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EFFECTIVENESS OF USING ARBUSCULAR MYCORRHIZAL FUNGI AND COMPOST TO INCREASE GOGO RICE PRODUCTION IN SUBOPTIMAL LANDS

EFEKTIFITAS PENGGUNAAN FUNGI MIKORIZA ARBUSKULAR DAN PUPUK KOMPOS UNTUK MENINGKATKAN PRODUKSI PADI GOGO DI LAHAN SUBOPTIMAL

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ABSTRACT

The expansion of upland rice cultivation into suboptimal lands, particularly Ultisols, represents a strategic approach to increasing national rice production. However, low soil fertility, acidic pH, and limited nutrient availability constrain productivity in such environments. This study aimed to evaluate the effectiveness of Arbuscular Mycorrhizal Fungi (AMF) and compost application in improving the growth and yield of upland rice (Inpago 12) cultivated on Ultisol soils in Deli Serdang and Langkat, North Sumatra. A factorial randomized block design with three factors, AMF dosage (0–600 spores), compost rate (0–5 t ha^{-1}), and location that was implemented with three replications (150 experimental units). Soil analysis confirmed acidic conditions with low nutrient status typical of Ultisols. Five AMF taxa were identified with root colonization ranging from moderate to very high (46.67–100%). ANOVA results revealed that location significantly affected most growth and yield parameters, whereas AMF and compost treatments showed limited statistical effects. The most effective treatment combination was 450 spores with 2 t ha^{-1} compost in Deli Serdang, which improved tiller number, biomass, and panicle production. These findings indicate that the effectiveness of AMF and compost application in Ultisols is highly site-specific and influenced by local soil characteristics.

KATA KUNCI:

Fungi mikoriza arbuskula, inokulan, padi gogo, produktivitas, ultisol

ABSTRAK

Perluasan budidaya padi gogo ke lahan suboptimal, khususnya Ultisol, merupakan salah satu strategi untuk meningkatkan produksi beras nasional di Indonesia. Namun demikian, rendahnya kesuburan tanah, pH yang masam, serta keterbatasan ketersediaan unsur hara menjadi faktor pembatas produktivitas pada kondisi tersebut. Penelitian ini bertujuan untuk mengevaluasi efektivitas aplikasi Fungi Mikoriza Arbuskula (FMA) dan kompos dalam meningkatkan pertumbuhan dan hasil padi gogo (Inpago 12) yang dibudidayakan pada tanah Ultisol di Indonesia. Penelitian menggunakan Rancangan Acak Kelompok (RAK) faktorial dengan tiga faktor, yaitu dosis FMA (0–600 spora), dosis kompos (0–5 ton ha^{-1}), dan lokasi, yang diulang sebanyak tiga kali (150 unit percobaan) di Deli Serdang dan Langkat, Sumatera Utara. Analisis tanah menunjukkan kondisi masam dengan status hara rendah yang khas pada Ultisol di Indonesia. Lima taksa FMA berhasil diidentifikasi dengan tingkat kolonisasi akar berkisar dari sedang hingga sangat tinggi (46,67–100%). Hasil ANOVA menunjukkan bahwa faktor lokasi berpengaruh signifikan terhadap sebagian besar parameter pertumbuhan dan hasil, sedangkan perlakuan FMA dan kompos menunjukkan pengaruh statistik yang terbatas. Kombinasi perlakuan paling efektif adalah 450 spora dengan 2 ton ha^{-1} kompos di Deli Serdang, yang meningkatkan jumlah anakan, biomassa, dan jumlah malai. Temuan ini menunjukkan bahwa efektivitas aplikasi FMA dan kompos pada Ultisol di Indonesia sangat bersifat spesifik lokasi dan dipengaruhi oleh karakteristik tanah setempat.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the world's most important staple food, providing more than 20% of the world's calorie needs for more than 3.5 billion people (Muthayya *et al*., 2014). Household rice consumption in Indonesia reached 20,685,619 tons in 2019, equivalent to 77.5 kg per capita per year (BPS, 2019). Based on BPS data, Indonesia's rice imports remain quite high, reaching 407,741.4 tons (BPS, 2022).

