DIVERSITY OF ARBUSCULAR MYCORRHIZAL FUNGI AND MYCORRHIZAL PLANT STATUS AT AGROFORESTRY SITES OF GUNUNG WALAT EDUCATIONAL FOREST

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Introduction

Gunung Walat is an educational forest managed by Faculty of Forestry Bogor Agricultural University. The forest was bothered by farmers who live around the forest since 1997 due to Indonesian economic crises. Consequently, the forest became degraded. It is not easy to rehabilitate the degraded sites for several major constrains related to existing unfavorable environmental conditions at the degraded sites. Edaphic factors (low nutrients, acidic soils), climatic factors (high level of solar radiation and high temperatures) and biological factors and low soil microbial activities) are some of these led to reduced performance of planted tree.

The application of beneficial microbial technology such as mycorrhizal fungi as alternative strategy should be attempted and developed in order to increase the survival, quality and growth rate of seedling and plant productivity in the field.

Arbuscular mycorrhizal fungi (AMF) belong to the Glomales (Zygomycetes), and about 130 species in the genera Glomus, Sclerocystis, Gigaspora, Enthtropospora, Scutellospora and Acaulospora have up to now been recognized as forming symbiotic associations with plants (Schenk and Perez, 1990). These fungi are extremely widespread; they not limited to any one plant family and have an exceptionally wide range of host and habitat (Smith and Read, 1997). The novel function of this fungi as biological agent for plant productivity as well as for bioremediation of heavy metal contaminated soil (Setiadi, 1998, Hashem, 1995) helping agent in early seedling establishment on degraded sites are recognized. arbuscular mycorrhizal fungi (AMF) have also been employed to increase resistance to plant pathogens (Liu, 1995) and Salinity (Azcon and El-Atrash, 1997).

To assess whether introduction of arbuscular mycorrhizal fungi (AMF) into a given ecosystem beneficial, it is necessary to evaluate the importance of the indigenous mycorrhizal population.

The recent work aimed to know the diversity of AMF and plant mycorrhizal status in Gunung Walat Educational Forest that further useful for supporting site rehabilitation through agroforestry system.

Methodology

Four damaged and cultivated plots in the forest belonged to four farmers have been selected for the study. Two plots (managed by Mr. Mami and Mr. Rosi) were intensively cultivated without cutting the existing trees (agroforestry) and the other two (managed by Mr. Gani and Mr. Aphid) were not intensively cultivated, but many trees have illegally been cut. The soil was collected from the rhizosphere of different plants grown at different soil depth (0-20 cm) and 20-40 cm). A 50 g sub-sample from soil sample was weighed and sieved to isolate the AMF spore according the method of Nicholson and Gaderman (1963), and the rest of the samples were for trapping to induce the production of mores spores for further study. The soil was also analyzed for their physical and chemical properties. The isolated spores were identified under microscope to genus level. The root samples collected were stained by Philip and Hayman (1970) method and the root colonization were observed under the microscope.

Results and Discussion

Physical properties of soil

Results of the analyses of the physical properties of soil samples collected from each site are presented in Table 1.

Table 1. The physical properties of soil samples.

Plots	Soil depth (cm)	Bulk Density (gr/cc)	Total pores (%)	Water content (% volume)				Pore drainage (%)		Available water (%)	Permeability (cm/jam)
				1.00	2.00	2.54	4.20	Fast	Slow		
Plot1 (Mami)	0 - 20	1.16	56.23	49.31	43.31	38.14	28.34	12.91	5.19	9.79	17.41
	20 - 40	1.24	53.39	48.24	43.71	37.78	27.98	19.37	5.93	9.79	19.49
Plot 2 (Rosi)	0 - 20	1.22	53.96	45.95	42.23	36.89	27.10	11.73	5.33	9.81	8.77
	20 - 40	1.23	53.58	45.84	41.57	37.39	37.45	12.00	4.18	12.81	9.36
Plot 3 (Gani)	0 - 20	1.15	56.60	52.49	45.13	39.44	28.71	11.47	5.69	10.73	7.70
	20 - 40	1.15	56.41	51.79	44.39	38.80	30.71	12.02	5.59	8.04	8.27
Plot 4 (Aphid)	0 - 20	1.24	53.02	48.25	43.35	39.13	26.15	9.47	4.21	12.98	5.79
	20 - 40	1.23	53.40	48.82	43.48	37.40	25.09	9.91	6.08	12.31	12.48

Physical properties among the four plots were generally similar, except for their permeability. Plot 1 has the highest permeability, while the upper layer (0-20 cm) of Plot 4 has the lowest.

