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Status of Arbuscular Mycorrhizal Fungi in the Poboya Gold Mine Area, Palu Municipality, Central Sulawesi

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Abstract: **Gold mining in Indonesia is carried out using an open-pit mining system, which has an impact on the loss of forest vegetation, soil properties in mining areas, loss of flora and fauna, as well as the occurrence of slopes that change hydrological conditions and soil fertility levels. The problem that often occurs is that post-mining land is difficult to grow plants due to the lack of nutrient content which results in plant death. Exploring the types of AMF in the vegetation composition in the mining area is an important initial study and is necessary to be able to identify and map the dominant and specific types of AMF that exist in the vegetation composition in the area. The aim of this research is to determine the status of arbuscular mycorrhizal fungi and vegetation composition in the Poboya gold mine area. The research was carried out from February 2023 to June 2023. Observations of vegetation types and taking soil and root samples were carried out on agroforestry land and secondary forest in the Poboya gold mining area, Palu Municipality, Central Sulawesi. Identification of arbuscular mycorrhizal fungal microbes was carried out at the Forest Biotechnology Laboratory, Bogor Agricultural Institute (IPB), Bogor, West Java. Analysis of soil properties was carried out at the Soil Science Laboratory, Faculty of Agriculture, Tadulako University, Palu. The research results showed that there were 5 types of AMF spores found at the research location, namely *Acaulospora sp2, Acaulospora sp3, Acaulospora sp4, Glomus sp6, Glomus sp7*. The results of observing the color of the spores showed that there were different types of spore colors including clear yellowish, yellow and brown. The density of Arbuscular Mycorrhizal Fungi spores was highest at the agroforestry research location, 11 spores were found per 20 g of soil, while at the secondary forest research location only 3 spores were found per 20 g of soil. The colonization level shows that the plants with the highest percentage of AMF colonization are white teak (*Gmelina arborea* Roxb) (91.8%) and Candlenut (*Aleurites moluccana* (L.)) (51.3%), the medium colonization level is Lamtoro (*Leucaena leucocephala*) (33.7 %) Vegetation composition In secondary forest areas the number and types of species are higher than in agroforestry areas. The highest relative density at each growth phase is found in agroforestry land, namely in Candlenut (*Aleurites moluccana* (L.)) and Lamtoro (*Leucaena leucocephala*.) plants.**

Keywords: **Status of AMF, Agroforestry, secondary forest, gold mining area.**

I. INTRODUCTION

Indonesia is an archipelagic country with rich natural resources, both biological natural resources and non-biological natural resources. Non-biological natural resources, especially mineral resources, are a large contributor to the country's foreign exchange in national development, therefore must be utilizedas much as possible for the benefit of the people and still paying attention to aspects of environmental sustainability [1].

Generally, gold mining in Indonesia is carried out using an open-pit mining system, which has an impact on the loss of forest vegetation, soil properties in mining areas, loss of flora and fauna, as well as the occurrence of slopes that change

hydrological conditions and soil fertility levels.which can result in disasters such as landslides, floods and so on[2]. A problem that often occurs is that post-mining land is difficult to grow plants due to the lack of nutrient content which results in plant death [3]. This impact can be reduced by reclamation activities.

The Poboya gold mining area has its own community mining permit (IPR), which was formalized in 2011 through a permit issued by the local government on the juridical basis of Regional Regulation No. 3 of 2011 with the area that can be managed by the community covering an area of 30 hectares. Permits are granted by the Palu City Government and PT. Citra Palu Mineral (CPM) as the owner of a mining business permit (IUP) with an area of 37 thousand hectares. Processing using the amalgamation method, which is a process of binding gold metal using mercury (Hg) in a tube called a drum. There is a gold processing process that will produce liquid waste which is placed in holding ponds and sludge resulting from processing which is dumped directly on the ground so that it can damage the environment.[4]

The presence of Arbuscular Mycorrhizal Fungi (hereinafter abbreviated as AMF) is important for the resilience of an ecosystem, plant stability and maintenance of biological diversity. The role of mycorrhiza in maintaining biodiversity and ecosystems

The mutualistic symbiosis formed between AMF and plant roots can form a large nutrient uptake area[5]. The use of mycorrhiza in the forestry sector can increase the growth of forestry plant seedlings so that they are more widely applied, especially on marginal land and improve terrestrial ecosystems [6]. Where ecologically and naturally the use of local potential AMF is given more priority.because they are able to live and adapt to the conditions of the mining environment[7].