Increasing rice production is achieved through land use expansion, including the utilization of suboptimal and marginal areas. The majority of suboptimal land used is ultisol soil. Low availability of phosphorus, soil organic matter, pH, and high aluminum saturation cause toxicity to plants (Aggita & Muktamar, 2015). The type of rice suitable for planting in this type of soil is upland rice. Upland rice plants have the advantage of being tolerant to drought or without flooding. Several upland rice varieties, namely superior varieties such as Inpago 8, Inpago 9, and Inpago 12, are also resistant to blast disease and tolerant to aluminum toxicity, which is a problem in dryland areas, and have the potential for quite high yields (8-10 tons/ha) (Lestari *et al*., 2020).

One effort to increase upland rice productivity on suboptimal land is the application of Arbuscular Mycorrhizal Fungi (AMF) to plants. AMF fungi offer a sustainable alternative to chemical fertilizers by improving nutrient uptake, soil health, and crop productivity, making them a key strategy for achieving global food security by 2050 (Igiehon and Babalola, 2017). AMF form a mutualistic symbiosis with plant roots and play a role in improving soil health and structure, facilitating nutrient uptake (P, N, and K), strengthening plant resistance to abiotic stresses, and maintaining soil microbial balance. Although their effectiveness can be compromised by intensive agricultural practices (Wang *et al*., 2021; Chaudhary *et al*., 2025). Several studies have also shown that AMF can increase resistance to plant pests and diseases (Campo *et al*., 2020; Bernaola *et al*., 2018). In addition, AMF has also been shown to significantly increase tolerance to abiotic factors such as shade stress, drought, high salinity, and heavy metal contamination (Amir *et al*., 2019; Li *et al*., 2019).

Apart from the influence of AMF, various studies show that the application of organic materials such as compost, biochar, or liquid organic fertilizer combined with inorganic fertilizer contributes to increasing soil fertility, the activity of rhizosphere microorganisms, as well as the growth and yield of upland rice (Rahmawati and Arifin, 2024). Plant responses to the application of organic materials tend to be influenced by the type, dose, combination of fertilizer, varieties used, and land conditions, especially in sub-optimal soils such as ultisol (Wahyudi *et al*., 2022). In general, the integration of organic and inorganic fertilizers has been proven to be able to improve the physical, chemical and biological properties of the soil thereby supporting the productivity of upland rice (Effendi *et al*., 2023). Based on this, this research aims to analyze the growth and yield response of upland rice to the application of AMF and compost fertilizer on sub-optimal land. It is hoped that the results of this research can become a scientific basis for developing sustainable fertilization strategies to increase upland rice productivity on sub-optimal land.

2. MATERIALS AND METHOD

2.1. Place and Time of Research

The research was conducted from March to December 2024 at two locations: Deli Serdang and Langkat, North Sumatra Province. Laboratory analyses were conducted at the Asian Agri laboratory in Paya Lombang, Tebing Tinggi, Serdang Bedagai Regency, North Sumatra, and the Center for Ecology and Ethnobiology Research, BRIN, Bogor, West Java.

2.2 Tools and materials

The tools used in this study were: analytical scales, pestle and mortar, stirrer, petri dish, oven, measuring cup, label, ruler, plastic, brown envelope, scissors, sieve, pH meter, hoe, tweezers, cover glass, film tube, microscope, and stationery. The materials used in this study included urea fertilizer, TSP, KCl, mycorrhizae (300 active propagules/g with 33 spores/g and consisting of 5 species of endomycorrhizae), plywood, aluminum foil, 30% glucose, Melzer reagent solution, 10% KOH, sodium pyrophosphate, bovine serum albumin, Biored dye, and Inpago 12 Agritan seeds (Upland Rice Inbred).

