The Effect of Bio-VA Mycorrhizae Inoculation on Biomass of Trees and Carbon Stock of Eight Forest Tree Species in Bodogol Plantation-Sukabumi, Indonesia (Pengaruh Inokulasi Bio- VA Mycorrhizae pada Biomasa Tanaman dan Stok Karbon dari Delapan Species Tanaman Hutan di Bodogol-Sukabumi, Indonesia)

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ABSTRAK

Studi tentang pengaruh Bio-Mycorrhizae (BIO-VAM) pada biomasa dari delapan species tanaman dan stok karbonnya dilakukan dengan metoda destruksi sampel dari tanaman yang terpilih di Bodogol, Sukabumi, Jawa Barat. Data yang didapat dari penelitian menunjukkan bahwa inokulasi Bio-VAM menunjukkan hasil yang positif terhadap biomasa tanaman dan stok karbon. Volume biomasa tanaman tertinggi ditunjukkan oleh species tanaman umbrella tree (*Maesopsis emenii.* Eng) yakni 387,5 g per tanaman apabila diinokulasi dengan mikorisa dan 211,6 g per tanaman tanpa mikorisa diikuti dengan sengon buto (*Enterolobium cyclocarpa* Griseb*),* rasamala (*Altingia excelsa* Noronhae)*,* manglid (*Magnolia blumei* Prantl), sawo duren (*Chrysophyllum cainito* L)., ki bereum (*Adinandra dumosa* Jack) bisbul (*Diospyros blancoi* Desr.) dan biomasa tanaman terendah ditunjukkan oleh species podocarp/ jamuju (*Podocarpus imbricata* R.Br*)* 82,76 g dengan inokulasi mikorisa dan 65,77 g tanpa inokulasi mikorisa. Karbon stok tertinggi ditunjukkan oleh tiga spesies tanaman yakni umbrella tree (*Maesopsis emenii.* Eng.) 3,23 ton C/ha dengan inokulasi mikorisa sementara tanaman kontrol menunjukkan 1,76 ton C /ha, dan 11,85 ton CO_2 /ha dan 6,46 CO_2 /ha. Diikuti oleh sengon buto (*Enterolobium cyclocarpa* Griseb), rasamala *(Altingia excelsa* Noronha*)* Kontribusi karbon stok terendah ditunjukkan oleh podocarp (*Podocarpus imbricata* Blume*)* yakni 0,07 ton C/ha (dengan inokulasi BioVAM) dan 0.05 ton C/ha (tanpa inokulasi BioVam) 0,26 ton CO_2 /ha dan 0,18 ton CO2. Tujuan dari penelitian ini adalah menganalisa pengaruh inokulasi Bio-VA Mycorrhizae terhadap produksi biomasa tanaman dan stok karbon selama pertumbuhan tanaman.

Kata Kunci: BIO-VAMycorrhizae, inokulasi, biomas tanaman hutan , stok karbon.

