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Physical Properties of Soil in Oil Palm Agroforestry Systems (*Elaeis Guineensis* Jacq.) With Gaharu (*Aquilaria malacensis* Lamk.) And in Oil Palm Monoculture Systems

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ABSTRACT

Oil palm cultivation generally carried out in monoculture. It has impact on decreasing soil fertility, one of them is phisychal soil nature. One of solution is oil palm cultivation by using agroforestry system. The purpose of this research is to compare soil nature on agroforestry oil palm (Elaeis gueneensis Jacq.) and aloes a.k.a. gaharu (*Aquilaria malacensis* Lamk.) between monoculture oil palm. This research was conducted at Bukit Kemuning, Tapung Hulu, Kampar for 4 months from November – Februari 2020. The method of this research used sampling method. Soil samples were taken from 4 sampling point: piringan of palm oil, gawangan hidup, gawangan mati and piringan of gaharu were repeated 6 times on each land. The observation parameters are several soil nature (topsoil depth, content, particle density, total pore space, moisture content, water holding capacity, permeability, infiltration, and soil resistance) and soil C-organic. The data were observed of each parameter analyzed statistically used t test. The results showed that agroforestry system increased C-organic content and improved selected soil nature (increase topsoil depth, total pore space, moisture content, water holding capacity, permeability, infiltration and decrease content, particle density and soil resistance).

Keyword : *physical properties, soil quality, oil palm and aloes, agroforestry, monoculture*

INTRODUCTION

Oil palm plantations are still being developed using monoculture system that has negative impacts for environment. According to some researchers, the negative impacts include; 1) increasing CO_2 gas emissions caused by decrease plant carbon stocks (Herman and Las, 2009). 2) causing low biodiversity of plantation areas due to has no forest vegetation (Danielsen et al., 2009) and (Heriansyah et al, 2020). 3) Oil palm plants on mineral soils often cause soil compaction be runoff and erosion (Suryanto and Wawan, 2017). 4) affecting soil compaction too fast decrease and capacity of infiltration, water movement soil and soil aeration (Muhdi, 2014). 5) planting one type plant only (oil palm) and it has periodic degradation of soil quality (Badrun and Mubarak 2010).

The alternatives can be done to reduce these negative impacts is to develop agroforestry system. Agroforestry system is a combination of trees and agricultural crops to increase productivity. Agroforestry system also provide positive role for environment and can supply organic matter and nutrient of controlling erosion through soil cover, there are canopy and litter (Young, 1997) and (Heriansyah, 2020). In addition, the other important roles are 1) Improving and maintaining the physical condition of soil, 2) Increasing soil fertility through biomass of tree root system at the soil surface, 3) Increasing soil biological activity and nitrogen mineralization through tree shade, 4) protecting the soil surface from erosion by canopy of tree vegetation.

One of the alternative plants can be intercropped with oil palm plants is the agarwood plant. In the environmental aspect, gaharu plant can contribute to intake organic material from resulting of leaf litter. In addition, environmental aspects, the high economic value of gaharu plants encourages people to cultivate gaharu, especially in Riau area (Suharti, 2010). The magnitude of positive impact on agroforestry system on environmental aspects, especially physical characteristics, it necessary for research to assess physical of soil in agroforestry system of oil palm cultivation and gaharu.

MATERIALS AND METHODS

2.1. Research Location

This research was conducted at Bukit Kemuning, Tapung Hulu, Kampar, Riau in the coordinates of the research location 0o 38 '51.42 "North Latitude and 101o 55' 44.53" BT. The research location has rainfall of ± 2500 mm / year, an average temperature of 26o - 28o C and humidity of 78o - 85o C. The research land used monoculture oil palm (1 ha) around 20 years and oil palm agroforestry land and gaharu (1 ha) around 10 years.

2.2 Research Implementation

a. Determination of Sample Location

The method used in this study was purposive sampling method with the location of agroforestry system and monoculture system, In agroforestry system and monoculture system, there are 6 replicate plot points by using zigzag method (systematic sampling) there are 1 plot point with 4 sample points, namely Weeded circle of gaharu, Weeded circle of oil palm, Frond stack and The inter-row. The number of soil sampling in each system was 24 sampling and the total about 48 sampling.

b. Sampling

Soil sampling in agroforestry systems and monoculture systems by using disturbed soil samples and undisturbed soil samples. Sampling in agroforestry systems and monoculture systems was carried out at a depth of 0-10 cm and 10-20 cm.

c. Laboratory Analysis

The physical of soil analyzed in this study were content weight, total pore space, field moisture content using the gravimetric method, water holding strength (WHC), permeability, infiltration and soil resistance.

d. Data analysis

Comparisons of physical characteristics in agroforestry systems and monoculture systems were analyzed by using 5% t-test.