2.3 Research methods

The research method used a Factorial Randomized Block Design (RAK) with three factors, namely the application of Mycorrhiza and compost. The experiment was repeated 3 times. The experiment consisted of three factors, the first factor is M0 = Soil without Mycorrhiza inoculation as a control; M1 = 150 spores of mycorrhiza; M2 = 300 spores of mycorrhiza; M3 = 450 spores of mycorrhiza; M4 = 600 spores of mycorrhiza. The factors consist of K1 = 5 tons of compost/ha; K2 = 4 tons of compost/ha; K3 = 3 tons of compost/ha; K4 = 2 tons of compost/ha; K5 = Without Compost. The third factor is T1: Deli Serdang, and T2: Langkat. The number of treatment combinations of the three factors is 5 × 5 × 2 = 50 combinations and each was repeated 3 times, so that the total experimental units in this study were 150 units. The growth and development of Inpago 12 Agritan plants were supported by the addition of urea, TSP, and KCl fertilizers at low doses based on soil test results, namely 217 kg urea/ha, 108 kg TSP/ha, and 83 kg KCl/ha.

The research stage begins with a location survey to identify land that represents sub-optimal conditions in North Sumatra and has the potential to be developed as agricultural land. Next, soil testing was carried out at the demonstration plot location before planting and treatment in order to determine the macro and micro nutrient content and obtain accurate data regarding the initial condition of the soil. Analysis of soil chemical properties in this research was carried out only at the initial stage before treatment application as basic data for determining fertilizer doses and initial land characteristics. Repeated measurements of soil chemical properties after application were not carried out because the focus of this research was to evaluate the response of plant growth and yield to the application of mycorrhiza and compost, not changes in soil chemical dynamics due to treatment.

Mycorrhizal application used a ready-to-use commercial mycorrhizal product consisting of five endomycorrhizal species with a content of 300 active propagules/g and 33 spores/g based on the information on the product label. Determination of the mycorrhizal dose (150, 300, 450, and 600 spores) was carried out by calculating the weight of the inoculum based on the number of spores per gram, then weighing it using an analytical balance. The weighed inoculum was mixed homogeneously with compost according to the predetermined treatment level and applied to the root zone during planting.

Upland rice cultivation was carried out on dry, acidic land with an area of 0.25 ha at each research location. Maintenance activities included fertilization of N, P, and K elements based on soil test results with doses of 217 kg urea/ha, 108 kg TSP/ha, and 83 kg KCl/ha, as well as control of pests and diseases that attack upland rice crops on sub-optimal land. Sampling was carried out at 110 days after planting with three replications for each treatment. Harvesting was carried out according to the treatment, starting with sampling, then continued in bulk. Observations of growth and yield parameters included plant height, number of leaves, number of tillers, fresh weight, dry weight of plants, number of panicles, root length, level of mycorrhizal infection in the roots, the number of spores formed and interacting with the roots at harvest, and measurement of soil pH in the zone accessible to mycorrhizal mycelium.

The level of AMF colonization in roots was calculated using a root staining method using 10% KOH and microscopic observation of the stained root segments. Each root segment was categorized as colonized or uncolonized based on the presence of mycorrhizal structures such as hyphae, arbuscules, and vesicles. The percentage of AMF colonization was calculated using the formula: Percentage of colonization (%) = (Number of colonized roots / Number of roots observed) × 100% (Idris *et al*., 2022). In addition, tests were also carried out on untreated soil and soil treated with mycorrhizae, as well as analysis of plant samples.

2.4 Data analysis

Differences in soil chemical content at the two locations were analyzed using the Mann–Whitney test. AMF colonization data and upland rice agronomic parameters were analyzed using analysis of variance (ANOVA). To meet the assumptions of normality and homogeneity of variance, data were transformed using the natural logarithm (ln) before analysis. All statistical tests, including the three-way ANOVA, were performed based on the transformed values. If the ANOVA results showed a significant effect, then the Tukey test was continued at the 5% significance level.