ABSTRACT

Study on the effect of Bio-Mycorrhizae (Bio-VAM) on biomass of eight species of trees and its carbon stock was done by using *destructive sampling* through the selection of plants in Bodogol, Sukabumi, West Java. The results showed that Bio-VAM inoculation performed positive result on tree biomass and carbon stock. Umbrella tree (*Maesopsis emenii* Engl.) showed the highest biomass volume both inoculated and control followed by elephant ear's fruit (*Enterolobium cyclocarpa* (Jacq) Griseb., rasamala (*Altingia exelsa* Noronha), manglid (*Magnolia blumei* Prantl), star apple (*Chrysophyllum cainito* L.), ki beureum (*Adinandra sp.),* velvet apple bisbul (*Diospyros blancoi* A.DC.), podocarp/jamuju (*Podocarpus imbricatus* Blume).. The highest biomass volume performed by *Maesopsis emenii.* Eng. resulted 387.5 g per plant when inoculated with mycorrhizae and 211.6 g per plant without mycorrhizae followed by ear's fruit (*Enterolobium cyclocarpa* Griseb.)*,* rasamala *(Altingia excelsa* Noronha*),* champaka (*Magnolia blumei* Prantl), star apple (*Chrysophyllum cainito* L.) kibereum (*Adinandra dumosa* Jack)*,* velvet apple (*Diospyros blancoi* Desr.) and the lowest was performed by podocarp (*Podocarpus imbricata* R.Br.) 82,76 g with mycorrhizae inoculation and 65.77 g without mycorrhizae inoculation. The most highest carbon stock were performed by three plants species that are umbrella tree (*Maesopsis emenii.* Eng) 3.23 ton C/ha with mycorrhizae where as control plant is 1,76 ton C /ha and 11.85 ton CO_2 /ha and 6,46 CO_2 /ha.. Following by elephant ear (*Enterolobium cyclocarpa* Griseb)*,* rasamala (*Altingia excelsa* Noronha) The lowest contribution of carbon stock performed by podocarpu (*Podocarpus imbricate.* Blume*)* which shows 0.07 ton C/ha (with mycorrhizae) and 0.05 ton C/ha (without mycorrhizae) , 0,26 ton CO_2 /ha and 0,18 ton CO_2. The aim of this research is to analyse the effect of Bio-VAM on biomass production and carbon stock during the growth of plants.

Keywords: BIO-VAMycorrhizae, inoculation, forest tree species,biomass, carbon stock

INTRODUCTION

The increased concentration of atmospheric CO_2 is one of the main reasons for global warming. It is widely accepted that forests play the important role in the sink of atmospheric CO_2. Nowadays, however the forest areas in the tropical region have been decreasing. Indonesia tropical forest area covers totally 120.35 millions hectar which belong to the third biggest forest after Brazil and Zaire. However, Department of Forestry in 2004 reported that the total area of degraded forest is 96.3 million hectars. From that total of degraded land forest, 54.6 millions

hectars is in natural forest, production and conservation forest and 41.7 millions hectars is outside forest area such as the forest areas along the river side. (Nawir *et al*. 2008). It was calculated that deforestration speed is 0.5 % per years (Forestry Dept of Indonesia and FAO 2002). This condition appeared because of the activities of illegal logging, forest fire, extensification of agriculture land, plantation establishment, transmigration program, mining activities etc.

Indonesian Government has put big effort for the success of reforestration program. The program covers the control of illegal logging including the marketing of illegal logg, restructur of forest sector, handling the forest fire, rehabilitation and conservation of natural forest which all put on government regulation.

At technical level, the availability of best quality of tree seedling become the crusial point since one of the technical hazard for reforestration program in tropical region is that Latosol soil type. Latosol is the infertile soil of which phosphate retention capacity is very high and spreads widely. In such a degraded land as Latosol, plant growth very poor. Most of the degraded area is Latosol (Wahyar *et al*. 1994)

R&C for Biotechnology LIPI has been succesfully completed the activities of research colaboration with R&D Department of Osaka Gas Co.Ltd, Japan on Development of Bio-VA Mycorrhizae technology for forest trees in Indonesia. The colaboration covered the technology transfer of Bio-VA Mycorrhizae production including the establisment of pilot scale production unit in Indonesia. The application of Indonesian Bio-VA Mycorrhizae at field sites have been done to understand the effect mycorrhizae inoculation on supporting the plants growth.

The effect of deforestration to global climate in many tropical countries will eventually be taken up in tree regrowth program for regreening of critical land. In this view the use of potential microbes for supporting the growth of plants will promotes the annual carbon emission from tropical landscapes. Bio-VA mycorrhizae inoculation has been characterized successfully in supporting the regreening program in Indonesia.