RESULTS AND DISCUSSION

a. C-Organic

The results of soil organic C analysis in oil palm agroforestry systems with gaharu and oil palm monoculture systems are presented in Table 1.

Table 1.C content - Organic Organic at several locations Sampling on agroforestry land and on oil palm monoculture land.

Sampling Location	Agroforestry (%)	Monoculture (%)	t Count	t Table 5%	S/NS
The inter-row	$2,41^{Sd}$	$2,01^{Sd}$	$2,845^{*}$	1,812	S
Frond stack	$4,11^{T}$	$3,65^{T}$	$1,905^{*}$	1,812	S
Weeded circle	$3,47^{T}$	$2,75^{Sd}$	$2,224^{*}$	1,812	S
Gaharu/RK	$3,59^{T}$	$2,52^{Sd}$	$8,905^{*}$	1,812	S
Average	**$3,39^{T}$**	**$2,73^{Sd}$**	**$1,334^{ns}$**	**1,943**	

Note : S = Significant S = Medium T = High

The results of the analysis in Table 1 showed the levels of C-organic in oil palm and gaharu agroforestry systems (high category) are higher than oil palm monoculture systems (medium category).

In agroforestry system, the levels of C-organic in stalk, oil palm and gaharu disc (high criteria) were higher than leaf of gaharu (medium criteria). Whereas in monoculture system, the levels of C-organic for gawangan mati (high criteria) were higher than gawangan hidup, piringan of oil palm and empty space (medium criteria).

Frond stack has C-organic for agroforestry system and monoculture system was classified as medium, but C-organic content for agroforestry system was higher than monoculture system. In gawangan mati, C-organic content for agroforestry system and monoculture system was classified as high, but C-organic content for agroforestry system was higher than monoculture system. Meanwhile, piringan gaharu and piringan sawit (palm) for agroforestry system were high category compared to monoculture system which classified as medium category. It showed the litter around sample location of agroforestry system can affect C-organic content.

According to Janudiaanto (2004), agroforestry system provides input of organic matter throughout the year through leaves, twigs and branches have been fallen above soil surface, it known as litter. Marpaung (2010) stated that the litter produced through the activities of soil microorganisms then mixes with soil, so that soil organic matter content increase. The low level of C-organic in medium category due to lack of vegetation around living fields of used the land as a transportation route during harvesting. According to Arsyad (2000), the growing vegetation acts as an addition to soil organic matter through stems, twigs and leaves falling to the surface of soil. This organic material acts as source of energy for microorganisms, and is transferred into the plant body to produce photosynthetic products such as sucrose (Heriansyah, 2019).

b. Bulk Density

The results of the t-test for bulk density in oil palm agroforestry systems with agarwood and oil palm monoculture systems are presented in Table 2.

Table 2. Value of Soil Fill Weight, Particle Density and Total Pore Space (TRP) in several sampling locations in the agroforestry system with a monoculture system

Pick up location Sample	Fill Weight (BD)			TRP			Air Content (%)			t-Table
	Agro	Mono	t-count	Agro	Mono	t- count	Agro	Mono	t-count	
Depth 0-10 cm										
The inter-row	1,22	1,59	3,153*	35,44	30,62	0,646^{ns}	23,43	19,97	0,884^{ns}	1,812
Oil palm	1,20	1,53	9,888*	42,70	34,64	2,742*	24,58	19,16	1,838*	1,812
Frond stack	1,03	1,11	1,342^{ns}	49,93	46,02	0,926^{ns}	26,42	23,06	0,654^{ns}	1,812
Gaharu/RK	1,17	1,48	4,203*	47,15	36,40	3,986*	23,22	19,18	1,470^{ns}	1,812
Average	1,18	1,43	2,003*	43,81	36,17	1,547^{ns}	25,36	19,89	4,346*	1,943
Depth 10-20 cm										
The inter-row	1,41	1,84	3,721*	33,11	26,42	0,961^{ns}	20,85	14,90	2,798*	1,812
Oil palm	1,32	1,56	2,876*	40,94	33,14	3,670*	18,71	16,87	0,405^{ns}	1,812
Frond stack	1,18	1,26	4,205*	45,91	43,54	2,180*	23,30	20,92	0,521^{ns}	1,812
Gaharu/RK	1,25	1,66	4,114*	43,83	33,86	2,537*	20,12	16,37	1,821^{ns}	1,812
Average	1,29	1,58	2,214*	33,11	26,42	0,961^{ns}	20,75	17,27	2,166*	1,943

