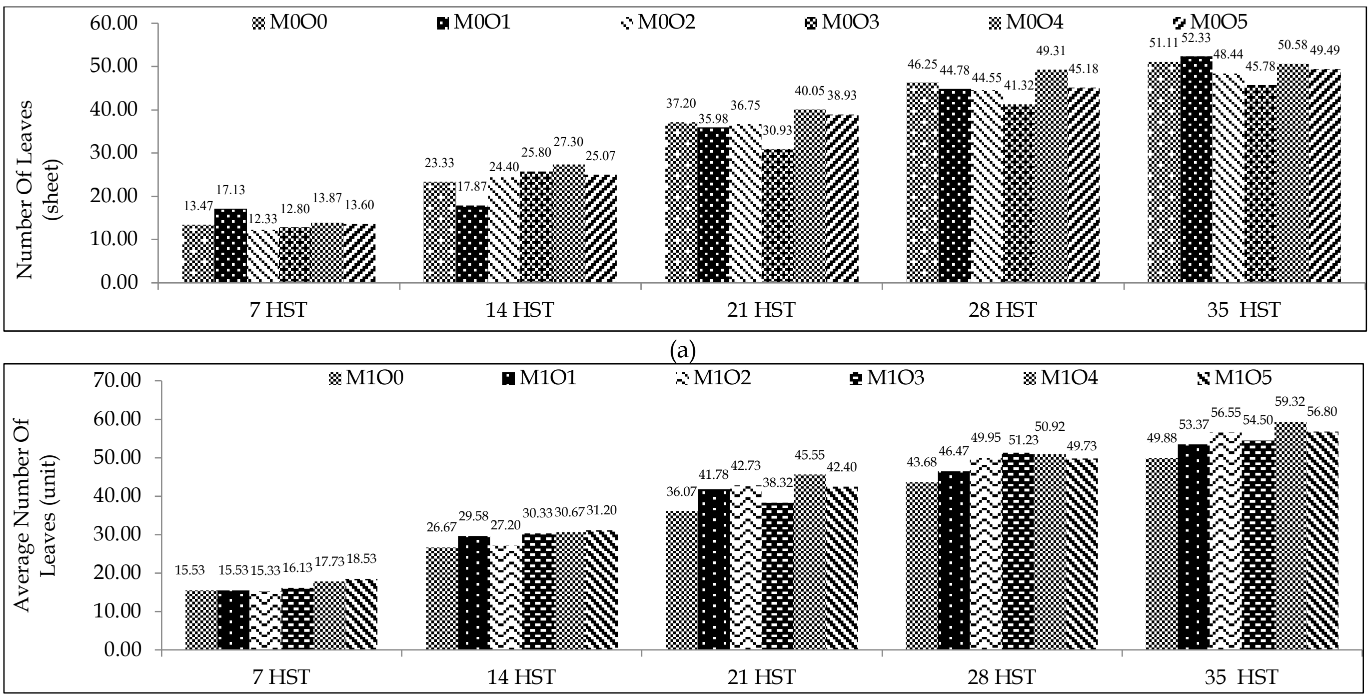
Data on the average number of leaves obtained were then analyzed for diversity to determine the effect of arbuscular mycorrhizal fungi and organic fertilizers on the number of shallot leaves, which can be seen in Table 2.

Table 2. Analysis of the Diversity of the Number of Leaves 7, 14, 21, 28, and 35 HST Due to the Application of Arbuscular Mycorrhizal Fungi and Organic Fertilizers

SK	DB	F Count					F Table 5%
		7 HST	14 HST	21 HST	28 HST	35 HST	
Main Plot							
Mycorrhiza (m)	1	14.77tn	15.17tn	2.17tn	0.46tn	1.37tn	18.51
Organic fertilizer (o)	5	1.32tn	0.91tn	1.84tn	0.54tn	0.52tn	2.71
Interaction (mo)	5	1.60tn	0.59tn	0.49tn	0.73tn	0.78tn	2.71
Total	35						
KK (%)		14.45	20.02	13.51	12.91	11.65	

Note: * Real impact tn Unreal effect

The results of the analysis of diversity in Table 2 showed that the mycorrhizal treatment of organic fertilizers and their interactions had no significant effect on the number of leaves at the ages of 7, 14, 21, and 35 HST. According to Hajoeningtijas et al. (2022) that the administration of AMF did not have a significant effect on increasing the number of leaves and the height of shallot plants, the number of leaves was more influenced by the availability of N in the soil. According to Idris et al. (2018), the application of chicken manure did not have a significant effect on increasing the number of leaves but had an effect on increasing production. This is in line with research conducted by Dani et al. (2021) which stated that adding several doses of chicken manure did not have a significant effect on increasing the number of shallots.



