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# Growth Of Angsana (*Pterocarpus indicus* Willd) Mycorrhizae 23 Months Age In POST Gold Mining

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**ABSTRACT.** Arbuscular Mycorrhizal Fungi (AMF) technology can increase the success of revegetation on post-mining land. In addition to the input of AMF technology, the selection of plant species is very important for the success of post-mining land reclamation. This study aimed to determine the effectiveness of AMF on the viability and growth of the 23-month-old mycorrhizal Angsana (Pterocarpus indicus Willd.) in the post-Bombana gold mining area, Southeast Sulawesi. This research was conducted in the post-gold mining area of PT. Panca Logam Makmur, North Rarowatu District, Bombana Regency and the Laboratory Unit of the Forestry Department, Faculty of Forestry and Environmental Sciences Halu Oleo University, Kendari for 8 months. The research design used a Randomized Block Design which was divided into nine treatments; control (A0), Claroideoglomus etunicatum (A1), Septoglomus constrictum A2), Acaulospora delicata (A3), Glomus claroideum (A4), Glomus coronatum (A5), Ambiospora appendicula (A6), Mixed AMF I (A7); (A1+A2+A6) and Mixed AMF II (A8); (A1+A3+A4+A5). The total number of plants used was 27 plants. The results showed that the application of arbuscular mycorrhizal fungi was effective in increasing the growth of P. indicus plants in post-gold mining areas. The treatment of G. coronatum, G. claroideum, A. appendiculate, and C. etunicatum significantly increased the growth of 23 months old P. indicus plant on post-gold mining land compared to control and other treatments. G. coronatum and G. Claroideum have the potential to be developed as mycorrhizal biofertilizers.

***Keywords:*** *Angsana, Arbuscular Mycorrhizal Fungi, Post-Gold Mining Land.*

## INTRODUCTION

Post-mining land is land that has changed as a result of mining activities (Suprapto 2008). Post-mining land has general characteristics, including compacted soil conditions that can damage the water system and soil aeration. Changes that occur also include changes in the landscape, changes in physical, chemical, and biological conditions of the soil, microclimate, and changes in flora and fauna (Siswanto et al. 2012). The condition of post-mining land that is poor in nutrients and high in metal content also occurs in post-gold mines in the Bombana region (Husna et al. 2019). These conditions can harm the function and development of plant roots. Therefore, it is necessary to input environmentally friendly technologies such as arbuscular mycorrhizal fungi (AMF). AMF is an essential component needed to help increase plant viability and growth in post-mining land restoration programs (de Moura et al. 2022).

Biofertilizer technology input in the form of AMF can support plant growth and nutrient improvement. AMF technology can increase the success of revegetation on post-mining land. AMF through the mechanism of nutrient and water absorption increases plant resistance to biotic and abiotic stresses and is able to improve soil structure (Husna et al.

2019a,b; 2021a,b). AMF was reported to increase the growth of plants grown on post-gold mining media at the plastic house scale (Husna et al. 2019b; Husna et al. 2021a; Tuheteru et al. 2020) and the field scale at 4 months after planting (Husna et al. 2021b; Arif et al. 2021). It is necessary to observe the sustainability of plant growth success in post-gold mining during the growing period. The effectiveness of AMF is also strongly influenced by land conditions and the type of AMF being tested.

In addition to the input of AMF technology, the selection of plant species is very important for the success of post-mining land reclamation (Setyowati et al. 2017). Angsana plant (Pterocarpus indicus Willd.) is a type of legume that is commonly grown for restoration activities on degraded land and damaged forests. P. indicus is an endangered species so it needs to be saved from its threat. Planting P. indicus in the post-mining land reclamation program is also part of the P. indicus conservation strategy in Indonesia. P. indicus has been planted in post-gold mines in Bombana District and has been evaluated for growth at 4 months after planting (Husna et al. 2021b). The purpose of this study was to determine the effectiveness of AMF on the viability and growth of 23 months old P. indicus mycorrhizal plants in the post-Bombana gold mining area, Southeast Sulawesi.

## MATERIAL AND METHODS

### Location and Time of Research.

This research was carried out for two months from March to April 2022 at the location in the Bombana Gold Post Mining Land with coordinates 4°39'27.7"LS 121°54'18.7" E. This research was conducted at the Laboratory of the Faculty of Forestry and Environmental Sciences, Halu Oleo University.

### Research Design.

This study was designed using a Randomized Block Design (RBD), consisting of nine treatments, namely: control (A0), Claroideoglomus etunicatum (A1), Septoglomus constrictum A2), Acaulospora delicata (A3), Glomus claroideum (A4), Glomus coronatum (A5), Ambiospora appendicula (A6), Mixed AMF I (A7); (A1+A2+A6) and Mixed AMF II (A8); (A1+A3+A4+A5). This study was divided into three groups where each group contained nine plants so total plants used were 27 plants.