3. RESULT AND DISCUSSION

3.1 Soil Chemical Properties Conditions

Overall, the soil at both research locations contained moderate to very low levels of chemical elements. Only the potassium (K) content at the Langkat research location was categorized as moderate. Based on the Mann-Whitney test, only the calcium (Ca) content was significantly different between the two locations. Based on soil laboratory tests, both soils were categorized as ultisols. The soil pH was also acidic, thus concluding that the soils are less fertile. Ultisols are categorized as soils with low fertility due to their low cation exchange capacity (CEC), organic matter, and pH (Purwanto *et al*., 2021). According to Widiatmaka *et al*., (2016), ultisols are old soils with high acidity and low Al exchange capacity. The solution to improving ultisol soil fertility is balanced fertilization and liming. This is done to increase soil pH and provide additional nutrients for plants. A higher pH also reduces Al-dd and aluminum saturation in the soil.

Ultisols are soil types capable of forming an argillic horizon due to increased clay fraction. According to Nita *et al*. (2015), ultisols are characterized by very low porosity due to the accumulation of clay beneath the tillage layer. Therefore, plant roots are unable to reach this horizon and only grow above the argillic horizon. Low soil organic carbon content will impact the soil C/N ratio, resulting in low soil biota. Efforts to increase the organic carbon content in ultisols can be achieved by adding organic matter (Hidayatullah *et al*., 2021; Pakpahan *et al*., 2022).

3.2. Growth and Production of Upland Rice

Based on the results of the analysis of variance presented in Table 2, the location factor (T) was the most consistent factor influencing most plant growth and production parameters. For plant height parameters, location had a highly significant effect ($p < 0.001$), while the mycorrhizal factors (M), compost (K), and all interactions between factors did not show a significant effect ($p > 0.05$). The average plant height in Deli Serdang (T1) was 114.04 cm higher than in Langkat (T2) at 97.40 cm. This indicates that differences in plant height growth were more determined by the environmental conditions of the location than by fertilization or mycorrhizal inoculation treatments. Although the 600 spore treatment (M4) produced the highest average, the difference was not statistically significant.

Table 1. Chemical Properties of Ultisol Soil at the Experimental Location

Soil Chemical Properties	Location	Value	Description	Mann-Whitney
pH H_2O	Deli Serdang	5.34 ± 0.26	Acid	ts
	Langkat	5.79 ± 0.79	Acid	
pH KCL	Deli Serdang	4.21 ± 0.08	Acid	ts
	Langkat	4.83 ± 0.28	Acid	
C organic (%)	Deli Serdang	1.16 ± 0.15	Low	ts
	Langkat	0.81 ± 0.20	Very Low	
N total (%)	Deli Serdang	0.01 ± 0.03	Very Low	ts
	Langkat	0.15 ± 0.03	Very Low	
Available P (ppm)	Deli Serdang	3.77 ± 0.61	Very Low	ts
	Langkat	6.77 ± 4.34	Low	
K	Deli Serdang	0.18 ± 0.04	Low	ts
	Langkat	0.36 ± 0.27	Medium	
KTK/CEC (me/100 g soil)	Deli Serdang	9.83 ± 0.67	Low	ts
	Langkat	13.42 ± 1.71	Low	
Ca	Deli Serdang	1.29 ± 0.23	Very Low	*
	Langkat	5.4 ± 1.77	Low	
Mg	Deli Serdang	0.43 ± 0.12	Very Low	ts
	Langkat	3.60 ± 0.13	Low	
C/N	Deli Serdang	7.87 ± 1.50	Low	ts
	Langkat	5.16 ± 0.47ts	Low	

Note: Values followed by the same letter indicate no significant difference. ts = not significant; * = significant at the 5% level based on the Mann–Whitney test.