Arbuscular mycorrhizal fungi (AMF) can be found in almost all ecosystems, including acid [8] and alkaline [9] lands. AMF can be associated with almost 90% of plant species. However, the level of population density and composition of AMF species varies greatly and is influenced by plant characteristics and environmental factors such as temperature, soil pH, soil moisture, phosphorus content and the host[10]. Thus, each ecosystem has the possibility of containing AMF of the same or different types, the diversity and distribution of AMF varies greatly due to varying environmental conditions[11].

The diversity of AMF on dry land in Indonesia is quite high. This is because Indonesia has a diversity of plants, which can be used as AMF hosts. [12] In cocoa plants on the islands of Java and Bali, AMF genus *Acaulospora* walkeri, while the results of [8] research show that AMF in former forest PMK, former rubber plantations, and ex-forest peat have different amounts and diversity of AMF.

Exploring the types of AMF in mining areas is an important initial study and is necessary to be able to identify and map the dominant and specific types of AMF that exist. This activity is very important to obtain information about the diversity of potential AMF types as an important source of material for selecting potential and effective AMF isolates that are able to adapt to specific land conditions and commodities. The effectiveness of each type of AMF, apart from depending on the type of AMF itself, also depends greatly on the type of plant and type of soil as well as the interaction between the three [13].

Each type of plant responds differently to AMF, as does soil type, which is closely related to pH and soil fertility levels. Each AMF has differences in the absorption of nutrients from the soil and plant growth [14], so that its ability to increase its effectiveness in increasing plant growth in the field can certainly be different.To obtain this potential inoculant source (FMA), it is necessary to identify the diversity of types and levels of colonization of arbuscular mycorrhizal fungi in vegetation in the Poboya Gold Mine Area, Palu Municipality, Central Sulawesi.

The aims of this research are:Knowing the status of AMF in vegetation in secondary forests and agroforestry in the Poboya gold mining area, Palu Municipality, Central Sulawesi and knowing the composition of vegetation in secondary forests and agroforestry in the Poboya gold mining area, Palu Municipality, Central Sulawesi.

II. RESEARCH METHODS

A. Location and materials

The research was carried out from February 2023 to June 2023. Observations of vegetation types and taking soil and root samples were carried out on agroforestry land and secondary forest in the Poboya gold mining area, Palu Municipality, Central Sulawesi. Identification of arbuscular mycorrhizal fungal microbes was carried out at the Forest Biotechnology Laboratory, Bogor Agricultural Institute (IPB), Bogor, West Java. Analysis of soil properties was carried out at the Soil Science Laboratory, Faculty of Agriculture, Tadulako University, Palu

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The tools used in this research were a hoe, ruler, plastic and label paper for taking soil samples. The laboratory equipment used for the isolation and observation of mycorrhizal spores is a set of filters (sieve) with 3 levels of filter size (250 µm, 125 µm, 60 µm, plastic cup, toothpick, spray flask, test tube, centrifuge, scale, petri dish , measuring cup, plastic funnel, and microscope.

Tool-The tools used for soil analysis are analytical scales, oven heater with a temperature of 105ºC, desiccator, clamp rod, aluminum cup, analytical register, precision of 2 decimal places, 100 ml shake bottle, volume measuring pipette, beaker, shaker machine, spray flask, pH meter, 25 ml burette, magnetic stirrer, 1000,500,100 ml measuring flask, 100 ml measuring cup and 250-500 ml Erlen Meyer.

The materials used were soil and root samples originating from the secondary forest area around the Paboya gold mine and the Poboya gold post-mining area. The laboratory materials used are 0.45 µm filter paper, label paper, PVLG (Poly Venyl Lacto Glycerol), distilled water, H2O, KCl 1 Ml, Potassium Dichromate (K2Cr2O7), concentrated Sulfuric Acid (H2SO4) Sodium Florida (NaF) and defenylamine indicator.

B. Method

Methods used Broadly speaking, the research is divided into two parts, field activities include collecting plant data, taking soil and root samples carried out in secondary forest areas and agroforestry areas around the Poboya gold mine.

Activities in the laboratory include identifying the type, density of AMF, level of AMF colonization on roots and analysis of the physical and chemical properties of the soil.

Implementation

Plant Identification Data Collection Techniques, sampling and sampling techniques

Research plots for data collection on vegetation composition were determined using purposive sampling at two observation locations, namely secondary forest land and agroforestry land. The area of each observation location is 2 hectares, at each location there are 3 plots with a size of 20 x 20 m each. Retrieval of plant identification data. Plots were built in the form of squares of different sizes for each phase of vegetation growth using the nested plot method. Plots measuring 1 m x 1 m, 5 m x 5 m, 10 m x 10 m and 20 m x 20 m respectively are used forcalculating seedling phase vegetation.