### Research Procedure.

The research starts with preparing the tools and materials needed to carry out research. The stages of the research are as follows: 1) This research is a follow-up study from previous research on a greenhouse scale related to the application of AMF for Angsana wood plants (Husna et al. 2020) and continued with field-scale research on a four-month-old post-gold mine (Husna et al. 2021b). At the age of Twenty Three months in the field, 15 leaves were harvested from each plant (randomly selected leaves that were old and green) in each treatment to keep the plant intact in the field (Giri et al. 2005), 2) The harvested leaves are then dried in an oven at 70°C for 2x24 hours. After that, the dry weight of the leaves was weighed using an analytical balance, and 3) Measurement of height, diameter, leaf size, width of the crown and length of plant roots.

**Parameters**

1) survival rate ([Σ Number of viable seedlings / Number of seedlings] x 100%), 2) plant height and diameter were measured on the stem at a height and diameter of 3 cm, number of plant petioles, leaf width measurement, measurement of plant leaf length, crown width and root length, 3) length and width and oven-dried weight of 10 leaves per plant (randomly selected) and 4) AMF colonization (%) = [Σ mycorrhizal field of view / observed field of view ] x 100% (Brundrett et al. 1996)

**Data Analysis.**

The data analysis used was the analysis of variance (F test) and continued with the different treatment tests according to Duncan Multiple Range Test (DMRT) at a 95% confidence level using the SAS version 9.1.3.

## RESULT AND DISCUSSION

A recapitulation of the results of variance (F test) of the effect of AMF treatment on growth parameters and AMF colonization in Twenty Three-month-old Angsana is presented in Table 1. Table 1 shows that AMF treatment had a very significant effect on the observed number of stalks leaf length, leaf width, leaf dry weight, and AMF colonization and significantly affected plant height. Observation of diameter, number of branches, the width of the crown, length of roots, and viability did not show a significant effect on the Angsana plant.

Table 1. Recapitulation of the results of the variance of the effect of AMF treatment on the growth parameters of the Angsana plant

| No | Parameter | ANOVA | Coefficient of variance |
|---|---|---|---|
| 1 | Height (cm) | * | 11.17 |
| 2 | Diameter (mm) | ns | 16.09 |
| 3 | Number of branches | ns | 22.74 |
| 4 | Number of stalks | ** | 12.39 |
| 5 | Leaf length (cm) | ** | 11.04 |
| 6 | Leaf width (cm) | ** | 9.78 |
| 7 | Leaf dry weight (g) | ** | 17.70 |
| 8 | Width of a crown (cm) | ns | 20.98 |
| 9 | Root length (cm) | ns | 17.09 |
| 10 | AMF colonization (%) | ** | 11.07 |
| 11 | Survival rate (%) | - | - |

Description: ** Very significant effect; * Have a real impact; ns = No significant effect; at the 95% confidence level, the survival parameters were not analyzed for variance but directly used the percent survival formula because they had the same results in all treatments..

The AMF treatments of G. coronatum, A. appendiculate, and G. claroideum increased AMF colonization and were not significantly different from those of A. delicata, Mixed AMF I, and Mixed AMF, but significantly different from control plants and other treatments. All AMF-colonized plants were characterized by the presence of external hyphae, internal hyphae, coil hyphae, and vesicles on root observations. The results of this study indicated that the AMF treatment was effective in increasing the growth of the Angsana (Pterocarpus indicus Willd) plant on post-gold mining land. The increase in the growth of the Angsana plant was strongly associated with AMF colonization. This study is in line with the research results of Husna et al. (2021b) that the level of AMF colonization in Angsana plants in the AMF treatment was higher than the control treatment.

The control treatment for AMF colonization was thought to come from nature or contaminated with AMF on the Angsana plant which was given AMF treatment around it through wind and water at the time in the greenhouse or in the field. Angsana plants that were colonized by AMF were evidenced by the presence of AMF structures in the form of internal hyphae, external hyphae, coiled hyphae, and vesicles (Suharno et al. 2014). This is in line with research by Goltapeh et al.(2008) the structure of long and fine hyphae can penetrate the soil to absorb water, and macro and micronutrients that cannot be reached by roots, while the vesicle structure acts as a store of food reserves (Smith and Read 2008). ), thus enabling the Angsana plant to survive in post-gold mining areas contaminated with heavy metals.