Table 2. Growth and Production of Upland Rice

Source	db	Mean square					
		TT (cm)	JA	JM	PA (cm)	BB (g)	BK (g)
M	4	0.02	0.04	0.062	0.06	0.22ts	0.14
K	4	0.01	0.04	0.139	0.03	0.03ts	0.05
T	1	0.98**	0.66**	0.89**	0.01	3.647***	4.42***
M × K	16	0.01	0.09	0.078	0.05	0.13ts	0.14
M × T	4	0.01	0.04	0.06	0.05	0.12ts	0.15
K × T	4	0.01	0.11	0.27*	0.06	0.33ts	0.34*
M × K × T	16	0.01	0.05	0.031	0.07	0.09ts	0.06
Galat	100	0.01	0.08	0.086	0.05	0.16ts	0.11

Note: The average figures in the same column and followed by the same letter are not significantly different according to the Tukey test at the 5% level. TT (plant height), JA (number of tillers), JM (number of panicles), PA (root length), BB (fresh weight), and BK (dry weight), ts = not significantly different ($p > 0.05$), * = significantly different at the 5% level ($p \leq 0.05$), ** = very significantly different at the 1% level ($p \leq 0.01$), *** = very significantly different at the 0.1% level ($p \leq 0.001$).

The results of the analysis of variance showed that the location factor (T) had a significant effect on the number of tillers ($p < 0.01$), while the mycorrhizal factor (M) and compost (K) did not show a significant effect. All interactions between factors, namely M × K, M × T, K × T, and M × K × T, also had no significant effect compared to an error of 0.08. Quantitatively, the number of tillers at location T1 tended to be higher than at T2, with several treatment combinations in T1 reaching a maximum value of 31.67 (M4K4T1), while the highest value in T2 only reached 21.00 (M2K1T2). These results indicate that differences in agroecological conditions between locations contributed more to tiller formation than variations in the doses of mycorrhizal and compost applied. In contrast to the previous parameters, root length was not significantly affected by location or other treatments ($p > 0.05$) as listed in Table 3. The average root length at T1 (14.40 cm) and T2 (14.48 cm) was relatively uniform, indicating that root system growth tended to be stable and unresponsive to treatment variations under the conditions of this study.

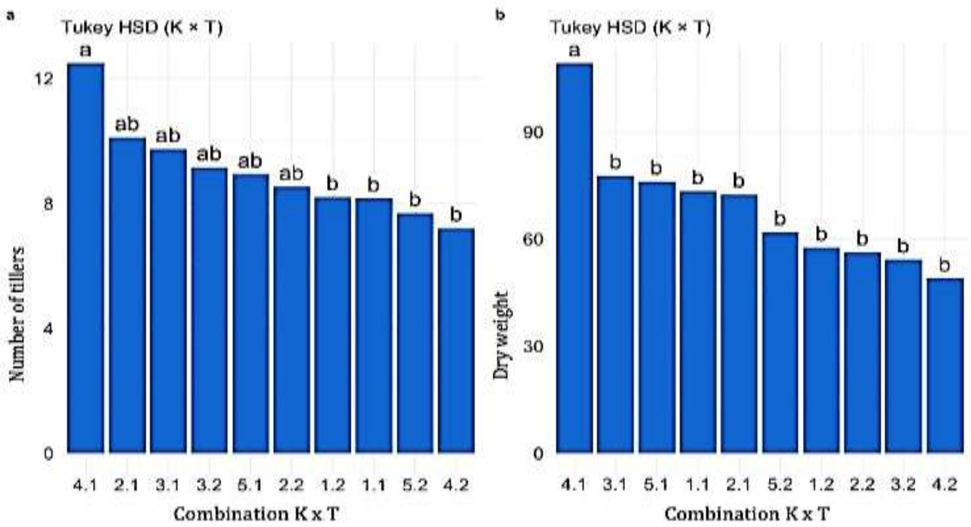

Figure 1. Tukey's further test results for the number of panicles with the KxT combination.

