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Response of Two True Shallot Seed Varieties to Indigenous Arbuscular Mycorrhizal Fungi Inoculation

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ABSTRACT

Seed availability poses a significant challenge for farmers, and True Shallot Seed (TSS) derived from seeds offers a potential solution to this problem. Currently, farmers primarily rely on bulb seeds for shallot cultivation. Therefore, extensive research on TSS seeds is crucial. This study aimed to investigate the impact of different indigenous FMA isolate types on the growth of various shallot varieties derived from seeds and the root infection of shallot plants. The research was conducted at the Wire House of the Faculty of Agriculture, Andalas University. A completely randomized design with two factors, namely the variety type and FMA dose, was employed, with three replications. The Lokananta and Sanren varieties were used, and the doses of FMA applied were 0, 10, 20, and 30 g/plant. The findings revealed no interaction between the variety type and FMA dose. The Sanren variety outperformed the Lokananta variety in plant height, number of leaves, percentage of root infection, root fresh weight, and root volume. Additionally, the FMA dose of 30 g/plant yielded better results regarding root fresh weight and volume.

Keywords: *Dose, Lokananta, Lowland, Sanren, Seed*

1. INTRODUCTION

The management and production of shallots, recognized as superior commodities (BPS, 2022), require continuous attention. Cultivating shallots poses several challenges, including the limited availability of seed tubers during the rainy season. This scarcity is primarily attributed to the significant number of seed bulbs that rot throughout this period (Askari-Khorasgani, O., & Pessarakli, 2020). To address this issue, Kamanga et al. (2021) have emphasized adopting cultivation technology to mitigate these problems. One such approach is the utilization of True Shallot Seed, a seed propagation method.

According to GAMS & IW (2017), True Shallot Seed (TSS) is a shallot cultivation method involving seed propagation. This technique offers various benefits, such as being virus- and disease-free, requiring fewer seed hectares, and reducing production costs. In a study conducted by Van den Brink and Basuki (2009), it was found that the use of TSS could significantly increase shallot productivity, with yields ranging from 36.2 to 42.5 tons per hectare, surpassing the yields obtained from bulbs produced by farmers (average of 17.1 tons per hectare) and imported tubers (average of 23.2 tons per hectare). Additionally, TSS results in shallots having a longer shelf life than tubers, ensuring a more stable supply. While seed propagation for shallots is commonly practiced in highland areas, research by Rosliani et al. (2016) has identified opportunities to enhance cultivation techniques for improved yields in lowland regions.

Shallot cultivation is commonly practiced on fertile land, competing with other vegetables for space due to limited land availability (Getahun, 2016). However, the continuous development has led to a decrease in fertile land, posing a challenge for shallot cultivation. This limitation can be addressed by utilizing Arbuscular Mycorrhizal Fungi (AMF).

Arbuscular Mycorrhizal Fungi (AMF) is a symbiotic relationship between fungi and plant roots. AMF serves various functions, such as a bioprotector, biofertilizer, and phytostimulator (Wangiyana et al., 2021). By facilitating the uptake of nutrients by plants, AMF enhances the availability of nutrients in the soil and helps protect plants from pathogen attacks. The effectiveness of AMF is particularly evident in nutrient-poor or acidic soils.

Spores of arbuscular mycorrhizal fungi exhibit resilience under specific circumstances influenced by agricultural practices such as soil management, fertilization, and crop selection (Melenium et al., 2022). Moreover, the efficacy of AMF is contingent upon its compatibility with the host plant. Indigenous AMF, derived from the rhizosphere of the same plant, demonstrates superior adaptability, facilitating rapid nutrient absorption and provision to plants. Indigenous AMF also exhibits accelerated growth rates, enhancing plant growth and development (Susila et al., 2017; Natawijaya et al., 2022). Research conducted by Armansyah et al. (2022) revealed that indigenous AMF sourced from the rhizosphere of coffee plants exhibited a higher spore count. Furthermore, various plant species and cultivars display distinct responses to AMF. Susila (2018) demonstrated that the application of AMF can reduce tuber weight loss in sensitive varieties by up to 8.31% and intolerant varieties by up to 15.58%.

