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POTENCY OF LAND UNDER SMALLHOLDER OIL PALM PLANTATION FOR SOYBEAN FARMING IN BUNGKU VILLAGE, JAMBI

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Abstract

The dry land in Jambi is also a target for smallholder oil palm plantation development in Indonesia that has limited availability of land for development of food crops such as soybean. Nowadays, Indonesia is one of importer countries of soybeans. The land under oil palm plantation can also be used for development of soybean simultaneously by intercropping systems. The objective of this research was to evaluate the land characteristics and suitability of land under several age-gradient of oil palm of smallholder for soybean growth and to find appropriate technology for that. The research was conducted at Bungku Village, Batanghari District, Jambi. Data of research consisted of secondary data (temperature and rainfall) from related institutions and primary data (characteristics and management system of land under oil palm). The primary data obtained was based on field observation and analysis of soil sample at laboratory. The land suitability was evaluated by matching method. The data was analyzed descriptively. The research showed that land under smallholder of oil palm plantation at Bungku Village consisted of 0, 1, 3, 6, 9, and 14 years old oil palm and had high compaction, low water content, and very low - low chemical fertility while it had high rainfall, temperature, and relative humidity. The research also showed that the land under several age-gradient (0, 1, 3, 6, and 14 years old) of oil palm were classified as marginally suitable (S3) for soybean growth with nutrient retention as its limiting factor while the land under 9 – years - old of oil palm was classified as moderately suitable (S2) for soybean and its limiting factor were nutrient retention and erosion hazard. Therefore, the development of soybean farming under oil palm plantation should use conservation farming system by combination of organic and inorganic fertilizer and conservation tillage application.

Keywords: *conservation tillage; intercropping system, land suitability; land under oil palm plantation; soybean*

Introduction

The oil palm plantation land is rapidly increasing and have impacts on environment of some regions in Indonesia. Bureau of Statistics Center data (2012) showed in 2012, area of oil palm plantation in Indonesia is 54.07 million ha. It increases 65.45% than in 2002. Expansion of oil palm plantation is also found in Jambi Province that the first is area of rubber production center. Data from Plantation Services of Jambi Province (2013) showed that area of oil palm plantation at Jambi in 2013 was 515 thousand ha. The area of oil palm plantation also increases rapidly than in 2003 those were only 302.15 thousand ha. Bungku Village where located at Batanghari District in Jambi Province is one of smallholder and plantation of oil palm plantation region that consist of several age-gradient. The oil palm generally plants in range 9 m x 9 m or 8 m x 8 m so between them can be used to plant annual crop that suitable especially legume for example soybean.

The soybean is one of species of legumes and the third most important food crops after paddy and corn. Demand rate of soybean in Indonesia is high because source of community nutrient (protein) and row material of some food industries. But planting area and productivity of soybean decrease in Indonesia (especially out of Java) so the production of soybean is low (Anggoro, 2013). Bureau Statistics Center data (2012) also showed that the national production of Soybean in 2012 only growth 0.04% with production is 907.03 thousand tons from 566.69 thousand ha whereas the Indonesia soybean consumption is 2.90 million tons. Therefore, most of Indonesia soybean consumption is

fulfilled by import. The government has decided to extent planting area of soybean until 400 thousand ha as a policy to increase soybean production. In 2013, soybean areas have extended 200 thousand ha and focused at Jambi, Sulawesi, and West of Nusa Tenggara.

Land under oil palm plantation is an alternative of available land to extend area of soybean farming land at Jambi Province. Therefore, development of oil palm plantation policy and area for soybean farming can be also implemented simultaneously. Besides intercropping system for soybean-oil palm can give environmental and economic value for oil palm plantation. The environmental value includes increasing of carbon sequestration, soil fertility (for examples content of soil organic carbon and nitrogen), and controlling run off and erosion on oil palm plantation, mitigate of carbon emission from soybean farming land because carbon sequestration capacity of soybean is lower than oil palm and others tree. Whereas the economic values are soybean production and increasing of oil palm farmer income.