(b)

Figure 2. (a) Average Number of Leaves in the Combination Without Mycorrhiza and Dosage of Organic Fertilizer, and (b) Combination of Mycorrhiza and Dosage of Organic Fertilizer

Figure 2 shows that the number of shallot leaves in the combination without mycorrhiza and various doses of organic fertilizers ranged from: 7 HST, namely 12.33 to 17.13 leaves, 14 HST, namely 18.87 to 27.30 leaves, 21

HST, namely 30 .93 to 40.05 strands, 28 HST namely 41.32 to 49.31 strands, and 35 HST namely 45.78 to 52.33 strands. According to Priyadi et al. (2021) that applying chicken manure at a dose of 10 tonnes/ha can increase the average number of shallot leaves to 34.84 at 45 HST and is not significantly different from increasing the dose to 20 tonnes/ha.

The number of shallots in the combination of mycorrhiza and various doses of organic fertilizers ranged from: 7 HST, namely 15.33 to 18.53 leaves, 14 HST, namely 26.67 to 31.20 leaves, 21 HST, namely 36.07 to 45.55 strands, 28 HST, namely 43.68 to 51.23 strands, and 35 HST, namely 49.88 to 59.32 cm. According to research by Utama et al. (2019) the use of mycorrhiza at 2 tons/ha can increase the number of shallots up to 53.33 strands in 35 HST.

Number of tillers per clump, dry tuber weight harvested per clump, tuber diameter per clump and dry plant weight harvested per clump

Data on the average number of tillers, harvested dry tuber weight, harvested dry plant weight per clump and tuber diameter per clump were obtained, then analysis of diversity was carried out to determine the effect of arbuscular mycorrhizal fungi and organic fertilizers which can be seen in Table 3.

Table 3. Analysis of Diversity in the Number of Tillers Per Clump, Weight of Dry Tubers Harvested Per Clump, Diameter of Tubers Per Clump and Weight of Dry Plants Harvested Per Clump as a Result of the Application of Arbuscular Mycorrhizal Fungi and Organic Fertilizers.

SK	DB	F Count: Number of tillers/clump	Harvest/clump dry tuber weight	Harvest/clump dry plant weight	Diameter of tuber/clump	F Table 5%
Main Plot						
Mycorrhiza (m)	1	34.09*	42.62*	44.00*	18.30tn	18.51
Plot Child						
Organic fertilizer (o)	5	1.97tn	3.02*	3.67*	1,59 tn	2.71
Interaction (mo)	5	0.51tn	1.77tn	1.63tn	0.86tn	2.71
Total	35					
KK (%)		32.69	25.06	25.90	26.41	

Note: * Real impact tn Unreal effect

The results of the analysis of diversity in Table 3 show that the single mycorrhizal treatment had a significant effect on the number of tillers, harvested dry weight and harvested dry plant weight. The independent treatment of organic fertilizers had a significant effect on dry harvested tuber weight and harvested dry plant weight while the interactions of the two had no significant effect on the number of tillers, harvested dry weight and harvested dry plant weight, while mycorrhizal and organic fertilizer treatments and their interactions had no significant effect on diameter. tubers.

The BNJ test results in Table 4 show that the number of tillers in the mycorrhizal inoculum treatment was significantly different from those not given mycorrhizal inoculum, while the treatment with organic matter was not significantly different. Observation of harvested dry tuber weight and harvested dry plant weight The treatment of mycorrhizal inoculums was significantly different from the treatment without mycorrhizal inoculums while the treatment without organic fertilizer was significantly different from the treatment of organic fertilizer 15 tonnes ha^{-1}, but not significantly different from the other treatments.