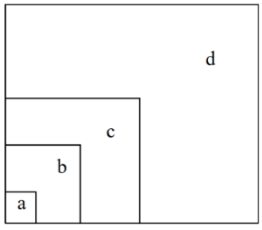

Figure 1. Plant identification data collection plot

Determining repeat points for soil sampling uses a non-proportional purposive sampling technique. This technique is determined based on existing field conditions, namely the distribution of vegetation growing at the location [15].

Three replicate samples were taken for each regional condition. Soil samples from each replication were taken from 5 sub-samples of 200 grams of soil in the rhizosphere area, namely at the tips of plant roots which are under the outer canopy at a depth of approximately 0-20 cm using a hoe, from each sample point 1 kg was then mixed. from each replicate sample. Each soil sample was placed in a plastic bag and labeled according to the location.

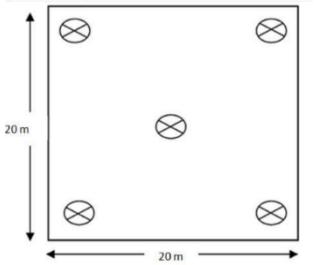

Figure 2. Sketch of sampling in research replications

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The root samples are represented by plants that dominate at the replicate sample points, amounting to 5-10 g. Then it is taken from several sub-samples of observations and combined into one to become a composite repeat sample. Then the root sample is put into a sample bottle and then given the location and date of collection.

must mention the time and place of research in the first part. Research methods must include: materials used, sampling (survey), research design and design, research implementation methods, and data analysis. All these parts must be written clearly but concisely.

C. Research variable

The observation variables are divided into three groups, namely environmental variables, mycorrhizal variables and vegetation variables. Mycorrhizal variables observed included (1) diversity of Arbuscular Mycorrhizal Fungi spores (2) spore density or number of AMF spores and (3) percentage of root colonization levels in plants. Observed vegetation composition variables include (1) Species density (2) Relative density. Environmental variables include (1) soil chemical properties (pH, organic C, available P and CEC), and (2) soil physical properties (water content, sand, dust, clay and soil texture).

D. Data analysis

Arbuscular mycorrhizal fungal spore density

Spore type density was analyzed per 20 g of soil sample, based on spore type groups according to the location of the land from which the soil sample was derived.

$$\text{Kepadatan spora} = \frac{\text{jumlah spora}}{20\ gram\ tanah}$$

Level of colonization by arbuscular mycorrhizal fungi

Calculation of the percentage of root colonization using the root length method. The percentage of root colonization was calculated and matched with a table calculated using formulas and criteria [17] which is modified as follows:

$$\text{Presentase Kolonisasi FMA pada akar} = \frac{\sum \text{Bidang pandang terkolonisasi}}{\sum \text{Bidang Pandang keseluruhan}} \times 100\%$$

TABLE 1. CRITERIA FOR THE EFFECTIVENESS OF THE DEGREE OF MYCORRHIZAL COLONIZATION

Degree of colonization %	Criteria
0-5	Very low
>5-25	Low
>25-50	Currently
>50-75	Tall
>75-100	Very high

Vegetation Data Analysis

The vegetation data that has been collected is then analyzed to determine the species density and relative density using the following formula [16]

$$\text{Specific density (K)} = \frac{Jumlah\ individu\ suatu\ jenis}{Luas\ total\ petak\ contoh}$$

$$\text{Relative Density (KR)} = \frac{Kerapatan\ suatu\ jenis}{Kerapatan\ totoal\ seluruh\ jenis}\ x\ 100\ \%$$

III. RESULTS AND DISCUSSION

A. Diversity of Arbuscular Mycorrhizal Fungi

The types of AMF found in secondary forest and agroforestry areas in the Poboya gold mining area are presented in table 2, as follows:

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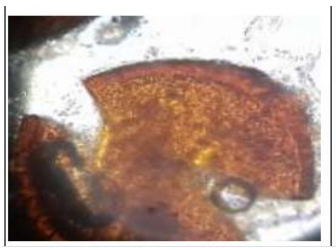
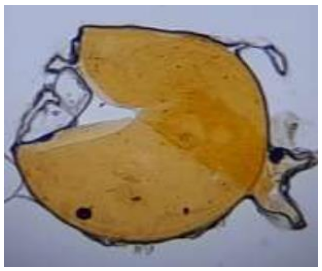
TABLE 2. DESCRIPTION OF AMF TYPES FOUND IN SECONDARY FOREST AND AGROFORESTRY AREAS IN THE POBOYA GOLD MINING AREA