For the purpose of contributing to global environment, especially to enhancing the CO_2 fixation, the regreening program of degraded land at buffer zone of Gede Pangrango Natural Park was established using new technologies of soil microorganism potential. The soil microorganism potential is Bio-VA-Mcorrhizae (Bio-VAM) fungus. Bio VA Mycorrhizae is a type of filiform fungus which spread hyphae networks in the soil and have symbiotic relationship with host plants. The function of Bio-VAM vigorously absorbing minerals, especially phosphate, other soil nutrition including water. These minerals then transfer to host plants. Plants forming symbiotic relationship with Bio-VAM are enhanced their growth and resistance to drought and disease. The mycorrhizae actually protect the root plant by covering the root surface with their hyphae so that the bacterial caused diseases of root will be died before they infect the root plant. In this case the mycorrhizae will produce the enzyme which could destroyed the protein of bacteria (Bajwa. *et al*. 1985). Hersanti *et al*. (1999) reported that the inoculation of mycorrhizae into the plant with doses 20 g/ 2 kg of soil could be able to protect the plants from root diseases caused by nematode (*Meloidogyne* sp). In addition of that, it was reported that the presence of mycorrhizae reduced diseases up 8 -17 % of *Rhizoctonia solani* (Kasiamdari *et al*. 1999). Mycorrhizae fungus actually best when inoculate at early stage of plant growth, since the fungus will get first chance to infect the first early coming root before they will infect with other indigenous mycorrhizae found in the soil.

Forest biomass could be define as weight unit per areas which are consist of weight of leaf, flower, fruits, trunk, root also dead plants (Brown *et al*. 1989). The amount of biomass was identified by tree age, diameter, height, soil fertility and silviculture system. Prediction of forest biomass is needed to understand the effect of carbon cycle (Morikawa 2002). Forest biomass normally composed of 45 -50 % of carbon (Brown *et al.* 1997; IPCC 1995). Nelson *et al.* 1999, reported that forest biomass data was very useful to evaluate the productivity the ecosystem. Forest is very important for CO_2 absorbtion and reduce the concentration of CO_2 in the air through the conservation and restructure of

forest management.

The aim of this research is to study the growth of eight forest tree species which inoculated with Bio-VAM and as the contras estimate the carbon content and formulated the allometric equation for estimating the biomass production and carbon stock during the plant growth.

MATERIAL AND METHODS

Research was conducted at Javan Gibbon Center, Bodogol, West Java , in conservation area of Gede Pangrango National Park . The location is 600 – 800 m above sea level with type A climate and average rain is 4,962 mm per year (Schmidt & Ferguson 1995) The latitude of location is 106^0 55' 17 '' East and 6^0 46' 38"

The area generally hilly with 25 % - 60 % slope. Based on the soil map published by Research Center for Soil and Agroclimate 1997, the soil type of that area is Latosol. The research activities was conducted at 20 months old plant after transplanting.

The research materials are eight tree species growing at Bodogol area at Sukabumi. The species are *Altingia excelsa* Noronha, *Enterolobium cyclocarpa* Griseb., *Maesopsis emenii* Engl**.,** *Podocarpus imbricata* R.Br., *Diospyros blancoi* (Desr.) Gurke, *Adinandra dumosa* Jack., *Chrysophyllum cainito* L. and *Magnolia blumei* Bl. The species was grown with 2 x 3 m distance and 250 trees were planted each species Those plants was treated by mycorrhizae and without mycorrhizae inoculation as control plant. From each population 50 plants were selected randomly and based on height and diameter of plant which continue measured every month, then 10 plants selected to be sampling .

Trees to be used for analyzing was observed and selected among the population Data about the plant was noted and after compiling data of trees, sampling was done based on distribution of tree diameter of trunk from the biggest to the smallest diameter. For this research 5 plants from each species is selected to be analyse, which are inoculated with BioVAM or as contras.

Branch was separated from stem (trunk) and then weight one by one. Life and a dead branch were separated and leaf also cut it off from branch.

Sample of trees was selected for measuring the dry weight. Sample was taken from lower part, middle part, upper part, root, living and dead part of small stem, leaf, 200 g each. Every sample then put on the paper bag and dried in the oven 85 ^{0} C for 48 hour (JICA, 2002).