The ANOVA results (Table 2) showed a significant interaction between compost and location (K × T) on panicle number. This indicates that plant responses to compost doses differed at each study location. Based on Tukey's further test on the K × T interaction, the K4T1 treatment combination (2 tons/ha in Deli Serdang) was in the "a" group, indicating that this treatment produced the highest number of panicles and was significantly different from most other combinations (Figure 1). The K2T1 and K3T1 combinations were included in the "ab" group, meaning they were not significantly different from either K4T1 or group "b." Meanwhile, the other treatment combinations, both at locations T1 and T2, were generally in the "b" group, indicating that their average values were relatively lower and not significantly different from each other. This pattern indicates that a significant increase in panicle number occurred only at the 2 tons/ha compost dose at location T1, while at location T2 the plant response to variations in compost dose tended to be homogeneous. Thus, the effectiveness of compost application on panicle formation is strongly influenced by the agroecological conditions of the location.

In biomass parameters, location factors again showed a dominant role. Plant fresh and dry weights were significantly to significantly influenced by location factors ($p \leq 0.001$). The average fresh weight in Deli Serdang (118.81 g) was higher than in Langkat (85.77 g), while the dry weight in T1 was also significantly higher than in T2. This confirms that biomass accumulation, both fresh and dry, is strongly influenced by growing environmental conditions. In contrast, mycorrhizal and compost factors did not show a statistically significant effect, although numerically the M4 (600 spores) and K4 (2 tons/ha) treatments tended to produce higher average values. Similar to the number of panicles, there was a significant difference in dry weight between the KxT combinations (Figure 1b). Treatment combination 4.1 showed the highest average number of panicles and was significantly different compared to all other combinations, which were statistically in the letter group "b" and had lower average values.

ANOVA results showed that location significantly affected plant height, number of tillers, number of panicles, fresh weight, and dry weight. Average plant growth and biomass in Deli Serdang were generally higher than in Langkat. This indicates that environmental factors contribute significantly more than variations in AMF and compost dosages. Environmental factors, such as location and growing season, influence rice growth and yield. Although genotype-environment interactions are not always statistically significant in commercial varieties with limited genetic diversity, they still determine yield stability and adaptability across conditions (Lee *et al.*, 2023). Significant differences in Ca content between locations likely contributed to improved soil chemistry in Deli Serdang, resulting in improved plant growth responses. This is because Ca strengthens the plant's antioxidant and detoxification systems, thus helping maintain rice growth (Rahman *et al.*, 2016). Physiologically, more favorable environmental conditions allow plants to maximize the genetic potential of the Inpago 12 variety. In other words, treatment effects become less apparent when environmental variability is significant.

3.2 AMF colonization

The results of AMF identification found that there are four types and one genus shown in Table 3. (1) Scutellospora calospora (T.H Nicolson & Gerd) C. Walker & F.E. Sanders is a fungus that has hyaline colored spores, round or spherical in shape with a size of 114-150 X 111-150 μm. (2) Glomus multicaulis Gerd. & B.K. Bakshi is a brown fungus. Round to oval in shape with a size of 135 – 160 X 114 – 165 μm. (3) Glomus aggregatum N.C. Schenck & G.S.Smith. a fungus that has hyaline colored spores, round in shape, loose sporocarp measuring 27-54 X 30-60 μm. (4) Acaulospora scrobiculata Trappe. It is a yellowish fungus, with ornaments on the surface of the spores in a round shape measuring 201 X 201 μm. (5) Glomus sp., a yellowish brown fungus, round in shape, loose sporocarp measuring 90-90 x 81-84 M.