Note : * (Significant = berbeda nyata) , ns = Tidak berbeda nyata

Table 2 showed the value of bulk density for oil palm agroforestry system with gaharu is lower than oil palm monoculture system. In agroforestry system and in monoculture system between gawangan hidup, piringan of palm oil, piringan of gaharu, the value of content weight was not much different. However, the value of content weight at three sample points is higher than in gawangan mati, depth of 0-10 cm and 10-20 cm.

At sample points of gawangan hidup, piringan of oil palm, and piringan of gaharu, the value content weight in agroforestry system is much different, but in non-sticky rice field there is not much difference between agroforestry system and monoculture system. This is due to the fact that in agroforestry system as well as in monoculture system at the point of gawangan mati sample there is organic material derived from the fronds. The increasing of C-organic in agroforestry system for all sample points was due to addition of organic material from gaharu leaf litter which fell to surface of soil around the sample points.

According to Sutedjo (2002), it explained one of the factors influence the value of soil bulk density is soil organic matter, where soil containing high organic matter have a low weight value and vice versa. Syahadat (2008) stated that the land in wandering area has lower content weight value than piringan area because the paddy field is place for accumulation of litter.

Based on soil depth, the value of fill weight with depth of 0-10 cm is lower than density with depth of 10-20 cm. It showed the deeper of soil on sample point, the higher the weight value of contents. According to Riduan et al (2015) the increasing soil depth, the lower of organic matter content and the easier soil compaction process, causing the physical properties of the soil content weight to be higher and vice versa. Hardjowigeno (2003) alsd states that the top soil has a lower bulk density than the subsoil.

c. Total Pore Space (TPS)

Table 2 showed the total pore space (TPS) in oil palm and gaharu agroforestry lands is higher than in monoculture oil palm land. In agroforestry system as well as in monoculture system between piringan of oil palm, piringan of gaharu and inanimic intercrops, the total pore space values were not much different. However, the value of TRP in gawangan hidup is much different and lower than inanimic, palm oil and agarwood both have depth of 0-10 cm and 10-20 cm.

At sample points in piringan of oil palm and piringan of gaharu, the TRP value in agroforestry system was much different and higher than that in monoculture system. However, the point of sample inanimate and live in-claw trees in agroforestry systems, the TRP value is not much different from monocstructural system. Based on soil depth, the TRP value has depth of 0-10 cm is higher than 10-20 cm. It showed that the TRP value in agroforestry system and monoculture system is inversely related to the weighted value.

Yulnafatmawita et al. (2008) stated that application of soil organic matter decreases the value of soil weight and increases the percentage of total soil pore space. According to Sumarni (2006), also explained that the low organic matter found in oil palm monoculture land resulted in soil becoming denser so that the soil porosity was less. Evarnaz et al. (2014) stated the effect of organic matter can reduce density of soil contents because it has a light weight so that it can increase the porosity of soil.

d. Air Content (%)

Table 2 shows the water content of field capacity in oil palm and gaharu agroforestry system is greater than the oil palm monoculture system. The value of field water content in agroforestry system and monoculture system between gawangan hidup, piringan of palm and gaharu is not much different, but the water content value at three sample points is lower than the value of water content in the inanimate rice field both depth of 0-10 cm and 0-10 cm. depth of 10-20 cm.

At sample points in piringan of gaharu, gawangan hidup and fixed range of water content in agroforestry system is much different and higher than of monoculture system. However, piringan of oil palm is not much different between agroforestry system and monoculture system.

Based on soil depth, the water content value depth of 0-10 cm is higher than 10-20 cm. Descriptively, the water content value is same as TRP value agroforestry system is higher than in monoculture system. Thus the TPS value and water content are influenced by the weight of content and organic matter present at sample point.