Dried weight of sample was calculated with equation describes by Heriyanto *et al*. (2002). Carbon content was calculate using equation describe by (Brown 1997; IPCC 2003):

Carbon content = Dried weight of plant x 50 %.

CO2 Absorbtion= Mr. CO_2/Ar. C (or 3,67 x carbon content)

Note : Mr : molecule relative., Ar : Atom relative.

Prediction of allometric equation was calculated by :

$$Y = aX^b$$

Notes:

Y = Dry weight of plant

X = Diameter of trunk 10 cm above root neck

a,b = coefisien

RESULTS

Diameter and height of plant

Sampling of 50 plants were randomly selected and from 50 plants , 5 plants of control and 5 plants from treated plants with BioVAM were chosen and collected than measuring the diameter and height of plants.

Average diameter and height of plants of eight forest trees are shown in Table 1.

The result in Table 1 shown that diameter and height of plant of treated plant (inoculated with Bio VAM) are higher than control plants. The highest result performed by *Maesopsis emenii* following *by Altingia excelsa* and *Enterobolium cyclocarpa.* These three species are most adaptable species o1n Bodogol area. Treatment with BIOVAM provide significant result of diameter and height of plants compared to untreated plants. *Maesopsis emenii* especially showed high diameter and height of plants when it treated with BIOVAM. All species of plants gave positif respond to the BIOVAM inoculation.

Plant Biomass

Plant biomass could be devided into two catagories. First is biomass above the ground (stem, branch, small branch, leaf, flower and fruit) and second is biomass under the ground (root). Kusmana *et al*. (1992) reported that plants biomass was identified by diameter, height of plant, weight of wood and soil fertility.

Furthermore to predict forest biomass, diameter of plant is more acurate than height of plants. Diameter of plants could be converted to biomass. In parallel, diameters of plants equal to biomass

Table 2 shows the data of dried weight every species of plant which are expressing the plant biomass.

Biomass of the upper part of plant whish inoculated with BioVAM is significant higher than control plants. *Enterobolium cyclocarpa* (sengon buto), *Maesopsis emenii*, (umbrella tree) and *Altingia excelsa* (rasamala) shows best respons on growing compare to the other species. Those three species grow faster and performed best adaptation with the environmentn in site. Umbrella trees and rasamala are very suitable to use for regreening program in Bodogol area since rasamala is identified as one of the local trees species found in Gede Pangrango National Park. It has good quality of wood and the young leaf is most preferable by javan gibbon , in which belong to the protected conservation animals in Indonesia. Similarly with umbrella tree where the fruits is most preferable fruit that the javan gibbon likely very much. The regreening program in Bodogol beside to save the local species and reforestration degraded land , it is also to provide main staple food for Javan Gibbon.

The data of total biomass from species respectively are as follows *Maesopsis emenii* (BioVAM)=3874.92 g, *Enterobolium cyclocarpa* (BioVAM)=1.997.28g, *Altingia excelsa* (BioVAM=

Table 1. Average of diameter and height trees of eight species model at Bodogol, Sukabumi, West Java.

Species	Treatment			
	Control		Bio-VA Mycorrhizae	
	Diameter (D_{10} cm)	Total height (m)	Diameter (D_{10} cm)	Total height (m)
Maesopsis emenii	5,84	2,53	6,1	3,37
Altingia excelsa	3,14	1,95	3,64	2,35
Enterobolium cyclocarpa	1,82	1,8	4,44	3,31
Magnolia blumei	1,82	0,97	2,36	1,70
Chrysopillum cainito	1,46	1,06	1,62	1,14
Adinandra dumosa	1,3	0,89	1,66	1,18
Podocarpus imbricate	1,08	1,37	1,14	1,42
Diospyros blancoi	0,98	0,76	1,16	0,83
Average	2,18	1,42	2,76	1,91

Table 2. Average dry weight of biomass of eight trees species model at Bodogol- Sukabumi, West Java.