No.	Species Morpho	Description	Documentation
1.	*Acaulospora sp1.*	Spores from the genus Acaulospora, clear to yellowish in color, 130 µm in diameter, and the spore-wall is ornamented.	
2.	*glomus sp1.*	The spores of the genus Glomus are brown, there are only a few layers of spore-wall, the spore diameter is 150 µm.	
3.	*Glomus sp2.*	The Glomus genus has brown spores, 200 µm in diameter, only forming sporewalls and there are distinctive characteristics of the spore-wall layer connected to the hyphae attachment.	
4.	*Acaulospora sp2.*	The spores of the genus Acaulospora are yellowish in color with an ornate sporewall shape.	
5.	*Acaulospora sp3.*	Genus Acaulospora with clear to yellowish spores, 130 µm in diameter. There are sporewalls and germinal-walls, where the spore-walls are ornamented.	

The results of AMF identification in secondary forest and agroforestry areas found 5 types of AMF consisting of 2 species of the genus Glomus and 3 species of the genus Acaulospora. The diversity of forms of AMF found in secondary land and agroforestry as a whole is in the form of ornamented sporewalls. The size of the Acaulospora AMF found was 130 µm in diameter and in the glomus genus it was found to be 150 and 200 µm in diameter. The color of the type of AMF found is different for each AMF species, including clear yellowish, yellow and brown.

AMF spores are formed as a result of the swelling of one or more subtending hyphae in the soil or roots [13]. Spore formation generally takes place if there is remobilization of nutrients from the roots, namely whenThe symbiosis of AMF and plants will die. The shape of the spores is generally round to oval with varying diameter sizes. Each spore is bounded by one or more layers called spore walls, each of which has a certain thickness [15].

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B. Spore density of arbuscular mycorrhizal fungi

Spore density is the number of spores found during observation. Calculation of spore density is based on the number of spores found in 20 grams of soil using the wet filter pour method. Spore density at each location is presented in the following table.

TABLE 3. ARBUSCULAR MYCORRHIZAL FUNGUS SPORE DENSITY

Location	morpho species	number of spores per 20 g sample
	*Acaulospora*sp1.	5
	Glomus sp1.	3
Agroforestry	*Glomus*sp2.	2
	*Acaulospora*sp2.	1
Secondary Forest	*Acaulospora*sp3.	3

From the data presented in table 2, it can be seen that 5 Acaulospora sp2 spores were found in the Poboya gold mining area, followed by 3 Glomus sp6 spores, 2 Glomus sp7 spores, and Acaulospora sp3. as many as 1 spore and Acaulospora sp4. as many as 3 spores. The spores found were the dominant Glomus sp type. This shows that the Glomus sp type has a fairly high level of adaptation to the environment compared to other types of AMF.

The highest spore density was seen in agroforestry areas compared to secondary forest areas. According to [18] that differences in land use types affect the population of AMF. Changes in habitat from forested to open habitat and used for various land uses have an impact on the number of spores and influence species diversity.

In general, spores are formed if there is a decrease in the amount of nutrients from the roots during AMF symbiosis and the plant will die [7] Roots are the part that functions in the process of absorbing nutrients, water and dissolved substances in the soil and will be transferred to the parts of the plant that need them [19].

shows that the number of AMF spores in a type of soil is determined by environmental differences, the season when soil samples are taken, the type of host plant, and the presence of other plants at the location where the soil sample is taken[8]. Arbuscular mycorrhiza is a fungus that does not have a specific host. Even plant samples from the Cyperaceae group in nutrient-poor savanna areas, mycorrhiza develop well by forming arbuscules in the cortex area[20]

The results of analysis of soil samples from secondary forest and agroforestry land show that in general the soil texture on the landIt is dominated by sandy loam, the percentage of secondary forest sand is around 63.6%. The sand fraction on agroforestry land is 68.2%. This means an increase in the sand fraction of up to 4.6%.