According to Amri et al. (2019) stated that the water content of field capacity is also influenced by organic matter, the higher of soil organic matter content, the higher of field water content. Hairiah et al. (2004) the high topsoil field water content in mixed gardens is due to accumulation of litter which functions to maintain soil moisture, evaporation, and increase soil microorganisms function to increase soil macro pores makes water easy to enter soil.

e. *Water holding capacity (WHC)*

Table 3 shows that the WHC value in oil palm and gaharu agroforestry land is higher than in monoculture systems. The WHC values in agroforestry systems and monoculture systems in dry palm with piringan of palm were not much different and between live gaharu and piringan gaharu were not different either. However, the WHC value was higher on piringan palm and gaharu agroforestry system both depth 10-20 cm in agarwood, the WHC value was much higher than in piringan of oil palm disc and gaharu.

It shows that WHC also influenced by high water content, porosity values and organic matter derived from gaharu plant litter found in agroforestry system. According to Lapadjati et al., (2016) organic matter can improve the capacity to bind water and pass water and help control surface runoff and erosion. According to Madjid (2010), if the soil has high porosity, water will easily enter the ground, as a result the groundwater holding capacity also increases.

Table 3. Field Moisture Content (%) and Water Holding Capacity (WHC) (%) in several sampling locations in agroforestry systems and monoculture systems

Pick up location Sample	WHC (%)			Permeability (cm / hr)			t-Table
	Agrofo-restry	Mono-culture	t- count	Agrofo-restry	Mono-culture	t-count	
Depth 0 – 10 cm							
The inter-row	33,16	27,06	1,876*	6,33 (AC)	2,86(AC)	5,056*	1,812
Oil palm	42,79	30,70	2,769*	9,17(AC)	3,93(AC)	6,321*	1,812
Frond stack	41,23	30,08	4,192*	9,31(AC)	5,15(AC)	5,236*	1,812
Gaharu/RK	31,50	27,53	1,307ns	7,35(AC)	3,45(AC)	4,636*	1,812
Average	37,17	28,05	2,897*	8,04(AC)	3,85(AC)	4,807*	1,943
Depth 10 – 20 cm							
The inter-row	30,99	26,17	1,681ns	5,02(AC)	2,92(AC)	5,294*	1,812
Oil palm	33,70	31,42	0,556ns	8,06(AC)	3,14(AC)	7,670*	5,056*
Frond stack	38,61	30,20	2,138*	8,28(AC)	4,10(AC)	5,479*	1,812
Gaharu/RK	37,19	27,85	2,954*	6,51(AC)	2,05(AC)	3,673*	1,812
Average	35,12	28,91	2,981*	6,97(AC)	3,05(AC)	4,509*	1,943

Note : * (Significant) , ns = (NonSignificant) AC = Rather fast

f. Soil Permeability (cm / hour)

Table 4 shows the soil permeability of oil palm and gaharu agroforestry lands is faster than in oil palm monoculture system. In agroforestry system, the permeability in piringan of gaharu and gawangan hidup was not much different, while the permeability value in piringan of gaharu was not much different. In monoculture system between fixed stalks, piringan of palm and agarwood, the permeability values were not much different and three sample points were slower than gawangan mati samples.

Based on soil depth, the permeability value is also faster in gawangan mati than in gawangan hidup, pringan of gaharu and palm. It shows the permeability value is directly proportional to the WHC value and field water content, the higher the WHC value and the water content, the faster of soil permeability. Thus the permeability value is also influenced by the total pore space.

Hanafiah (2005) stated that porosity is very important in soil permeability, the larger the pores in the soil, the faster of soil permeability. Maysarah and Nelvia (2018) explain that the high and low permeability values are influenced by the total soil pore space, so that soils with high total pore space will reduce soil compaction.

f. *Soil Infiltration (cm / hour).*

Table 4 shows the value of soil infiltration rate in oil palm and gaharu agroforestry system is faster than oil palm monoculture system. In agroforestry system, the infiltration rate in piringan of gaharu and in living area was not much different, while the infiltration rate in the stalk and piringan of palm was not much different. In monoculture system between fixed stalks, piringan of palm and gaharu, the infiltration rate values were not much different and the permeability values of three sample points were slower than gawangan mati samples.