Species	Biomass (gram)							
	Control				Bio- VA Mycorrhizae			
	Stem	Above ground	Root	Total	Stem	Above ground	Root	Total
Maesopsis emenii	1.126,95	1.563,17	552,54	2.115,79	1.638,1	2.872,66	1.002,26	3.874,92
Altingia excelsa	298,97	851,74	208,62	1.060,35	437,72	1.255,12	258,34	1.513,47
Enterolobium cyclocarpa	107,55	136,69	85,25	221,94	1.032,53	1.217,06	780,21	1.997,28
Magnolia blumei	50,42	112,23	40,84	153,08	158,88	250,34	81,67	353,74
Chrysophyllum cainito	60,46	121,59	32,38	153,97	53,98	131,13	38,54	169,67
Adinandra dumosa	30,33	58,49	26,68	85,17	51,61	94,35	35,99	130,34
Diospyros blancoi	18,61	54,07	13,46	67,53	30,05	93,35	27,29	120,64
Podocarpus imbricata	30,81	55,33	10,45	65,77	39,46	68,48	14,28	82,76

1513.47 g, *Magnolia blumei* (BioVAM) = 353.74 g, *Chrysophyllum cainito* (BioVAM)=169.67 g, *Adinandra dumosa* (BioVAM) =130.34 g, *Diospyros blancoi* (BioVAM)=120.64 g dan *Podocarpus imbricata* (BioVAM) sebesar 82.76 g.

Allometric equation and carbon content

1. Allometric equation

Alometric equation is the relationship between one parameter and biomass amount which simplified the measurement of carbon content. To formulate allometric equations, destructive samplings were done in exsisting plantations, secondary forest, shrubs and grasslands. For tree species, not only above ground biomass but also root biomass was measured. Carbon contents of biomass and soil were analyzed using NC analyzer.

Measurement of forest biomass by destructive samplings need time and costly. However, to simplified the measurement was done using allometric equation. This formulation is suitable to predict the total biomass of trees. Using this equation the total biomass of trees could calculate by measuring the diameter of trees.

Table 3 shows the allometric equation of eight species of plants and the graphic of every allometric equation is shown in Appendix I.

Table 3 explained the relationship between biomass of every part of tree (root, stem) and diameter, coeffisien value (R^2) for every relationship is above 0.8 which means that the relationship are very close. Therefore for trees biomass could be further measured through the diameter of plants.

Carbon Stock

Based on formulation describe by Brown *et al.* (1997), 45% - 50% of dried biomass could be assumed as carbon stock content. Table 4 shows the carbon stock of stem, leaf , branch and root of eight species of trees at 20 moths old.

Table 4 explained the data of carbon content and CO2 absorption of eight tree species at 20 months old. The data is as follow : *Maesopsis emenii* (BioVAM) is 3,23 ton C/ha dan 11,85 ton CO_2/ha, whereas *Maesopsis emenii* (control) is 1,76 ton C/ha dan 6,46 ton CO_2/ha, *Enterolobium cyclocarpa* (BioVAM) 1,66 ton C/ha and 6,09 ton CO_2/ha, *Enterolobium cyclocarpa* (control) is 0.18 ton C/ha and 0.66 CO2 ton/ha, *Altingia excelsa* (BioVAM) is 1,26 ton C/ha dan 4,62 ton CO_2/ha, *Altingia excelsa* (control) is 0,88 ton C/ ha dan 3,23 ton CO_2/ha.

DISCUSSION

The potential of mycorrhizal fungus has been known since decades. Recent advances in mycorrhizal research is focusing on the implementation of the fungus into forest trees which are related to the fauna conservation program. Reforestration program still become the main issue in Indonesia in connection with the forest destruction by illegal logging. The tropical rain forest in Indonesia decreases sharply and caused the environmental problems leading to the global warming. Indonesia's forests are large and are being lost at significant rates, which results in global warming pollution ranked as 5th largest in the world (accounting for about 5% of the world's emissions).