The development of soybean farming does not need only land availability, but also suitable land quality for soybean growth. The land quality is influenced by type and age of crop on its surface very much. The oil palm plantation at Bungku Village in Batanghari District (Jambi Province) consists of productive and unproductive. Sunarti *et al.,* (2008) showed that compaction of soil under smallholder of oil palm at Batang Pelepat Watershed (1.05 g/cm^3) is higher than under smallholder of rubber and secondary forest that have bulk density 0.92 and 0.81 g/cm3 respectively. Sunarti (2010) showed soil organic carbon of Hapludult under smallholder of oil palm (1.90-2.29%) is lower than under smallholder of rubber (2.29-3.20%) and secondary forest (2.96-7.33%) as well. The objectives of this paper are to discuss potency of land under several age-gradient of oil palm for soybean farming and it limiting factors and technology alternative that can be used for intercropping system for soybean-oil palm development.

Materials and Methods

The research was carried out at Bungku Village, Bajubang Sub-District, Batanghari District (Jambi Province) in 2013. Research materials consist of disturbed and undisturbed soil sample, plastic bag and label. The disturbed soil samples were taken in composites under several age-gradient of oil palm (0, 1, 3, 6, 9, and 14 years old) and randomized on 10 point. Whereas the undisturbed soil samples were taken with ring sampler (**Table 1**). They were 3 (three) samples under each age-gradient of oil palm. Equipment for research included auger, meter, profile knife, thermometer, Geographical Positioning System (GPS), ring sampler, block note, marker, and pen.

Data of research are secondary and primary data. The secondary data were administrative, soil type, slope, and land use maps, rainfall, temperature, and relative humidity of Bungku Village in 2002-2013. The maps were used to decide intensive observation location and point of soil sampling. The primary data were selected land characteristics, temperature, and relative humidity under several age-gradient of oil palm plantation. The selected land characteristics were got by direct measurement/observation in the field and soil sample analysis at laboratory. The data of climate and land characteristics were used to define class of land suitability for soybean (**Table 1**).

The class of land suitability of soil under oil palm plantation for soybean was decided with matching method (Djaenuddin *et al.*, 2003). Based on classification of land suitability can be defined potency of soil under oil palm plantation for soybean farming. Data of climate, land characteristics, and potency of soil under oil palm plantation for soybean farming were analyzed descriptively.

Table 1. Type, using, and collection method or source of data

No	Type of data	Using	Data collection technique or source
I	Map of administration, soil type, slope, and land use	Decide intensive observation location and sampling point	Bogor Center of soil Research, Bureau of development planning Jambi Province, and Batanghari Watershed Authority
II	Climate:		
	Rainfall during 2003-2012	To get criteria of water availability for land suitability analysis	Secondary data from climate station of Sultan Thaha Syaifudin Airport
	Temperature during 2003-2012	To get suitability of temperature for land suitability analysis	Secondary data from climate station of Sultan Thaha Syaifudin Airport
	Temperature under several age-gradient of oil palm	To get and discuss temperature under oil palm plantation	measurement in the field
	Relative humidity during 2003-2012	To get suitability of humidity for land suitability analysis	Secondary data from climate station of Sultan Thaha Syaifudin Airport
	Relative humidity under several age-gradient of oil palm	To get and discuss relative humidity under oil palm plantation	measurement in the field
III	Land characteristics:		
	a. Coarse material, soil depth, slope, drainage, erosion hazard, flooding hazard, surface stonsiness, and surface outcrop	For land suitability analysis or to get class of land suitability for soybean	Direct observation/measurement in the field
	b. Chemical soil properties: cation exchanges capacity (CEC), *Base* saturation, pH H_2O, N-total, K_2O, P_2O_5, salinity, organic carbon, etc		disturbed Soil sample analysis at laboratory
	c. Soil bulk density and porosity	To describe physical land characteristics	Undisturbed Soil sample analysis at laboratory

Results and Discussion

Climate

The rainfall data during 10 last years from Sultan Thaha Syaifudin Airport climate station showed that rainfall at research site was classified high (2 282.82 mm). Dry month (with rainfall <75 mm) is only 1-2 months. Therefore the site is moderate humid with relative humidity value 85.75%. The average annual temperature was 28.16^{o}C, maximum and minimum temperature were 32.37^{o}C and 23.96^{o}C respectively (**Table 2**). The rainfall, humidity, and temperature at research site were still suitable for soybean.