The fast rate of infiltration in oil palm and gaharu agroforestry land is also influenced by the content of organic matter derived from leaf litter, twigs and plant roots. Where the decomposed agarwood leaf litter can affect the size of soil porosity so that it affects the slow rate of soil infiltration.

Table 4. Infiltration rate (cm / hour) and Soil Resistance (SR) (kgF / cm2) at several sampling locations in agroforestry systems and monoculture

Pick up location Sample	Sample	Agroforestry	Monoculture	t count	t Table
Infiltration Rate (cm / hour)	The inter-row	13,98	6,53	4,735*	1,812
	Oil palm	19,44	8,67	5,683*	1,812
	Frond stack	19,67	11,34	4,908*	1,812
	Gaharu	15,56	7,44	4,818*	1,812
	Average	17,16	8,49	4,918*	1,943
Soil Resistance (kgF/cm^2)	The inter-row	1,58	2,00	2,712*	1,812
	Oil palm	1,38	2,33	3,664*	1,812
	Frond stack	0,25	0,63	3,503*	1,812
	Gaharu/ empty space	1,17	1,46	2,573*	1,812
	Average	1,09	1,61	1,077ns	1,943

Note : * (Significant) , ** (Non-Significant)

According to Panjaitan et al., (2013) the infiltration rate of gawangan mati is higher than piringan of oil palm and infiltration rate piringan of oil palm is higher than gawangan hidup of 0-20 cm. Nurmegawati (2011) stated that organic matter can increase the stability of aggregate has effect on pore stability so that it will increase the capacity of infiltration rate. Junaedi (2010) explained the low soil organic matter is due to lack of binding of primary grains into aggregates by organic matter so that soil porosity decreases, decreased porosity can result in a decrease in infiltration rate.

h. Soil Resistance (SR)

Table 4 shows in oil palm and gaharu agroforestry systems, the soil density (soil resistance) is smaller than the oil palm monoculture system.

The value of soil resistance in piringan of gaharu is much denser than piringan of palm, however, the value of soil resistance in piringan of gaharu is much denser than piringan of gaharu. Thus, the value of soil resistance in gawangan mati is much more loose than piringan of gaharu, piringan of palm and gawangan hidup.

The value of soil resistance in monoculture system at the point of gawangan hidup, piringan of oil palm and agarwood was much denser than monoculture system. However, the value of soil resistance in land monoculture systems was no more dense than in land agroforestry systems. Overall, the value of soil resistance in agroforestry system is not much different from monoculture system. This indicates the effect of field moisture content, permeability, high TPS (Table 4.3) and is influenced by high organic matter (Table 4.11) in gawangan mati makes the soil more loose or soil density is small.

Maryamah (2010) stated that soil compaction causes an increase in water-binding pores and soil resistance, permeability will decrease with increasing soil density. According to Marieta (2011) organic matter resulting from decomposition of remaining vegetation (litter) helps in formation of soil aggregates by forming granules and increasing the volume and number of soil pores exist, so it tends to reduce the level of resistance. Simanjuntak (2005) stated that dense soil causes slow air exchange, low oxygen content in the soil, and permeability is inhibited, so that water will be stagnant and inhibit plant growth.

Conclusion

Based on the results of the research has been done, the conclusions obtained are as follows:

1. The value of bulk density and soil resistance in agroforestry system is lower than monoculture system. The value of TPS, water content and WHC in agroforestry systems were higher than in monoculture systems. So that the permeability value and infiltration rate in agroforestry systems are faster than in monoculture systems.
2. The values of bulk and soil resistance are lower in gawangan mati than in gawangan hidup, piringan of palm and gaharu. The values of TPS, moisture content, WHC and soil resistance were higher in gawangan mati compared gawangan hidup, piringan of oil palm and gaharu both in agrofoforestry system and in monoculture system. So that the permeability value and the infiltration rate of gawangan mati are also faster than gawangan hidup, palm and aloe disc.

REFERENCES

Arsyad, S., 2000, Konservasi Tanah dan Air, IPB Press, Bogor.

Badrun, Y. dan Mubarak. 2010. Dampak Industri Perkebunan Kelapa Sawit Terhadap Lingkungan Global. Pusat Penelitian Lingkungan Hidup Universitas Riau. Pekanbaru,

Danielsen, F., H. Beukema, N. D. Burgess, F. Parish, C. A. Brühl, P. F. Donald, D. Murdiyarso, B. Phalan, L. Reijnders, M. Struebig, E. B. Fitzherbert. 2009. *Biofuel plantations on forested lands: double jeopardy for biodiversity and climate. Conserv Biol*. Volume 23 Nomor 2 : 348-358.