The AMF treatment of G. coronatum significantly increased the increase in height of the 23-month-old Angsana plant and was not significantly different from the Mixed II AMF treatment, and significantly different from the other treatments (Table 2). The AMF treatment of G. Coronatum significantly increased the number of leaf stalks of the plant and was not significantly different from the A. delicata and C. Etunicatum. All AMF treatments significantly increased the leaf length and width of the Angsana plant and were significantly different from the control plants. The AMF treatment of G. claroideum significantly increased the dry weight gain of the leaves of the 23-month-old Angsana plant on post-gold mining land and was not significantly different from the AMF treatment of C. etunicatum, G. coronatum, and A. appendiculate, and significantly different from the control plants and other treatments.

Table 2. The average increase in height, and a number of stalks. The length and width of the leaves of the Angsana plant (*Pterocarpus indicus* Willd) aged 25 months after planting

| Treatment | AMF colonization (%) | Plant height (cm) | Number of stalks | Leaf lenght (cm) | Leaf widht (cm) | Leaf dry weight (g) |
|---|---|---|---|---|---|---|
| Control | 14.16±0.22 d | 499.57±12.34 c | 31.33±5.84 d | 7.23±0.53 b | 4.00±0.22 c | 1.43±2.58 c |
| *C. etunicatum* | 31.97±0.43 c | 612.20±42.56 bc | 98.66±4.70 ab | 11.42±1.05 a | 4.99±0.43 b | 4.41±0.65 ab |
| *S. constrictum* | 30.42±0.62 c | 565.00±66.98 bc | 87.00±10.50 bc | 10.98±0.81 a | 4.96±0.62 b | 3.40±0.24 b |
| *A. delicata* | 43.49±0.20 b | 593.90±30.04 bc | 101.33±5.81 ab | 11.81±0.19 a | 5.79±0.20 ab | 3.58±0.32 b |
| *G. claroideum* | 57.14±0.25 a | 573.97±52.49 bc | 84.33±3.28 bc | 11.11±0.68 a | 5.50±0.25 ab | 5.03±0.45 a |
| *G. coronatum* | 62.43±0.11 a | 747.87±44.62 a | 115.33±11.28 a | 10.91±0.53 a | 5.37±0.11 ab | 4.20±0.36 ab |
| *A. apendiculata* | 62.14±0.29 a | 59,004±26.83 bc | 71.00±1.52 c | 11.37±0.23 a | 6.11±0.29 a | 4.18±0.18 ab |
| Mixed FMA I | 44.32±0.45 b | 593.97±19.18 bc | 88.67±5.36 bc | 10.34±1.24 a | 5.43±0.45 ab | 3.32±0.29 b |
| Mixed FMA II | 43.93±0.41 b | 670.93±28.87 ab | 72.66±7.75 c | 11.40±0.55 a | 5.22±0.41 ab | 3.35±0.02 b |
| CV | 11.07 | 11.17 | 12.39 | 11.04 | 9.78 | 17.70 |
| Pr> F | 0.0075 | 0.0234 | <.0001 | 0.0084 | 0.0085 | 0.0004 |

Note: The average value followed by the ± standard error value with the same letter in the same column shows no significant difference according to the DMRT test ($\alpha = 0.05$); CV (Coefficient of variance).

In general, the treatment had no significant effect on the variables of diameter, number of branches, the width of the crown, and root length of the 23-month-old Angsana plant (Table 1). Although the effect was not significant, the AMF treatment tended to increase the diameter increase. Canopy width and root length of Angsana plants compared to control plants (Figure 1). AMF treatment of G. claroideum tended to increase the number of branches of the Angsana plant compared to control plants and other treatmentsents.

The results of this study showed that the G. coronatum AMF treatment significantly increased the height of the Angsana plant compared to other AMF treatments and control treatments. This is in line with various studies that have been carried out previously that the application of AMF can increase plant height growth (Husna et al. 2019b, 2020, 2021a,b, Arif et al. 2021). The existence of AMF symbiosis with Angsana roots is thought to be able to improve the soil structure of post-gold mining land and increase the ability to grow plants. This study is in line with the research study of Husna et al. (2018) that the effect of AMF colonization on roots can increase the growth and nutrient accumulation (uptake) of Angsana plants. AMF has external hyphae, with the help of external hyphae roots can increase the absorption area, especially phosphorus (Indriani et al. 2016) and protect plants from biotic and abiotic stresses (Nanjundappa et al. 2019). Absorption of nutrients, especially P, occurs because AMF produces phosphatase enzymes that allow an increase in P in the soil so that plants can absorb nutrients in sufficient quantities and help plants from heavy metal stress (Miransari, 2017). This increase was caused by the role of AMF in the plant root system which causes the photosynthetic activity to increase so that more photosynthate is produced. Furthermore, it affects plant biomass (Lambers et al. 2008). AMF inoculation was effective in increasing the leaf length and leaf width of 23-month-old Angsana plants in the field. This study is in line with Sinaga et al. (2014) and Husna et al. (2021b) that the application of AMF can increase the development of leaf dimensions in plants and leaf dry weight of plants in post-gold mining fields.