Soil physical properties in secondary forests with agroforestry land are presented in Figurethe following 3:

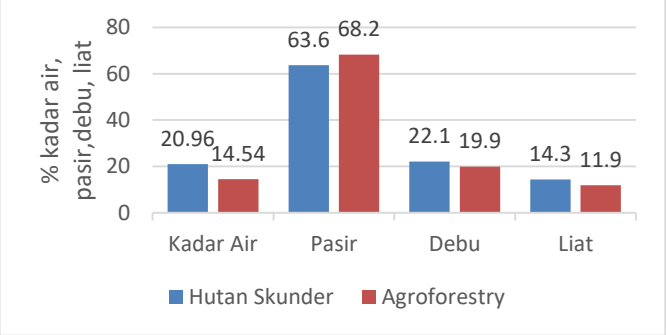

Figure 3. Physical properties of soil in the Poboya gold mining area

The sandy loam soil texture is thought to be related to the type and density of AMF as well as being related to the chemical properties of the soil at the location where it was collected. In sandy clay soil structure conditions, the water and nutrients available in the soil cannot be held properly so they cannot be absorbed by plants optimally [21]. Soil with a sand texture has a small surface area, making it difficult to absorb and retain water and nutrients. Conditions like this result in the soil being less fertile and having large pores so that in the dry season the water content in the soil is very small.

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The AMF genus has different adaptability to soil texture, this is in line with statement that in soils dominated by dusty clay fractions and tending to be clay, the Glomus genus is usually found, then in sandy soils it is dominated by the Acaulospora and Gigaspora genera.

The water content at the research location shows that the highest percentage of water content is found in the secondary forest area, namely 20.96%, then the water contentin agroforestry areas with a value of 14.54%. The AMF population in agroforestry areas is relatively denser than the AMF population in secondary forests, this shows that water content is related to the density and diversity of the spore population, where AMF can live well in dry conditions or with little rain.

Stated that dry conditions or little rain will increase the formation of new spores and the composition of spore diversity. Dry conditions will stimulate the formation of many spores as a natural response to AMF and an effort to maintain its existence in nature[22].

Soil water content is one of the factors that influences AMF population density. Stated that in moist soil conditions, the AMF sporulation process becomes lower so that the number of spores contained in the soil is also small. Drought does not inhibit growth, but on the contrary, high humidity will inhibit the development of spores and also increase the development of lateral roots and after colonization will help the rate of root elongation and the number of mycorrhizae increase rapidly thereby producing new spores[23].

The results of the analysis of soil chemical properties at the research location show that there are differences in the properties of secondary forest land and agroforestry land, which can be seen in TableThe following 4:

TABLE 4. CHEMICAL PROPERTIES OF THE POBOYA GOLD MINING AREA

Parameter	Soil Example	
	Secondary Forest	Agroforestry
PH H2O (1 : 2.5)	7.8	7.69
PH KCL (1 : 2.5)	7.3	6.96
N-Total (%)	0.41	0.18
P2O5 HCL 25% mg/100g	61.96	63.34
C-Organic (%)	5.04	3.39
CEC (cmol(+)kg-)	38.64	25.98

From the results of the analysis of the chemical properties of secondary forest soil, C-organic was 5.04%(classified as high), while on agroforestry land it was 3.39% (classified as medium). The total N value also decreased compared to secondary forest land with a value of (0.42%, classified as medium), while on agroforestry land it was 0.18% (classified as low). Secondary forests have a lower P2O5 content than agroforestry land. The P2O5 content in secondary forests is 61.96 mg/100 g (classified as very high) and in agroforestry land it has a higher value of 63.34 mg/100 g (classified as very high). The Cation Exchange Capacity (CEC) value in secondary forest areas is higher (38.64) than in agroforestry areas (25.98) due to a decrease in pH and organic matter levels.

The chemical properties of the soil in the two research areas show that the chemical content of the soil in the agroforestry area is lower than in the secondary forest area. Changes in soil chemical properties can also be seen in table 6, differences in changes in nutrient status such as the percentage of organic C, total N, PH, P2O5, and CEC. In agroforestry areas these factors are generally lower than in secondary forest areas. The type and density of AMF is thought to be influenced by lower soil chemical properties in agroforestry areas. This happens because mycorrhizal spores can develop optimally in nutrient-poor soil. Low availability of the N nutrient will increase plant dependence on association withwith mycorrhiza because low nutrient availability can optimize mycorrhiza in nutrient absorption[24].