Therefore, research is conducted on using indigenous AMF in shallot cultivation with seeds, known as TSS, as an innovative technology to enhance shallot production. This research aims to determine the influence of indigenous AMF isolate types on the growth of several shallot varieties from seeds and the root infection of shallot plants.

2. MATERIAL AND METHODS

The study was conducted at the Andalas University Wire House, Limau Manis, Pauh District, Padang (La -0.914518, Lo-100.459526), at an elevation of +200 m above sea level (masl). It took place from January to May 2023. The research utilized shallot seeds of the Lokananta and Sanren varieties, KOH 10%, HCl 1%, lacto glycerol trypan blue, Ultisol, and multispore AMF (Glomus and Scutelospora). The equipment employed included plant pots, soil spoons, digital scales, buckets, plastic labels, paper labels, thread, black marker, stationery, tape measure, ruler, seed bed, cellphone camera, binocular microscope, razor blade, knife, scissors, raffia rope, sprinkler, preparation glass, dropper pipette, cover glass, film bottle, hotplate, and gloves. The research was conducted using a Completely Randomized Design (CRD) with 2 factors and 3 replications each. Factor 1 consisted of 2 varieties (Sanren and Lokananta), while factor 2 was the mycorrhizal dose, which included 0 g, 10 g, 20 g, and 30 g AMF/plant. Each experimental unit comprised 5 plant pots, totaling 120 pots. The initial preparation is by organizing all tools and materials and sowing propagation materials in a seedbed with a seeding medium of soil, cow manure, and husks in a 1:1:1 (V:V: V) ratio for 30 days. The seeds were soaked in fresh water at an average temperature for 12 hours before sowing. Additionally, planting media and indigenous AMF isolates were readied. Planting was carried out after sowing, using sterilized soil and manure to eliminate harmful microorganisms. The prepared AMF isolate was then added to the pot according to the treatment dose. Subsequently, the shallot seeds were transferred into individual pots, followed by maintenance and observation.

The variables observed included plant height, leaf count, tuber diameter, root infection percentage, fresh root weight, and root volume. The research data was analyzed using the F test at a 5% significance level, with significantly different data further examined through Duncan's New Multiple Range Test (DNMRT).

3. RESULT AND DISCUSSION

3.1 Plant Height

The findings from examining various shallot plants 6 weeks after planting (WAP) using the 5% level Duncan's Multiple Range Test (DMRT) revealed significant variations in plant height between the two different shallot varieties. However, no significant differences were observed in plant height when considering the dosage of arbuscular mycorrhizal fungi (AMF). Furthermore, no interaction was observed between the shallot varieties and the dosage of AMF. The average observations are presented in Table 1.

Table 1. Mean plant height of two seed-origin shallot varieties (TSS) to different doses of FMA

Mycorrhizal Dosage (g/plant)	**Plant Height (cm) Variety**		**Mean**
	Lokananta	**Sanren**	
0	45,63	53,43	49,53 ± 5,52
10	52,57	54,60	53,58 ± 1,44
20	51,13	54,60	52,86 ± 2,45
30	47,87	55,93	51,90 ± 5,70
Mean	49,30 ± 3,14 b	54,64 ± 1,02 a	

Note: Numbers followed by different lowercase letters in the row indicate significant differences in the DMRT test at the 5% level.

The effects of two varieties of shallots were found to be distinct, while the AMF dose had a consistent impact. As Saidah et al. (2019) stated, the Sanren variety of shallots exhibited taller plants and more leaves. This finding aligns with the description of the Sanren shallot variety, known for its taller plants than the Lokananta type. Figure 1 provides visual evidence of this distinction.

Under optimal circumstances, the genetic potential of plants will manifest flawlessly. This observation supports the viewpoint of Azmi et al. (2011) that the planting location plays a significant role in influencing plant growth, which is further influenced by environmental factors and seasonal variations. Consequently, disparities in plant height can be attributed to the diversity arising from different varieties of shallots planted and their interactions with the prevailing environmental conditions.