The development of soybean under oil palm plantation needs consideration about climate condition under oil palm plantation as well. Result of research showed that the relative humidity and temperature under oil palm plantation were variously based on age of oil palm but not different significantly to data from climate station. The relative humidity under 14 years old of oil palm was higher than the younger of oil palm. On the contrary, temperature under 14 years old of oil palm was lower than the younger of oil palm. It was due to difference of coverage capacity of age-gradient of oil palm. The coverage capacity of older of oil palm is wider than the younger. Gaol (2013) showed that the 5 years old of oil palm only has coverage of canopy 28.26 m^2 and the 10 years old of oil palm has coverage of canopy 38.46 m^2.

Table 2. Distribution of the rainfall, temperature, and relative humidity of research site in 2003-2012

Month	Rainfall [mm]	Maximum Temperature [°C]	Minimum Temperature [°C]	Average Temperature [°C]	Relative Humidity [%]
January	181.79	31.60	23.10	27.35	86.00
February	199.47	32.00	24.20	28.10	86.00
March	249.88	32.00	24.50	28.25	88.00
April	215.05	32.50	23.40	27.95	87.00
May	160.60	33.00	25.40	29.20	83.00
June	85.42	31.08	23.70	27.39	86.00
July	122.35	32.40	24.50	28.45	84.00
August	169.76	32.60	24.20	28.40	86.00
September	133.36	31.07	23.00	27.04	85.00
October	233.88	32.00	24.20	28.10	85.00
November	271.31	32.70	23.70	28.20	87.00
December	258.95	31.05	23.60	27.33	86.00
Total	2.281.82				
Average	190,15	32.00	23.96	27.98	85.75

Source: Climate station of Sultan Thaha Syaifudin Airport (2013)

The coverage of canopy always causes lower temperature under vegetation than bare land. The temperature under the youngest oil palm was assumed the same as the temperature on the bare land. The result of research showed that temperature under oil palm was inversely to age of oil palm and lower that the bare land temperature or the older oil palm the lower temperature. On the contrary, the increasing of relative humidity under oil palm was relevant to increasing of oil palm age. The relative humidity under 14 years old of oilm was higher than 0-9 years old of oil palm (**Figure 1**). According to criteria of land suitability (Djaenuddin *et al.*, 2003), relative humidity and temperature under oil palm plantation at research site was still in suitable range for soybean growth. The temperature and relative humidity were advantages factor or potency for Bungku Village to develop soybean under oil palm plantation. But still need experiment to study sunlight avaibility for soybean under several age-gradient of oil palm plantation.

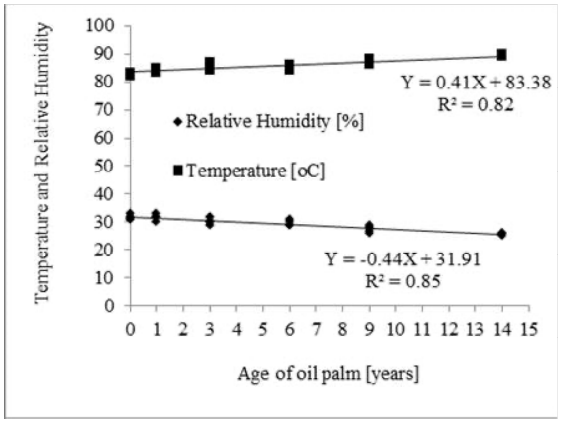

Figure 1. Relationship between age of oil palm and temperature and relative humidity under oil palm

The land characteristics under oil palm plantation at Bungku Village

The vegetation coverage on soil surface and management system related to soil properties changes. The land of smallholder oil palm at Bungku Village consists of several age-gradient (0, 1, 3, 6, 9, and 14 years old). The land under each age-gradient of oil palm showed different characteristics. The farmer on smallholder of oil palm at Bungku Village applied inadequate technology. Generally, land under oil palm plantation was covered with shrub because the farmer only applied minimum

maintenance for the land. The coverage of shrub has positive impact for mitigate erosion of top soil under oil palm plantation. The result of research showed that erosion on soil under 0, 1, and 3 years old of oil palm plantation was moderate and under 6, 9, and 14 years old of oil palm was low. It related to slope of oil palm plantation was 8% (sloping/rolling). The soil under oil palm plantation at Bungku Village has been also never flooded. The indicators were no spotting and corrosive on each horizon of soil because soil drainage was good as well. Besides on the soil under oil palm plantation was not found surface stonsiness and outcrop surface (**Table 3**).