Table 4. Average Number of Tillers Per Clump, Dry Tuber Weight Harvested Per Clump, Tuber Diameter Per Clump and Dry Plant Weight Harvested Per Clump and Effects of Application of Arbuscular Mycorrhizal Fungi and Organic Fertilizers

Treatment	Number of tillers/clump (stems)	Weight of dry tubers harvested/clump (grains)	Harvested dry plant weight/clump (gr)	Big tuber circumference (cm)
No mycorrhizal inocula	6.06 b	39.33 b	48.11 b	1.21 a
With mycorrhizal inocula	10.81 a	59.82 a	77.46 a	1.78 a
BNJ 5%	3.49	13.50	19.03	0.57
Organic Fertilizer Dosage (ton ha-1)				
0	6.73 a	4033 b	47.06 b	1.27 a
3	7.97 a	54.13 ab	68.6 ab	1.45 a
6	9.13 a	54.96 ab	70.37 ab	1.52 a
9	6.60 a	37.70 b	47.76, b	1.30 a
12	10.0 a	50.16 ab	64.56 ab	1.62 a
15	10.2 a	60.17 a	78.33 a	1.81 a
BNJ 5%	5.00	22.55	29.51	0.72

Note: Numbers followed by the same letters based on different columns are not significant in the BNJ test at the 5% level

The results of the analysis of diversity showed that there was no interaction of AMF and organic fertilizers on the number of shallot tillers. Independently the application of AMF had a significant effect on the number of tillers, the application of AMF inocula resulted in 10.81 stems whereas without using AMF inocula only 6.06 stems as shown in table 4. This suggests that the condition of the peat soil used as the growth medium is perfectly mature as well as the application of AMF creates favorable soil conditions for the development of shallot bulbs so that the tiller formation process runs optimally besides that, during growth AMF is also active in absorbing nutrients through external hyphae and is exchanged with energy from plants in the form of simple sugars which are utilized for plant development (Malik et al., 2017) while the dose treatment of organic fertilizers had no significant effect, according to Damanik et al. (2018), that mycorrhizae can increase the number of shallot tillers to a significant difference, while organic fertilizers cannot increase the number of tillers.

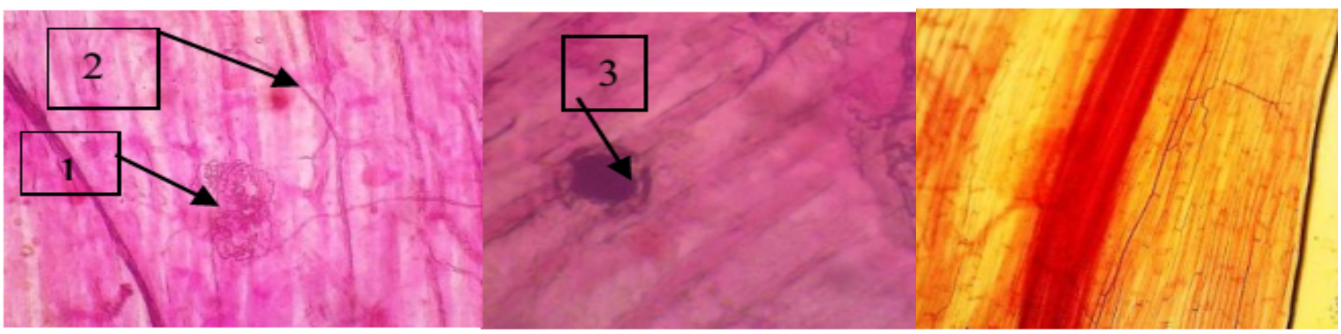
The application of AMF inocula independently had a significant effect on the harvested dry tuber weight and harvested dry plant weight without treatment without AMF inocula. According to Saleh et al. (2021), the addition of 10 g/plant of mycorrhizal fungi can increase shallot production by up to 8 tons/ha. Organic fertilizers independently have a significant effect on harvested dry tuber weight and harvested dry plant weight. Provision of AMF and organic fertilizer in the form of chicken coop has an effect on the weight of harvested tubers per clump and the weight of dry harvested plants per clump because the amount of nutrients in the soil can be absorbed well by plants during tuber formation so that the application of chicken manure has a significant effect on the weight of fresh tubers (Nasution et al. al., 2016).