The efficacy of the AMF dose treatment was observed to be more favorable at a dosage of 10 g per plant (M2), specifically resulting in a height of 53.58 cm. Different clones and growth types also influence the variation in shallot plant height. At the same time, the length of the leaves is affected by the planting location, which is influenced by the surrounding environment and the season (Azmi et al., 2016; Abdillah Siregar & Ulpah, 2024).

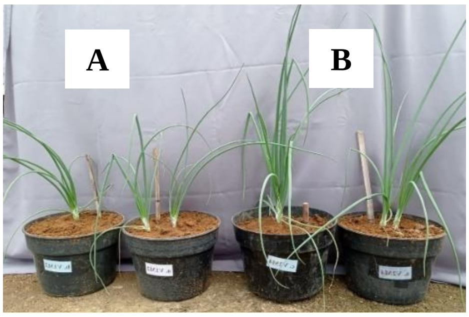

Figure 1. Growth of shallot varieties Lokananta (A) and Sanren (B) at 45 HST

3.2 Leaf Count

According to Tsagaye et al. (2022), each variety's potential yields and characteristics differ due to the genetic potential of individual plants. Environmental factors, such as high rainfall and genetic factors, contribute to the short leaf length. The research has been tailored to specific locations and conditions, resulting in a diverse range of varieties, as Sumarni and Rosliani (2010) stated. They further suggest that the growth process of shallots from seeds can be influenced by transparent plastic shade and plant density. Table 2 provides a visual representation of these findings.

Table 2. Mean number of leaves of two seed-origin shallot varieties (TSS) against different doses of FMA

Mycorrhizal Dosage (g/plant)	Leaf Count of Variety		Mean
	Lokananta	Sanren	
0	7,33	9,33	8,33 ± 1,41
10	8,00	10,00	9,00 ± 1,41
20	7,33	9,33	8,33 ± 1,41
30	7,33	9,67	8,50 ± 1,65
Mean	7,50 ± 0,34 b	9,58 ± 0,32 a	

Note: Numbers followed by different lowercase letters in the row indicate significant differences in the DMRT test at the 5% level.

Based on the data presented in the table, it is evident that the treatment applied to the two different varieties significantly impacts the quantity of plant leaves. Specifically, the Sanren variety exhibited the highest average response to the treatment, with a value of 9.58. Alavan et al. (2015) highlighted that variances in plant appearance are influenced by varietal distinctions, which stem from genetic variations or their reactions to environmental stimuli. Similarly, Manik et al. (2019) suggested that the genetic makeup of each specific variety determines the number of leaves. The diversity in leaf numbers among different plant varieties or clones can consequently affect the leaf characteristics of subsequent generations.

According to Saidah and colleagues (2019), the Sanren type of shallots exhibits larger plants and a more significant number of leaves. This result aligns with the characteristics of the Sanren variety, which has taller plants and a higher leaf count than the Lokananta variety. The data presented in Figure 2 and Figure 3 further supported these observations, showing plant height and leaf quantity growth patterns.