The results of AMF colonization on upland rice roots in marginal land showed moderate to very high levels (Table 3). The moderate category was only found in two treatments, namely M0K5 and M1K5, at the Langkat research site. According to Syarif & Nasution (2017), to increase AMF colonization from moderate to high levels, a consortium inoculant can be applied. The results of this study are better than those of previous research conducted by Syarif & Nasution (2017), where AMF in upland rice on ultisol land only ranged from 10-65%, while the highest result in Winata *et al.*'s (2014) study was only at 75.56%.

Table 3. Results of AMF Colonization on Upland Rice Roots in Marginal Dry Land

Deli Serdang			Langkat		
Treatment	AMF Colonization (%)	Description	Treatment	AMF Colonization (%)	Description
M0K1	66.67	High	M0K1	60	High
M0K2	86.67	Very high	M0K2	73.33	High
M0K3	66.67	High	M0K3	60	High
M0K4	80	Very high	M0K4	60.67	High
M0K5	66.67	High	M0K5	46.67	Medium
M1K1	100	Very high	M1K1	80	Very high
M1K2	86.67	Very high	M1K2	53.33	High
M1K3	86.67	Very high	M1K3	73.33	High
M1K4	60	Tinggi	M1K4	66.67	High
M1K5	66.67	Tinggi	M1K5	46.67	Medium
M2K1	93.33	Very high	M2K1	80	Very high
M2K2	86.67	Very high	M2K2	60	High
M2K3	100	Very high	M2K3	93.33	Very high
M2K4	100	Very high	M2K4	93.33	Very high
M2K5	86.67	Very high	M2K5	86.67	Very high
M3K1	86.67	Very high	M3K1	93.33	Very high
M3K2	100	Very high	M3K2	86.67	Very high
M3K4	100	Very high	M3K4	80	Very high
M3K5	100	Very high	M3K5	73.33	High
M4K1	100	Very high	M4K1	100	Very high
M4K2	100	Very high	M4K2	100	Very high
M4K3	100	Very high	M4K3	80	Very high
M4K4	100	Very high	M4K4	86.67	Very high
M4K5	80	Very high	M4K5	100	Very high

According to Genre *et al*., (2020), mycorrhizae exhibit diverse phenotypes depending on partner taxonomy, physiology, and cellular interactions. Furthermore, interactions between AMF and rice can be significantly influenced by factors such as AMF species (Chan *et al*., 2013), rice variety (Huang *et al*., 2020), and soil properties (Fiorilli *et al*., 2013). The morphological characteristics of the identified AMF taxa are presented in Figure 2. Although AMF colonization levels at both locations were high to very high (46.67–100%), most growth parameters showed no significant differences between treatments with and without mycorrhizae. This is likely due to the highly acidic ultisol soil conditions (pH 5.3–5.7) with very low available P content, so that even though AMF successfully colonized roots, the availability of mobilizable nutrients remained limited. In general, AMF thrive optimally at a pH range of 5.5–7.0, so their physiological effectiveness may decrease under extremely acidic conditions (Mulyadi and Jiang 2023). Furthermore, the Inpago 12 variety used is known to be tolerant to acidic soils and Al stress, so this plant's genetic adaptive capacity may be sufficient to absorb nutrients without additional mycorrhizal support (Yullianida *et al*., 2019).

In terms of dry weight (DW), the best treatment in Deli Serdang was a combination of 450 spores and 2 tons of compost/ha (M3K4), indicating a synergy between increased hyphal exploration and improved soil chemical properties by compost. However, in Langkat, the best treatment was different, indicating that the optimal dose of spores and compost was strongly influenced by local conditions, such as relatively higher Ca and P content compared to Deli Serdang. This finding confirms that the effectiveness of AMF on ultisols is contextual and cannot be generalized, as also reported for ultisols in other regions, where the success of AMF application is highly dependent on the interaction between soil conditions, inoculum dose, organic matter, and plant variety characteristics.