The phase or age of oil palm and intensity of farmer interaction to land influenced on soil compaction. The result of research showed that the bulk density (compaction) of the land under the youngest oil palm (0 years old) was lower than the older oil palm (**Table 3**). The soil under 9 years old of oil palm has the highest bulk density because this is productive phase of oil palm. The interaction between farmer and land was more intensive, but the soil compaction under the 14 years old of oil palm was lower than the 9 years old of oil palm or bulk density was 1.35 g/cm^3 because there was much litter so the soil has higher organic matter (3.14%) than soil organic matter under the 9 years old of oil palm (2.90%).

The rate of soil compaction is higher according to increasing of soil depth. The result of research showed that up to 60 cm depth, the deeper of soil depth the higher soil compaction (**Table 3**) because clay content on sub soil (B horizon) was higher so the soil texture is clay. Whereas, the texture of on top horizon was clay loam and silty clay loam (**Table 3**). Nurdin (2012) also showed clay of soil increase according to increasing of soil depth up to B horizon.

Table 3. Geomorphology and porosity of soil under several age-gradient of oil palm at Bungku Village, Bajubang Sub District, Batanghari District, Jambi Province

Type of land characteristics	U0	U1	U3	U6	U9	U14
Drainage	well	Well	well	well	well	well
Texture	Clay loam	Silty clay loam	Clay loam	Clay loam	Clay loam	Clay loam
Coarse material [%]	15	15	20	25	28	30
Soil depth [cm]	80	155	155	135	80	65
Peat maturity	-	-	-	-	-	-
Peat depth [cm]	0	0	0	0	0	0
Sulfudic depth [cm]	-	-	-	-	-	-
Slope [%]	8	8	8	8	8	8
Erosion Hazard	Moderate	Moderate	Moderate	Low	Low	Low
Flooding hazard[cm/month]	F0	F0	F0	F0	F0	F0
Surface stonsiness [%]	0	0	0	0	0	0
Surface outcrop [%]	0	0	0	0	0	0
Bulk density 0-30 cm [g/cm^3]	1.21	1.26	1.29	1.36	1.38	1.35
Bulk density 31-60 cm [g/cm^3]	1.31	1.45	1.52	1.66	1.95	1.84
Porosity 0-30 cm [%]	53.74	51.67	50.77	47.83	47.26	48.35
Porosity 31-60 cm [%]	50.11	44.38	41.83	36.32	25.47	29.55

The rate of soil compaction under oil palm was one of limiting factors for land under oil palm using for development of food crop like soybean. Generally, under oil palm was planted legume cover crop that can increase soil porosity. The high soil compaction cause low infiltration capacity of soil because the result of research showed that the higher soil compaction under oil palm plantation the lower soil porosity (**Table 3**). Optimizing of land under oil palm plantation for soybean farming should be with soil management system to decrease soil compaction. Tillage with soil organic matter application will be more effective to decrease soil compaction under oil palm plantation so can be used for food crop (soybean) development. Muchtar & Soelaeman (2010) showed that application of manure 10 tons/ha can decrease soil compaction (or soil bulk density) and increase soil porosity and permeability. Furthermore Adrinal *et al.,* (2012) also showed that intensive tillage with organic mulch

(kirinyuh) also can decrease soil bulk density up to 1.26 g/cm^3. Besides no tillage with straw rice mulch can increase soil moisture up to 27.97%. It is higher than soil moisture on conventional tillage (12.24%)

The soil under oil palm plantation with high soil compaction and low soil organic matter in related to rooting system influence on chemical soil properties as well. The result of research showed that chemical properties of soil under oil palm were various according to age-gradient of oil palm. The chemical properties of soil under all of age-gradient of oil palm plantation were very low to low (**Table 4**), but still suitable for soybean. Fertility status of soil under several age-gradient of oil palm was limiting factor for the land under oil palm plantation for agriculture development. The low fertility cause low nutrient availability for crop. Increasing of the chemical fertility status can be done by fertilization. The fertilization should be combine organic and inorganic fertilizer. The function of organic fertilizer is to increase soil organic matter and effectiveness of inorganic fertilizer, and decrease soil compaction.