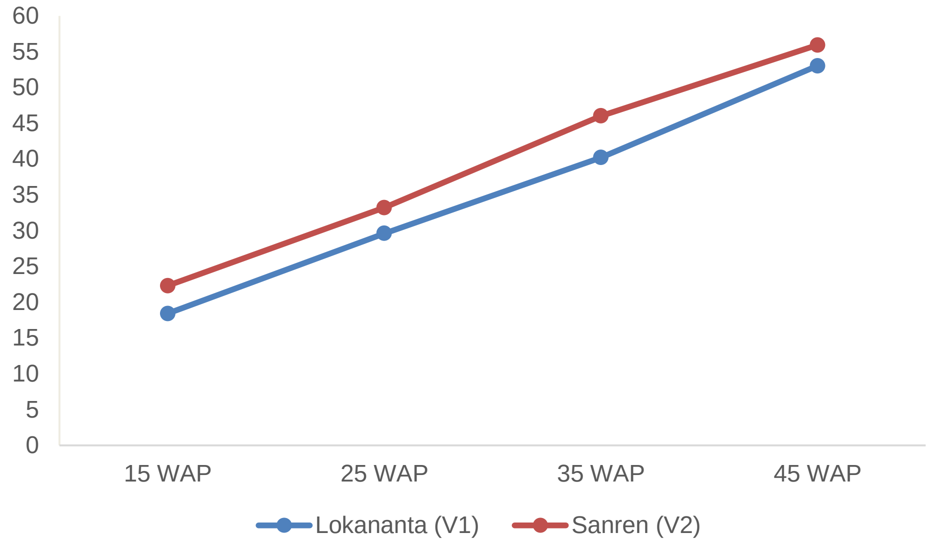

Figure 2. The growth rate of shallot plant height at the age of 15 weeks to 45 weeks due to a variety of treatment

The figure above illustrates a clear trend in the growth rate of Sanren and Lokananta varieties from 15 WAP to 45 WAP (Week After Planting). The Sanren variety exhibited a higher growth rate, ranging from an average of 22.3 cm to 55.9 cm, compared to Lokananta. This disparity can be attributed to the rapid growth and development experienced by the stems, leaves, and roots of the Sanren variety. However, during the later stages of plant growth (35-45 WAP), there is a noticeable slowdown in growth as the top part of the plant experiences increased development, leading to competition between the top and bottom parts of the plant, both of which serve as essential receivers (sinks) (Oliveira, 2015).This result can also be observed in the variable rate of the leaf count shown in Figure 3.

Similarly, the Sanren variety exhibited a higher growth rate in the number of leaves than the Lokananta variety, ranging from 3.7 to 10. Both varieties of shallots experienced an increase in the growth rate of leaf numbers starting at 25 WAP, with a significant increase observed at 35 WAP. Environmental factors and the genotype of each shallot seed greatly influence the formation of leaves. The greater the number of leaves formed, the more optimal the growth and resulting outcomes, which aligns with the viewpoint expressed by Putra, B and Ningsi (2019). According to their research, plants with a higher leaf count contribute to increased photosynthate yields, which can be utilized to produce dry matter.

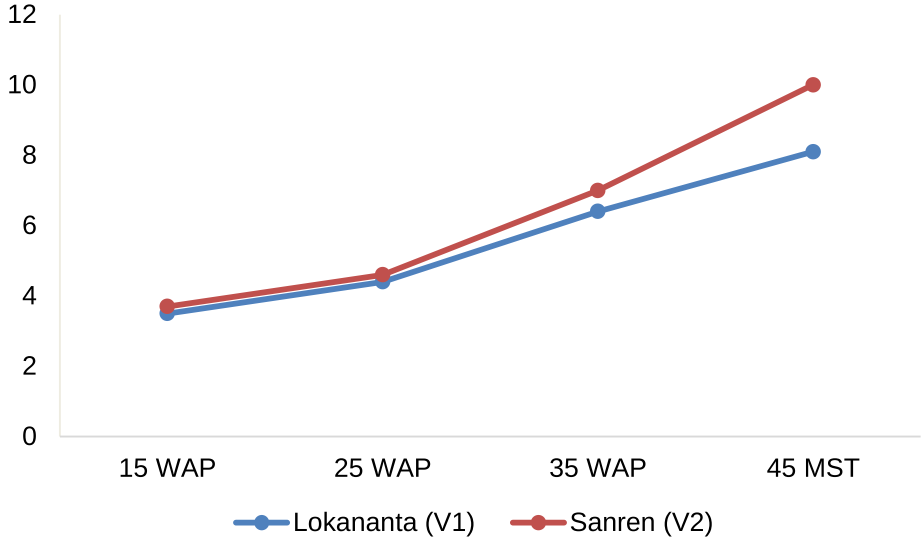

Figure 3. The growth rate of the number of shallot leaves at the age of 15 MST- 45 MST due to varietal treatment

3.3 Tuber Diameter

The observed bulb diameters showed no significant difference between the two varieties. The data in Table 3 reveals that the Sanren variety has an average bulb diameter of 31.82 mm, which is not significantly different from the Lokananta variety, which measures 31.22 mm.