The high dry harvested tuber weight and harvested dry plant weight in the 3 ton ha^{-1} organic fertilizer treatment was caused by the availability of nutrients as a result of the mineralization process of organic fertilizer into the soil, so that plant metabolism can run optimally due to the presence of mycorrhiza. Meanwhile, the low dry weight of harvested tubers and harvested dry plant weight in the treatment of 9 tons ha^{-1} (Table 4) suggests that the increase in dry weight is not only influenced by the availability of nutrients but also greatly influenced by the level of disease attack that attacks plants, namely the fungus *Fusarium sp*. which attacks the body parts of plants to the tubers. This fungus attacks the leaf parts of plants, initially causing symptoms of chlorosis on the leaves until the leaves of the plant die as reported by Warman et al. (2021) that the acidic peat soil environment with high humidity and heat triggers the attack of the fungus *Fusarium oxysporum* more quickly.

The interaction between mycorrhiza and manure did not show a significant difference. According to Farida et al. (2015), that there is no real interaction between the combination of mycorrhiza and manure applications on plant growth and production, in general the application of AMF and organic fertilizers functions to assist plants in obtaining nutrients and water in the soil so that plant metabolic processes can run optimally which in turn can increase the yield of assimilate which will be used in the formation of roots, stems and leaves (Octavia et al., 2016).

The results of the analysis of diversity showed that the mycorrhizal and organic fertilizer treatments and their interactions had no significant effect on shallot bulb diameter according to the results of the study by Saleh et al. (2017) that there is no significant difference in the effect of using AMF and irrigation techniques on shallot bulb diameter. In addition, Salamandane et al. (2022) stated that an additional dose of chicken manure had no significant effect on increasing the diameter of the tuber. The application of a dose of 2.65 kg/m^2 was better than a dose of 21.2 kg/m^2.

Observations were made using a microscope after the roots were stained (Irmayani et al., 2022) so that it was easier to determine if there were signs of mycorrhizal infection. The following is a picture of the differences between plant roots colonized with AMF and plant roots without AMF colonization.



(a) (b)

Figure 3. Cross-section of mycorrhizal roots formed 1. Arbuscular, 2. Vesicles, and 3. Internal hyphae (a) and non-mycorrhizal (b)

Root colonization is a form of symbiotic process between host plant roots and AMF. According to Baptista et al. (2011) the process of root colonization is divided into 4 stages, namely before infection, penetration of hyphae in the roots of the host plant, hyphae grow and develop in the root cells and the final stage of AMF will carry out its function to help absorb nutrients and water for the host plant. The results of observations on shallot plant root samples formed internal and external hyphae, vesicles, and arbuscular structures (Figure 3). The structure formed by the AMF spores functions in carrying out an important role in the association process. Hyphae are formed from the germination of spores, which play a role in absorbing nutrients and water from the outside into the roots and then used in the process of growth and development of the host plant. The arbuscular structure has a tree-like shape, formed by branches of intraradical hyphae that lie between the cell wall and the cell membrane.

Based on the results of observations on all samples of shallot plant roots that had been inoculated with AMF, it showed that all plant roots were colonized by AMF. Muryati et al. (2020) stated that the percentage of root colonization of maize and shallots was higher than the infection rates of 58% and 56% compared to Jatropha curcas, which was only 31%. Morte et al. (2000) stated that the ability of AMF to support root growth and colonization varied depending on the suitability of the combination of fungi and host. Infection that occurred in shallot roots in this study indicated a compatibility between plant roots and AMF inoculants, and was supported by environmental conditions that supported the occurrence of infection. Anwarudinsyah et al. (2005) stated that the reaction compatibility, incompatibility, infectivity and effectiveness of AMF were strongly influenced by several things such as the environment, the type of mycorrhiza, and the type of plant.

Conclusion

The application of AMF and organic fertilizers and their interactions did not affect the number of leaves and shallot plant height. While the application of organic fertilizer at a dose of 3 tons ha-1 has been able to increase the yield of harvested dry tuber weight and harvested dry plant weight which were not significantly different from the application of organic fertilizer up to 15 tons ha^{-1}, because at this dose AMF works optimally. AMF application alone provides significantly different results than without using AMF.

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