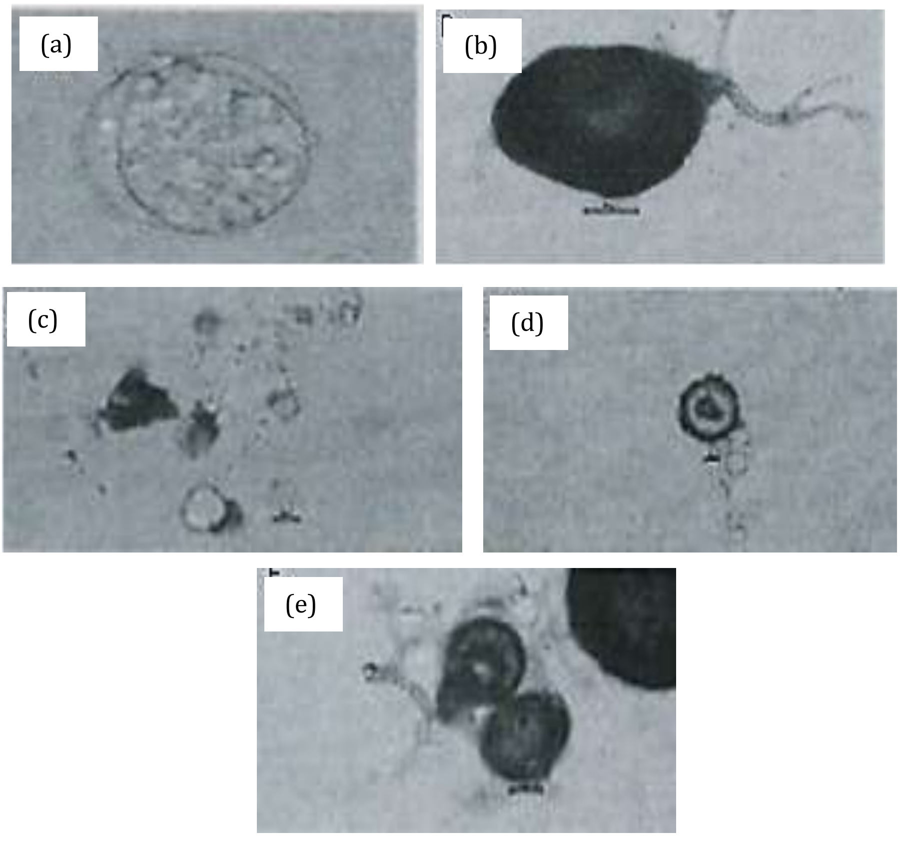

Figure 2. Performance of AMF types in the study, (a) *S. calospora* (T.H Nicolson & Gerd) C. Walker & F.E. Sanders, (b) *G. multicaulis* Gerd. & B.K. Bakshi, (c) *G. aggregatum* N.C. Schenck & G.S.Smith, (d) *A. scrobiculata* Trappe, (e) *Glomus* sp. (Source: Idang Sumanta. Cryptogram Lab. Botany Field. BRIN).

4. CONCLUSION

This study showed that the soil at both research locations was classified as Ultisol with acidic characteristics and low to very low nutrient status, and five species of Arbuscular Mycorrhizal Fungi (AMF) were found, namely *Scutellospora calospora*, *Glomus multicaulis*, *Glomus aggregatum*, *Acaulospora scrobiculata*, and *Glomus* sp., with moderate to very high levels of root colonization (46.67–100%). Location factors were the most dominant factors influencing the growth and yield of upland rice, while the application of AMF and compost generally did not have a significant effect on most parameters. However, the interaction of compost and location significantly affected the number of panicles and dry weight, with the combination of 450 AMF spores and 2 tons of compost ha^{-1} in Deli Serdang being the most effective treatment in increasing the number of tillers, biomass, and number of panicles. Overall, the effectiveness of AMF and compost applications on Ultisol soils is location-specific and is strongly influenced by soil characteristics and growing environmental conditions.

5. ACKNOWLEDGEMENTS

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