Table 3. The mean diameter of onion bulbs inoculated with FMA in two different varieties at age 94 HST

Mycorrhizal Dosage (g/plant)	Tuber Diameter Variety		Mean
	Lokananta	Sanren	
0	30,23	32,83	31,53 $\pm$ 1,84
10	32,37	31,07	31,72 $\pm$ 0,92
20	31,53	31,03	31,28 $\pm$ 0,35
30	30,77	32,37	31,57 $\pm$ 1,13
Mean	31,22 $\pm$ 0,93	31,82 $\pm$ 0,91	

Note: Numbers followed by different lowercase letters in the row indicate significant differences in the DMRT test at the 5% level.

The maximum growth of tuber diameter for both varieties was observed following the plant description, as illustrated in Figure 4. This observation aligns with the vegetative growth, particularly plant height. It is believed that taller plants tend to have broader leaves, leading to increased photosynthate production. A study by Shofiah, DKR., and Tyasmoro (2018) indicated that plants with large leaf blades and extensive leaf areas tend to contain higher levels of chlorophyll, facilitating growth through enhanced photosynthesis. Previous research has shown a significant correlation between plant height and tuber diameter, while wet and dry biomass yields did not exhibit substantial differences (Wati & Sobir, 2019). These findings contradict Saidah et al. (2019), who reported in Sigi Regency, Central Sulawesi, where the Lokananta and Sanren varieties displayed distinct responses regarding shallot bulb growth and yield. This disparity could be attributed to variations in regional and environmental conditions. A study by Sumarni et al. (2012) conducted in the lowlands of Cirebon revealed that the growth and yield of shallots were unaffected when exposed to different varieties from seed.

Figure 4. Bulbs of shallot varieties Lokananta (A) and Sanren (B) 94 HST

3.4 Percentage of Root Infection

The percentage of root infection varies between the two varieties, as evidenced by Table 4 and Table 5. Based on the information presented in Table 4 and Table 5, it is evident that plants not treated with AMF did not show any colonization, indicating a 0% colonization rate. This lack of colonization in plants where AMF was not applied can be attributed to using sterile soil as the planting medium. Sagala et al. (2013) have previously stated that sterilized planting media do not support the colonization of plant roots and the presence of AMF. The naturally occurring AMF in the planting media may become inactive in such conditions. Furthermore, there are variations in colonization results between the Lokananta and Sanren varieties. The Lokananta variety exhibited the highest percentage of colonization when given an AMF dose of 10 g/plant, whereas the Sanren variety showed the highest colonization rate at an AMF dose of 30 g/plant. These differences can be attributed to the variations in the characteristics of the two varieties. According to Sumarni et al. (2012), each array possesses different potentials, including their ability to adapt to the environment.

Tabel 4. Persentase kolonisasi akar tanaman bawang merah varietas Lokananta pada beberapa dosis Fungi Mikoriza Arbuskula umur 45 HST

Mycorrhizal Dosage (g/plant)	Root Colonization Percentage of Varieties Lokananta (%)	Remark
0	00	Extremely low
10	40	Intermediate
20	25	Low
30	20	Low

Category description: 0-5% = very low, 6-25% = low, 26-50% = medium, 51-75% = high, 76-100% = very high (Rajapakse & Miller, 1992)

3.5 Fresh Root Weight

The fresh weight of the roots can be observed in Table 6. Based on Table 6, the Sanren variety provides a higher average fresh root weight than the Lokananta variety, reaching 2.68 g. This result is attributed to the variety's influence on root growth. Awas et al.

(2010) stated that even when planted in the same soil, each variety responds differently due to varying root and leaf growth.