Chemical properties of soil

Generally, upper layer of the soil (0-20 cm) has better chemical property compared with the lower layer (Table 2). Soil pH of the soil was generally acidic (4.4-5.4), and Na and K content were low, but Mg and Ca were high, and P was medium to high. The C-organic content in Plot 4 was low, while in the three other plots was medium. The kation exchange capacity in all plots was commonly medium (Table 2).

Diversity of AMF

Analyses of biological properties of soil were focused on the beneficial microorganism for promoting plant growth, especially arbuscular mycorrhizal fungi AMF). Results of the AMF analyses are presented in Table 3.

Table 2. The chemical properties of soil.

No	Sample Plots	Soil depth (cm)	pH		C	N	C/N	Available P	Exchangeable cations					CEC	SB	Exchangeable Al/ H		Textur 3 fr		
			H_2O	KCl	Org	Total	Ratio	Bray I (ppm)	Ca	Mg	K	Na	Total	Meq/100 g	(%)	meq/100g Al	H	Sand	Silt	Loam
1	Plot 1	0 - 20	5.3	4.6	2.6	0.23	11.27	23.60	5.47	2.59	0.31	0.26	8.63	18.07	47.79	0.08	0.16	13.17	44.17	42.71
	(Mami)	20 - 40	5.2	4.4	2.3	0.2	11.01	19.97	4.70	2.23	0.28	0.23	11.16	15.58	45.11	0.07	0.17	12.52	44.56	42.42
2	Plot 2	0 - 20	5.4	4.6	3.1	0.28	11.05	31.35	6.90	4.09	0.28	0.24	11.68	19.45	59.38	0.06	0.15	10.1	44.18	45.71
	(Rosi)	20 - 40	5.25	4.5	2.8	0.23	10.65	27.05	5.43	2.53	0.25	0.21	8.41	15.96	52.65	0.09	0.12	11.07	42.45	46.56
3	Plot 3	0 - 20	5.25	4.5	3.1	0.26	11.75	21.05	4.78	2.55	0.25	0.26	7.81	18.22	43.08	0.06	0.12	12.73	40.9	46.34
	(Gani)	20 - 40	4.4	4.4	2.8	0.24	11.25	17.15	4.28	2.05	0.21	0.20	6.75	17.26	39.20	0.09	0.14	12.53	41.41	46.05
4	Plot 4	0 - 20	5.4	4.7	1.7	0.16	10.4	27.56	5.19	2.07	0.30	0.17	7.74	18.25	42.38	0.07	0.19	13.73	41.73	44.53
	(Aphid)	20 - 40	5.2	4.5	1.4	0.14	10.2	21.87	4.33	1.70	0.26	0.15	6.45	16.86	37.89	0.09	0.18	11.27	42.63	46.09

Table 3. Spore numbers and AMF diversity in study site.

No	Location	Depth (cm)	Spora Number/ 50 g soil		
			Glomus	*Gigaspora*	*Acaslospora*
1	Plot 1 (Mami)	0 - 20	133	2	1
		20 - 40	34	1	3
2	Plot 2 (Rosi)	0 - 20	12	2	1
		20 - 40	10	-	-
3	Plot 3 (Gani)	0 - 20	55	10	3
		20 - 40	15	2	1
4	Plot 4 (Aphid)	0 - 20	108	1	7
		20 - 40	87	1	3

Table 3 shows that there were differences in spore numbers and diversity. Plots 1 and 2 have the highest number of AMF spores, respectively. Spore numbers and were highest in the upper part of soil layer, and getting lower with depth.