Indonesia's forests cover approximately 463,300 square miles, between 1990 and 2005 approximately 108.110 square miles of Indonesian forest disappeared . To anticipate this condition The Kyoto Protocol treaty was negotiated in December 1997 at the city of Kyoto, Japan. The Kyoto Protocol is a legally binding agreement under which industrialized countries will reduce their collective emissions of greenhouse gases by 5.2% This international agreement was aims to reduce carbon dioxide emissions and the presence of greenhouse gases. Countries that ratify the Kyoto Protocol are assigned maximum carbon emission levels and can participate in carbon credit trading (Schmidt's 2010).

One effort that has been done to anticipate this statement is to support the reforestration program in Indonesia. The activities actually focusing on the preparation of forest tree seedling and by mycorrhizae fungus inoculation it help the establishment the seedling to be transfer in the fields since degraded land to be greening by the plants are often extreme condition. The area of regreening program is in Latosol soil type. Latosol is a type of soil which is not very fertile with the high phosphate retention capacity. (Wahyar *et al*. 1994) In this condition mycorrhizae fungi could actually work to absorb the phosphate and transfer it to the plant (Cavagnaro *et al*. 1999)

Mycorrhizae fungi will be established the

Table 3. Allometric equation of eight trees species at Bodogol, Sukabumi

Species	*Allometric and determination coefisien* (R^2)	
	Control	**Bio –VA Mycorrhizae**
Altingia excelsa	$Y = 50{,}639X^{2{,}3599}$	$Y = 34{,}264X^{2{,}6712}$
	$R^2 = 0{,}9724$	$R^2 = 0{,}9181$
Podocarpus imbricata	$Y = 45{,}383X^{2{,}4841}$	$Y = 53{,}39X^{2{,}2767}$
	$R^2 = 0{,}9787$	$R^2 = 0{,}9528$
Adinandra dumosa	$Y = 39{,}988X^{2{,}3005}$	$Y = 26{,}363X^{2{,}6701}$
	$R^2 = 0{,}9471$	$R^2 = 0{,}9503$
Enterolobium cyclocarpa	$Y = 43{,}343X^{2{,}3396}$	$Y = 36{,}614X^{2{,}1229}$
	$R^2 = 0{,}9547$	$R^2 = 0{,}9959$
Maesopsis emenii.	$Y = 0{,}6604X^{4{,}3786}$	$Y = 156{,}06X^{1{,}7576}$
	$R^2 = 0{,}9008$	$R^2 = 0{,}9184$
Magnolia blumei	$Y = 36{,}024X^{2{,}1063}$	$Y = 35{,}511X^{2{,}3144}$
	$R^2 = 0{,}9753$	$R^2 = 0{,}9971$
Diospyros blancoi	$Y = 56{,}746X^{2{,}2651}$	$Y = 54{,}982X^{3{,}0291}$
	$R^2 = 0{,}8904$	$R^2 = 0{,}9932$
Chrysophyllum cainito	$Y = 54{,}995X^{2{,}3301}$	$Y = 31{,}337X^{2{,}6505}$
	$R^2 = 0{,}981$	$R^2 = 0{,}8588$

symbiotic association relationship with host plants and mycorrhizae hypae will grow far from the root area and they will search plants nutrition especially phosphate and water. Mycorrhizae will support the growth of plants by providing the growth plants nutrition. (Harijadi 1979, Anonymous 1981). Mycorrhizae will established the hyphae blanket on the surface of root, therefore the mycorrhizae could act as a buffer zone for protecting the plant from root diseases. The diseases caused by Fusarium sp and dried shoot diseases caused by Pestalotia sp are very common to destroyed the forest trees e,g Pinus merkusii (Rahayu 1999). By mycorrhizae fungi inoculation the presentage of diseases could be reduced significantly.