Stated that in nutrient poor conditions (low available P) some vegetation will experience difficulties in the growth process and absorbing some nutrients, especially available P, as one solution the vegetation will further increase its symbiosis with mycorrhiza to help in nutrient absorption. If mycorrhizae experience pressure in their environment, they will tend to sporulate more. In contrast to the smaller number of mycorrhizal spores found in secondary forest areas with higher P-availability than agroforestry land.[25]

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States that CEC in soil is very dependent on soil pH. CEC is a chemical property of soil that is closely related to soil fertility, because soil will not be able to absorb and provide nutrients for plant growth if it has a low CEC[26]

C. Level of colonization by arbuscular mycorrhizal fungi

The results of the analysis of the level of AMF colonization in plants that were analyzed to see whether there was AMF colonization were the dominant plant species in the agroforestry area and secondary forest around the Poboya gold mining area. The results of the analysis of colonization levels in plants are presented in the following table;

TABLE 5. ARBUSCULAR MYCORRHIZAL FUNGAL COLONIZATION RATE

No	Plant	Scientific name	Colonization (%)	Criteria
1	Gondang	*Vicus varigieta Blume*	5.2	Low
2	Candlenut	*Aleurites moluccana*(L.)	51.3	Tall
3	Lamtoro	*Leucaena leucocephala*	33.7	Currently
4	Pulutan	*Urena lobate*(L.)	5.1	Low
5	White Teak	*Gmelina arborea*Roxb.	91.8	Very high
6	Coffee	*Coffea sp*	20	Low
7	Soursop	*Annona Muricate* (L.)	12.8	Low
8	Yellow Bamboo	*Bambusa vukgaris*Var. striata	9.5	Low
9	Forest fern	*Athyrium filix-femina*(L.) Roth	14.6	Low

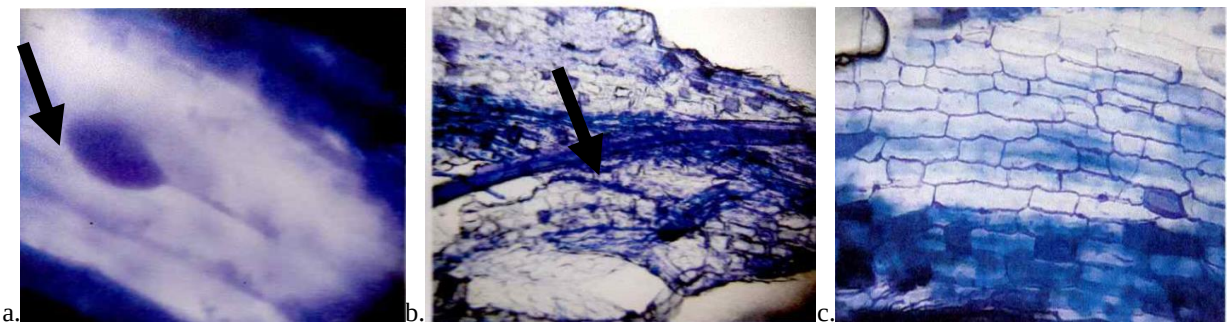

Figure 4. Colonization structure of arbuscular mycorrhizal fungi: a. The structure of mycorrhiza is in the form of vesicles, b. mycorrhizal structure in the form of internal hyphae, c.root cells that are not colonized by mycorrhiza

Based on the results of the colonization analysis, it can be seen that White Teak*Gmelina arborea*Roxb)is a plant with a very high percentage of AMF colonization (91.8%), the high percentage is found in Candlenut (Aleurites moluccana (L.)) (51.3%), the medium percentage is found in the medium plant Lamtoro (Leucaena leucocephala) (33, 7%) while the low percentage of AMF colonization is Gondang (Vicus varigieta Blume) (5.2%), Pulutan (Urena lobate (L.)) (5.1%), Coffee (Coffea sp) (20%), Soursop (Annona muricate (L.)) (12.8%), Yellow Bamboo (Bambusa vukgaris Var. Striata)(9.5%), Forest Fern (Athyrium filix-femina (L.) Roth)(14.6). This condition is thought to be caused by differences in soil texture, soil fertility levels and different environmental conditions in agroforestry areas and secondary forest areas. Apart from that, differences in colonization percentages are thought to also be influenced by plant species and their sensitivity to mycorrhiza. According to [27]it is said that the development of mycorrhiza is influenced by the sensitivity of the host plant to soil temperature, light intensity, nutrient and soil water content, soil pH, organic matter, root residue and heavy metals.

The percentage of infection in plant roots is related to the ecological system of both AMF and host plants in their habitat[28]. Alsorevealed that the structures produced by AMF in plant root systems are very important in symbiosis. The three important components in the mycorrhizal root system are their role in the roots themselves, internal hyphae associated with the roots, and external hyphae associated with the soil.[10]

In the observation results, not all roots appeared to have internal spores in the plant root cells (Figure 7). Indeed not all types of AMF are able to form complete structures in root cells. Some types of AMF may form internal spores, but other types cannot. Likewise, vesicles are considered as structures for storing food reserves, and branching hyphae form auxiliary cells in the soil.