Mycorrhiza dosage also significantly impacts root fresh weight. The average results show that the highest mycorrhiza dosage, at 30 g/plant, reaches 2.33 g. According to Nurmasyitah et al. (2013), determining the mycorrhiza dosage significantly affects the soil's total nitrogen, and there is a specific dosage composition between standard fertilizer and mycorrhiza biofertilizer to enhance the soil's total nitrogen. Budi S and Sari (2015) state that nitrogen, such as roots, is crucial for plants' vegetative organ development.

This sentiment is also echoed by Syahril (2021), who said that the growth and yield of shallots can be influenced by the mycorrhiza dosage provided. Research by Ansyar et al. (2017) shows better results with a combination of worm compost and mycorrhiza at 10 g/plant.

Table 5. Percentage of root colonization of shallot plants of Sanren variety at several doses of Arbuscular Mycorrhizal Fungi at the age of 45 HST

Mycorrhizal Dosage (g/plant)	Root Colonization Percentage of Varieties Sanren (%)	Remark
0	00	Extremely low
10	20	Low
20	50	Intermediate
30	60	High

Category description: 0-5% = very low, 6-25% = low, 26-50% = medium, 51-75% = high, 76-100% = very high (Rajapakse & Miller, 1992)

Table 6. Fresh weight of FMA-inoculated roots in two different varieties at age 94 HST

Mycorrhizal Dosage (g/plant)	Root Fresh Weight (g) Variety		Mean
	Lokananta	Sanren	
0	0,67	2,07	1,37 ± 0,99 b
10	1,33	2,43	1,88 ± 0,78 a
20	1,25	3,00	2,12 ± 1,24 a
30	1,42	3,23	2,33 ± 1,28 a
Mean	1,17 ± 0,34 b	2,68 ± 0,53 a	

Note: Numbers followed by different lowercase letters in the row indicate significant differences in the DMRT test at the 5% level.

3.6 Root Volume

The results of root volume observations can be seen in Table 7. The Sanren variety exhibits an average yield of 1.25 ml, surpassing the Lokananta variety, which yields 0.54 ml. According to Meliala (2011), a variety is considered adaptive if it demonstrates robust growth in its designated region, maintains high and consistent production levels, and fosters coexistence with its surroundings. This notion aligns with Allard's (1960) assertion that the immediate environment surrounding a plant, influenced by its genetic makeup, plays a significant role in its development. It is essential to note that plant genes can only manifest specific characteristics under suitable environmental conditions.

The average mycorrhizal dose per plant was recorded at 30 g, with the highest dose being 1.02 ml, followed by doses of 20 g and 10 g per plant. Mustafa et al. (2015) say mycorrhiza can boost root growth by enhancing nutrient uptake and releasing components typically bound in clay particles. Furthermore, available phosphorus (P) can promote cell division, particularly during meristem development, enhancing plant growth.

Table 7. Root volume of FMA-inoculated shallots in two different varieties at age 94 HST

Mycorrhizal Dosage (g/plant)	Root Volume (ml) Varieties		Mean
	Lokananta	Sanren	
0	0,33	1,04	0,69 ± 0,50 b
10	0,58	1,21	0,90 ± 0,45 a
20	0,67	1,29	0,98 ± 0,44 a
30	0,58	1,46	1,02 ± 0,62 a
Mean	0,54 ± 0,15 b	1,25 ± 0,17 a	

Note: Numbers followed by different lowercase letters in the row indicate significant differences in the DMRT test at the 5% level.

4. CONCLUSION

According to the findings of the study, it is evident that there are notable variations in results based on the type of variety utilized. The Sanren variety exhibits greater plant height, leaf count, fresh root weight, and root volume than the Lokananta variety. The application of AMF did not yield a significant variance in the vegetative growth of TSS shallots. However, it did have an impact on fresh root weight and root volume. Upon analyzing the average outcomes, it is apparent that the AMF dosage does not differ significantly from the two varieties under examination, indicating the absence of interaction between the two factors.

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