Carbon stock is one of the indicator to understand the impact of mycorrhizae inoculation. The result of carbon stock experiment confirmed that mycorrhizae could increase the total biomass of plants which directly increased the carbon content or carbon dioxide. Total highest dried weight of plants showed by *Maesopsis emenii* Engl. (BioVAM) is 3.874,92 g, follow by *Enterolobium cyclocarpa* Griseb. (BioVAM) is 1.997,28 g, and *Altingia excelsa* Noronhae (BioVAM) is 1.513,47 g. Heriyanto & Siregar (2007ab) reported that *Pinus merkusii* Jungh et de Vriese could performed the carbon content 11.93 ton C/ha equivalent to 43.74 ton CO2/ha . In *Acacia mangium* Willd. the carbon content is 31.4 ton / ha or equal to 115.29 ton CO2 /ha. This data confirmed that the carbon content and CO2 absorption is identified according to the species of trees and age . The average of carbon content and CO2 absortion of eight species at 20 months old showed that *Maesopsis emenii* (BioVAM) 3,23 ton C/ha and 11.85 ton CO_2/ha, *Maesopsis emenii* (control) is 1,76 ton C/ha dan 6,46 ton CO_2/ha become the best trees species to be used for regreening progam at Bodogol area, West Java however the alternative species is *Enterolobium cyclocarpa* and *Altingia excelsa. Maesopsis emenii* is the forest species which originally comes from Africa and cultivated in Indonesia. The chacteristic of plant is fast growing and easily adapted in extreem condition. This species is commonly used for regreening and Javan Gibbon conservation program since the fauna are most preferable to eat fruit of this tree. *Altingia excelsa* which commonly named rasamala is a native species found in Gede Pangrango National Park. The shoot of young leaves is often picked as a fresh salad and the sweety scanted seeds is commonly provide

Table 4. Average carbon content and carbondioxide of eight trees species (ton/ha)

Species/Code	Biomass (g)					Carbon content (ton C/ha)	Carbondioxide (ton CO_2/ha)
	Leaf	Branch & twig	Stem	Above ground	Root		
Altingia excelsa (control)	28.55	265,21	298,97	851,74	208,62	0,88	3,23
Altingia excelsa (BioVAM)	493.54	323,87	437,72	1,255,12	258,34	1,26	4,62
Podocarpus imbricata u (control)	18.58	5,93	30,81	55,33	10,45	0,05	0,18
Podocarpus imbricata (BioVAM)	22. 43	6,60	39,46	68,48	14,28	0,07	0,26
Adinandra dumosa (control)	18,12	10,04	30,33	58,49	26,68	0,07	0,26
Adinandra dumosa (BioVAM)	28,03	14,71	51,61	94,35	35,99	0,11	0,40
Enterolobium cyclocarpa (control)	15,00	14,14	107,55	136,69	85,25	0,18	0,66
Enterolobium cyclocarpa (BioVAM)	65,49	119,04	1,032,5	1,217,06	780,21	1,66	6,09
Maesopsis emenii (control)	251,83	184,48	1,126,9	1,563,17	552,54	1,76	6,46
Maesopsis emenii (Bio VAM)	552,06	682,51	1,638,1	2,872,66	1,002,26	3,23	11,85
Magnolia blumei (control)	38,84	22,99	50,42	112,23	40,84	0,13	0,48
Magnolia blumei (Bio VAM)	67,24	45,95	158,88	250,34	81,67	0,29	1,06
Diospyros blancoi (control)	30,68	4,78	18,61	54,07	13,46	0,06	0,22
Diospyros blancoi (BioVAM)	48,49	14,8	30,05	93,35	27,29	0,10	0,37
Chrysophyllum cainito (control)	45,24	15,88	60,46	121,59	32,38	0,13	0,48
Chrysophyllum cainito (BioVAM)	43,87	33,28	53,98	131,13	38,54	0,14	0,51

for Javan Gibbon feed. The wood has the economic value for timber used in heavy construction, plywood and pulp since the bark color is light grey and smooth (Orwa *et al*. 2009)

CONCLUSION

Mycorrhizae fungi play an important role and beneficial on supporting the grow of plants. Application of BioVAM is very usefull and indirectly could support the CDM program in providing best plant biomass for carbon stock.