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Soil conditions with low nutrient content, especially phosphorus, will cause increased colonization of AMF on plant roots, basically AMF is needed by plants to absorb phosphorus. Stated that, high availability of phosphorus in the soil directly reduces AMF activity so that the presence of AMF is reduced, conversely, low phosphorus available in the soil increases the formation of AMF in plants because in soil conditions like this, plants tend to utilize AMF as a one way to get nutrients in the soil.[29]

D. Composition of plant species in the vegetation in the Poboya gold mining area

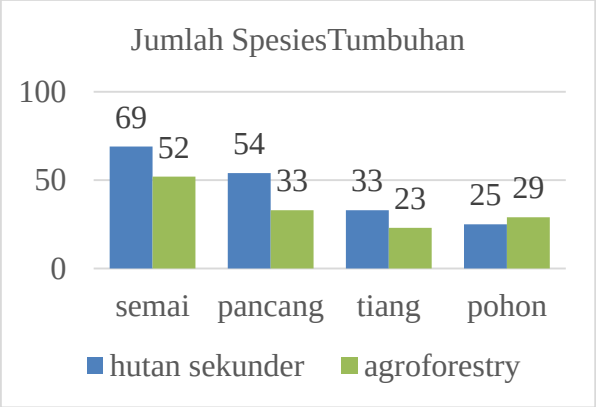

Figure 5. Number of plant species at the two research locations

Based on the inventory carried out at two research locations, it was recorded that the secondary forest area had a higher number of plant species than the agroforestry area, but the tree phase in the agroforestry area was recorded to be higher. Vegetation analysis of the number of species present in various phases of vegetation growth showed that the composition of the vegetation in secondary forest and agroforestry areas no longer follow the general pattern of tropical forest vegetation. Tropical forests have a vegetation composition that reflects the dynamics of regeneration that occurs naturally, where vegetation in the seedling phase has the highest number of species, then the number of species decreases in the sapling, pole and tree phases[30].

E. Relative density

According to [31] density is the number of individual stands of a species in an area. The relative density in the Poboya gold mining area is presented in tables 4 and 5, as follows:

TABLE 6. RELATIVE DENSITY OF PLANTS IN THE GROWTH PHASE ON SECONDARY FOREST LAND.

Local name	Scientific name	Relative density			
		seedling	stake	pole	tree
Gamal	*Glyricida spium*(Jacq). Steud.	8.7	5.56	-	-
Candlenut	*Aleurites moluccana*(L.)	14.49	16.67	18.18	40.00
Coffee	*Coffea Sp*	1.45	3.7	6.06	-
White Teak	*Gmelina arborea*Roxb	4.35	-	9.09	16.00
Angrung	*Trema orientalis.*	4.35	7.41	12.12	20.00
Soursop	*Annona Muricate*L.	7.25	3.7	9.09	-
BambooYellow	*Bambusa vukgaris*Var. striata	-	-	2.9	-
Gondang	*Vicus varigieta*Blume	7.25	14.81	15.15	24.00
Fern	*Athyrium filix-femina*(L.) Roth	11.59	-	-	-
Taipa	*Mangifera indica*	2.9	-	12.12	-
Forest Chili	*Capsicum irutescens*	4.35	-	-	-
Sri Kaya	*Annona squamosa*L.	7.25	7.41	-	-
Javanese wood	*Lannea coromandelica*	-	4.35	11.11	-
Lamtoro	*Leucaena leucocephala*	13.04	18.52	18.18	-
Fence Distance	*Jathropa curcas*Linn	5.8	-	-	-

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TABLE 7. RELATIVE DENSITY OF PLANTS IN THE GROWTH PHASE ON AGROFORESTRY LAND

		Relative density			
Local name	Scientific name	seedling	stake	pole	tree
Candlenut	*Aleurites moluccana*(L.)	19.23	18.18	39.13	86.20
Angrung	*Trema orientalis.*	5.77	12.12	21.74	-
Soursop	*Annona Muricate*L.	9.62	-	-	-
Gondang	*Vicus varigieta*Blume	7.69	15.15	-	-
Gamal	*Glyricida spium*(Jacq). Steud	11.54	12.12	-	-
Lamtoro	*Leucaena leucocephala*	15.38	21.21	17.39	-
Pulutan	*Urena lobate*(L.)	13.46	9.09	-	-
Forest Chili	*Capsicum irutescens*	7.69	-	-	-
Coffee	*Coffea sp*	-	3.03	-	-
White Teak	*Gmelina arborea*Roxb	-	-	21.74	13.79

The results of vegetation analysis of the number and types of species at various growth phases at the two research locations show varying composition at each growth phase. In secondary forest areas the number and types of species are higher than in agroforestry areas. Plant species in the seedling phase are most often found in secondary forest areas, in the sapling and pole phase the most species are also found in secondary forest areas, in the tree phase they are found most often in agroforestry areas.