Hanafiah, K, A, 2005, *Dasar-Dasar Ilmu Tanah*, Grafindo Persada. Jakarta.

Herman, A. F. dan I. Las. 2009. Analisis finansial dan keuntungan yang hilang dari pengurangan emisi karbon dioksida pada perkebunan kelapa sawit. *Jurnal Litbang Pertanian*. Volume 28 Nomor 4, Halaman 127-133. Lembaga Riset Perkebunan Indonesia, Bogor

HERIANSYAH, P. (2019). Multiplikasi Embrio Somatis Tanaman Anggrek (Dendrobium sp) Dengan Pemberian Kinetin Dan Sukrosa Secara In-Vitro. Jurnal Ilmiah Pertanian, 15(2).

Heriansyah, P. (2020). Rahasia Mudah Menguasai Kultur Jaringan Tanaman: Teori dan Praktiknya. Penerbit Lindan Bestari.

Heriansyah, P., Seprido, S., & Andriani, D. (2020). Identifikasi Anggrek Alam Pada Kawasan Rawan Gangguan Di Suaka Marga Satwa Bukit Rimbang Dan Bukit Baling Resort Kuantan Singingi. Agro Bali: Agricultural Journal, 3(2), 164-170.

Lapadjati, K. K., Wardah, Rahmawati. 2016. Sifat Fisik Tanah Pada Hutan Tanaman Kemiri, Lahan Agroforestri Dan Lahan Hutan Sekunder Di Desa Labuan Kungguma Kabupaten Donggala Sulawesi Tengah. *Jurnal Warta Rimba*. Vol. 4 No. 2 , Palu.

Madjid, 2010. Dasar Dasar Ilmu Tanah. Fakultas Pertanian. Unsuri.

Maysarah dan Nelvia. 2018. Sifat Fisika Tanah Perkebunan Kelapa Sawit (*Elaeisguineensisjacq*.) Setelah Diaplikasi Tandan Kosong Kelapa Sawit Dan Limbah Cair Pabrik Kelapa Sawit. *Jurnal Dinamika Pertanian* Volume XXXIV Nomor 1 (27–34).

Marieta. 2011. Karakteristik Sifat Fisik dan Hidrologi Tanah pada Berbagai Penggunaan Lahan: Studi Kasus di Desa Cimulang, Kecamatan Rancabungur, Kabupaten Bogor, Jawa Barat. *Skirpsi*. Bogor: Institut Pertanian Bogor.

Muhdi. 2004. Kerusakan Fisik Lingkungan Akibat Penyaradan Dengan Sistem Mekanis. Skripsi Ilmu Kehutanan Fakultas Pertanian Universitas Sumatera Utara, Medan.

Nurmegawati. 2011. Infiltrasi pada hutan Di Sub Das Sumani Bagian Hulu Kayu Aro Kabupaten Solok. *Jurnal Hidrolitan*, Vol 2 : 2 : 87-95, 2011.

Pandjaitan, Fany Juliarti. 2013. Sifat Fisika Ultisol Di Bawah Tegakan Kelapa Sawit (Elaeis Giuneensis Jacq.) Yang Berbeda Umur Dan Kaitannya Dengan Pemadatan Tanah. Agroteknologi. Universitas Riau. Riau

Sumarni, N., Hidayat, A., dan Sumiati, E., 2006. Pengaruh Tanaman Penutup Tanah dan Mulsa Organik terhadap Produksi Cabai dan Erosi Tanah. *Jurnal Hortikultura*., Vol 16(3):197–201.

Young, R. A. 1997. Comparison of Four Agroforestry System with Crop Monoculture. Agroforestry of Soil Management. CAB International and ICRAF. Wallingford.

Suharti S, Pratiwi E, Santoso, Turjaman M. 2011. Feasibility of gaharu inoculation business at different stem diameter and period of inoculation. p 41-58. *Proceding of Gaharu wokshop: Bioinduction technology for sustainable development and conservation of gaharu*. Forestry Research and Development Agency (FORDA). Bogor.