Biodiversity of mycorrhizae fungi from soil should be put on priority consideration and action in regard to the reduction of tropical rain forest land area in Indonesia. As reported that mycorrhizae always live symbiotically with host plant. Pilot project for microbes application should be established in parallel with the advance research of its microbes. Indigenous species of mycorrhizae fungi could be developed further as biofertilizer through the selection activities while the result of advance research could be implement for strain quality improvement of mycorrhizae. Modification with other potential soil microbes may improve the quality of biofertilizer which could support the program of regreening in Indonesia.

The result of carbon stock experiment confirmed that mycorrhizae could increase the total biomass of plants which directly increased the carbon content or carbon dioxide. Total highest dried weight of plants showed by *Maesopsis emenii* Engl. (BioVAM) is 3.874,92 g, follow by *Enterolobium cyclocarpa* Griseb. (BioVAM) is 1.997,28 g, and *Altingia excelsa* Noronhae (BioVAM) is 1.513,47 g.

Allometric equation of total dried weight and diamter are as follwos : *Altingia excelsa* (control) ialah $Y=50,639X^{2,3599}$ (R^2=0,9724), *Altingia excelsa* (BioVAM) is $Y=34,264X^{2,6712}$ (R^2= 0,9181), *Podocarpus imbricata* (control) is $Y = 45,383X^{2,4841}$ (R^2 = 0,9787), *Podocarpus imbricata* (BioVAM) is $Y = 53,39X^{2,2767}$ (R^2= 0,95), *Adinandra dumosa* (control) is $Y=39,988X^{2,3005}$ (R^2=0,95), *Adinandra dumosa* (BioVAM) is $Y=26,363X^{2,6701}$ (R^2= 0,95), *Enterolobium cyclocarpa* (control) is $Y= 43,343X^{2,3396}$ (R^2=0,96), *Enterolobium cyclocarpa* (BioVAM) is $Y=36,614X^{2,1229}$ (R^2=0,99), *Maesopsis emenii* (control) is $Y = 0,6604X^{4,3786}$ (R^2=0,90), *Maesopsis emenii* (BioVAM is $Y=156,06X^{1,7576}$ (R^2=0,92), *Magnolia blumei* (control) is $Y= 36,024X^{2,1063}$ (R^2=0,98), *Magnolia blumei* (BioVAM) is $Y=35,511X^{2,3144}$ (R^2=0,99*), Diospyros blancoi* (control) is $Y=56,746X^{2,2651}$ (R^2=0,89), *Diospyros blancoi* (BioVAM) is $Y = 54,982X^{3,0291}$ (R^2=0,99), *Chrysophyllum cainito* (control) is $Y=54,995X^{2,3301}$ (R^2=0,98) and *Chrysophyllum cainito* (BioVAM) is $Y= 31,337X^{2,6505}$ (R^2=0,86).

The average of carbon content and CO2

absortion of eight species at 20 months old are *Maesopsis emenii* (BioVAM) 3,23 ton C/ha and 11,85 ton CO_2/ha, *Maesopsis emenii* (control) is 1,76 ton C/ha dan 6,46 ton CO_2/ha, *Enterolobium cyclocarpa* (BioVAM) 1,66 ton C/ha and 6,09 ton CO_2/ha, *Enterolobium cyclocarpa* (control) is 0.18 ton C/ha and 0.66 ton CO2/ha, *Altingia excelsa* (BioVAM) is 1,26 ton C/ha and 4,62 ton CO_2/ha, *Altingia excelsa* (control) is 0,88 ton C/ha dan 3,23 ton CO_2/ha.

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