Differences in vegetation structure and composition are due to differences in the character of each plant. Apart from that, variations in plant structure and composition in a community are influenced, among other things, by plant phenology, dispersal and natality[32].

Density shows the density of plant growth at each observation station. [33] categorized density into 4 categories, namely: low category with a value of 12-50%, medium category with a value of 51-100%, good category with a value of >201%. Based on the results of analysis on secondary forest land, the highest relative density value was in the seedling category, namely Kemiri(*Aleurites moluccana*(L.))amounting to 14.49%. The highest relative density value in the sapling category was for Lamtoro (Leucaena leucocephala) at 18.52%. The highest relative density value in the pole category is for Kemiri (Aleurites moluccana (L.)) and Lamtoro (Leucaena leucocephala) at 18.18%, while the highest relative density value in the tree category is for Kemiri (Aleurites moluccana (L.)) which is 40.00 %.

On agroforestry land, the highest relative density value in the seedling category is for candlenut (Aleurites moluccana (L.)) at 19.23%. The highest relative density value in the sapling category was for Lamtoro (Leucaena leucocephala) at 21.21%. The highest relative density value in the pole category is for Candlenut (Aleurites moluccana (L.)) 39.13%, while the highest relative density value in the tree category is for Candlenut (Aleurites moluccana (L.)) namely 86.20%. Candlenut (Aleurites moluccana (L.)) and Lamtoro (Leucaena leucocephala) plants also at the research location had quite high levels of AMF colonization, namely 51.3% and 33.7%. This shows that Kemiri (Aleurites moluccana (L.)) and Lamtoro (Leucaena leucocephala) have the largest number of individuals and have the ability to adapt well to environmental conditions.

In connection with environmentally friendly land rehabilitation efforts, the use and utilization of organisms, both plants as phytoremediation and land reclamation processes, is very important . With the carrying capacity of AMF as multi-functional microorganisms for plant growth, in marginal conditions it has a big influence on plant vitality. Therefore, efforts to discover types of AMF and the prospects for local AMF utilization are considered more environmentally friendly than other methods This process of course goes through long stages, starting from isolating AMF types, selecting superior types, testing plant compatibility, propagating and using them in the field[34]

IV. CONCLUSION

Based on research conducted on secondary forests and agroforestry in the Poboya gold mining area, it can be concluded that:

1. The types of AMF spores found at the research location were 5 types of AMF, namely*Acaulospora sp2, Acaulospora sp3, Acaulospora sp4, Glomus sp6, Glomus sp7*. Observation of the color of the spores shows that there are different types of spore colors including clear yellowish, yellow and brown. The highest density of Arbuscular Mycorrhizal Fungi spores was found in agroforestry land with 11 spores per 20 g of soil, while in secondary forest land the spores were found as many as 3 spores per 20 g of soil. The level of colonization shows that the plants with the highest percentage of AMF colonization are White Teak (Gmelina arborea Roxb) (91.8%) and Candlenut (Aleurites moluccana (L.)) (51.3%), the moderate level of

colonization is found in Lamtoro plants (Leucaena leucocephala) (33.7%) and low colonization levels, namely Gondang (Vicus varigieta Blume) (5.2%), Pulutan (Urena lobate (L.))(5.1%), Kopi (Coffea sp) (20%), Soursop (Annona muricate (L.))(12.8%), Yellow Bamboo (Bambusa vukgaris Var. Striata) (9.5%), Forest Fern (Athyrium filix-femina (L.) Roth)s(14.6%)

2. Vegetation composition In secondary forest areas the number and types of species are higher than in agroforestry areas. Plant species in the seedling phase are most often found in secondary forest areas, in the sapling and pole phase the most species are also found in secondary forest areas, in the tree phase they are found most often in agroforestry areas. The highest relative density at each growth phase is found on agroforestry land, namely candlenut plants(Aleurites moluccana (L.))and Lamtoro (Leucaena leucocephala).

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