Plant Diversity and Mycorrhizal Status

The plants diversity and mycorrhizal status collected from four different locations in Gunung Walat educational Forest varied (Table 4). Among 2 tree species assessed, all had mycorrhizae and 12 crops species assessed, 10 of them had mycorrhizae.

Table 4. The plant species found in plots of study.

No Plot	Name of plant species	Mycorrhizal status
Plot 1 (Mami)	*Agathis lorantifolia*	+
	Coffe robus	+
	Salacca edulis	+
	Manihot esculata	+
	Cardamom sp	+
	Musa paradisiaca	-
	Copsicum sp,	+
	Lenca	+
	Taro	+
	Ananas comusus	+
	Sereh	-
Plot 2 (Rosi)	*Accacia mangium*	+
	Aghatis lorantifolia	+
	Coffe robusta	+
	Salacca edulis	+
	Manihot esculenta	+
	Cadamon sp	+
	Musa paradisiaca	-
	Taro	+
	Gude	+
Plot 3 (Gani)	*Musa paradisiaca*	-
	Gude	+
	Leunca	+
Plot 4 (Aphid)	*Musa paradisiacal*	-
	Oryza sativa	+
	Manihot esculanta	+
	Gude	+

Based on the physical, chemical and biological properties analyses, the soil in Gunung Walat Educational forest has generally low to medium fertility. Plot 4 has the lowest fertility, this might be caused by the removal of trees (trees have been previously clear cut), which reduced the production of organic matter and increased soil erosion. In this type of site, input, such as inorganic, organic fertilizer, and bio-fertilizer need to be applied to improve trees and crops productivities.

The analysis of biological properties of the soil found diverse morpho-types of mycorrhizal spores, which could be grouped into three genera, i.e. *Gigaspora, Glomus* and *Acaulospora*. The potential and application of mycorrhiza to enhance plant growth and productivity has been widely known (Budi *et al.*, 1998; Smith and Read, 1997; Lemoine *et al.*, 1992).

The richness of arbuscular mycorrhizal fungi (AMF) spore found in Plot 1 might be due to the favorable sites for sporulation, and also the plant species found in that plot were more divers than the other plot (Table 4). According to Abbott and Gazey (1994), there are many factors that affect the sporulation of arbuscular mycorrhizal fungi (AMF) i.e.: the host, edaphic, climate and biological factor.

The diversity of arbuscular mycorrhizal fungi (AMF) studied at the site show that the upper layer of the soil were more divers than the lower layer, this might be correspond with the physical and chemical properties of the soil (see Table 2 and 3). The arbuscular mycorrhizal fungi (AMF) species and spore number is dominated by Glomus sp followed by Gigaspora sp.

The data presented in *Table 3* indicate that there are particular patterns in the formation and sporulation of arbuscular mycorrhizal fungi (AMF) which depend largely on the characteristics of the site. According to the hypothesis of Cornnell (1978), the diversity of species should be lower for minimal and maximal disturbance, for recent and distant disturbance and for minor and major levels of disturbance than that of intermediate levels of disturbance. Due to its obligate symbiotic, the abundance of arbuscular mycorrhizal fungi (AMF) in the ecosystem certainly depend on the host in the site.

Those data also indicate that the abundance of AMF found in Agroforestry site that can be subsequently used as a bank of glomalean fungi. A large diversity of arbuscular mycorrhizal fungi (AMF) found on those site, could be used as a base for selecting effective arbuscular mycorrhizal fungi (AMF) to be used for increasing the crop productivity in Agroforestry system.

Conclusions

1. The soil fertility of Agroforestry site in Gunung Walat was low to medium.
2. Beneficial microbes, especially mycorrhiza (AMF) were found in the site and could be used to develop bio-fertilizer in the near future.
3. The diversity of AMF varied depend on the site condition and the soil depth
4. Almost the plant species found in the site had mycorrhizae.

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