In this study, C. claroideum was more effective in increasing the growth of the Angsana plant. This species is thought to be effective because it has relatively small spores, high sporulation ability in various environmental conditions, and is able to adapt to various soil conditions and (Kivlin et al. 2011; Shukla et al. 2013). C. claroideum species were also reported to be effective in increasing the growth of P. indicus and Kalappia celebica plants at the plastic house scale (Husna et al. 2019, 2020, 2021a) and field scale (Husna et al. 2021b; Arif et al. 2021).

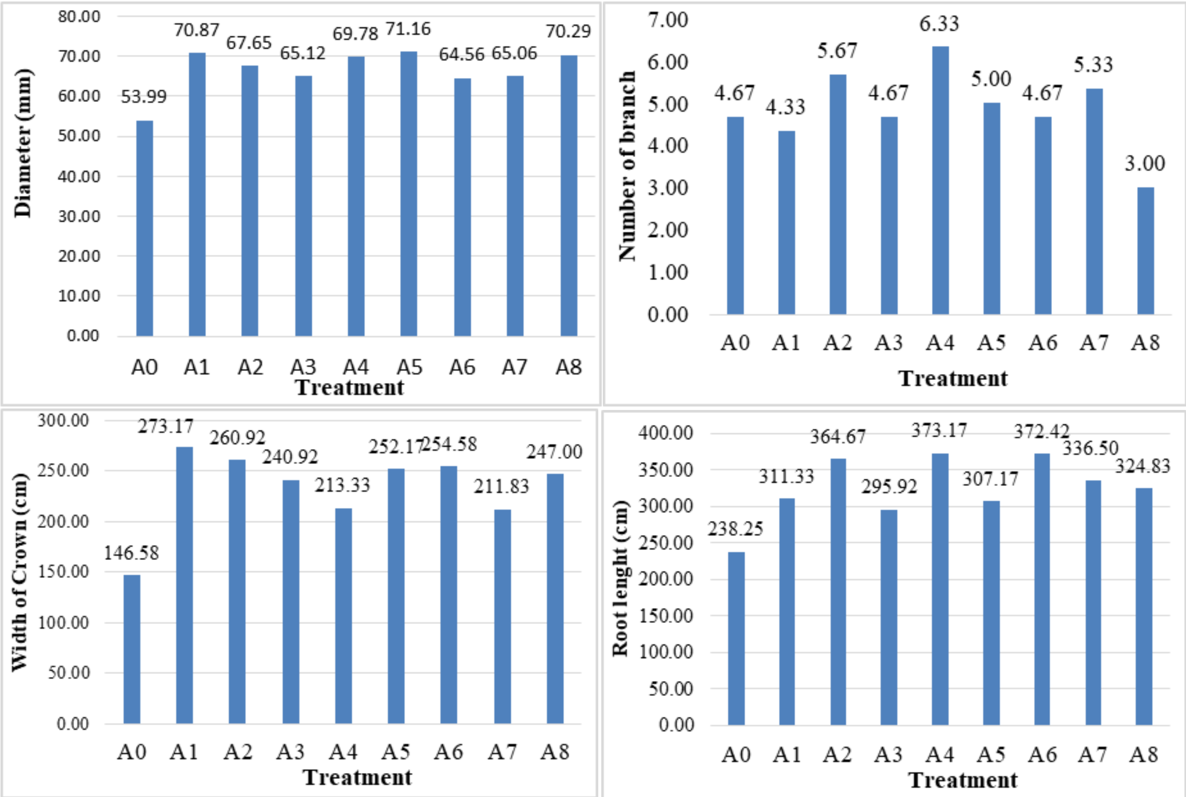


Figure 1. Graph of the average increase in diameter (mm), number of branches, the width of the crown and root length of the 23-month-old Angsana (Pterocarpus indicus Willd) plant; Control (A0), FMA *C. etunicatum* (A1), FMA *S. Constrictum* (A2), FMA *A. delicata* (A3), FMA *G. Claroideum* (A4), FMA *G. Coronatum* (A5), FMA *A. Apendiculata* (A6), AMF Mix I (A7), AMF Mix. II (A8).

## CONCLUSION

Based on the results of the research that has been carried out, it can be concluded that the AMF treatment of G. coronatum, G. Claroideum, A. appendiculate, C. etunicatum treatments significantly increased the growth of 23 months old Angsana (Pterocarpus indicus Willd) plant on post gold mining land compared to treatment control and other treatments. AMF species of G. coronatum and G. Claroideum is potential to be developed as mycorrhizal biofertilizers.

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