Table 4. The chemical characteristics of soil under several age-gradient of oil palm at Bungku Village, Bajubang Sub District, Batanghari District, Jambi Province on 2013

Type of land quality variable	Age-gradient of oil palm/soil fertility status					
	U0/FS	U1/FS	U3/FS	U6/FS	U9/FS	U14/FS
pH H2O	4,82/VL	4,65/VL	4,60/VL	4,60/VL	5,44/VL	4,83/VL
pH KCl	4,07/VL	4,36/VL	3,75/VL	3,70/VL	4,68/VL	4,03/VL
Organic Carbon [%]	1,73/L	2,16/M	1,49/L	2,17/M	1,68/L	1,82/L
Organic matter [%]	2,97/L	3,72/M	2,56/L	3,73/M	2,90/L	3,14/L
N-total [%]	0,18/L	0,17/L	0,12/L	0,17/L	0,15/L	0,14/L
P-available [ppm]	4,31/VL	5,00/VL	7,10/VL	4,44/VL	4,85/VL	4,38/VL
P_2O_5 [ppm]	64,94/VL	70,05/VL	96,47/VL	65,49/VL	70,67/VL	64,72/VL
Ca [me/100g]	2,55/L	2,86/L	1,03/L	0,93/L	3,78/L	2,47/L
Mg [me/100g]	1,33/M	1,70/M	0,54/L	0,44/L	1,94/M	1,32/M
K [me/100g]	0,27/L	0,30/L	0,27/L	0,26/L	0,35/L	0,27/L
Na [me/100g]	0,19/L	0,23/L	0,16/L	0,19/L	0,25/L	0,17/L
CEC [me/100g]	13,09/L	13,39/L	12,13/L	11,51/L	12,96/L	13,28/L
KB [%]	33,14/L	37,89/L	16,53/L	15,82/VL	48,79/M	31,65/L
Al [me/100g]	4,38/VL	3,03/VL	4,56/VL	4,37/VL	2,71/VL	4,35/VL
Base saturation [%]	33,47	22,64	37,57	37,96	20,89	32,71
H [me/100g]	0,57/VL	0,38/VL	0,51/VL	0,64/VL	0,43/VL	0,54/VL
K_2O [me/100g]	0,38/VL	0,39/VL	0,36/VL	0,37/VL	0,41/VL	0,38/VL
Salinity [dS/m]	1,48	1,51	1,47	1,71	1,47	1,45
Alkalinity [%]	1,41	1,68	1,34	1,63	1,93	1,26

Remark: U0= under oil palm 0 years old; U1= under oil palm 1 years old; U3= under oil palm 3 years old; U6= under oil palm 6 years old; U9= under oil palm 9 years old; U14= under oil palm 14 years old; FS=Fertility Status; VL=very low; L=Low; dan M=Moderate.

Potency of land under oil palm plantation at Bungku Village for soybean

Based on climate and land physical and chemical characteristics were known that the land under oil palm plantation at Bungku Village has potency for soybean farming. But it should be accompanied technology package that can decrease soil compaction, increase nutrient availability, and mitigate erosion because the result of research showed that the land under several age-gradient (0, 1, 3, 6, and 14 year) of oil palm were marginally suitable (S3) with nutrient retention (especially pH or soil acidity) as limiting factor and the 9 years old of oil palm was moderately suitable (S2) with nutrient retention and erosion hazard as limiting factors (**Table 5**).

Table 5. The land suitability class of the soil under several age-gradient of oil palm for the soybean at Bungku Village, Bajubang Sub District, Batanghari District, Jambi Province

The type of land characteristics	The land suitability class	The limiting Factor
U0	S3	nr (nutrient retention)
U1	S3	nr (nutrient retention)
U3	S3	nr (nutrient retention)
U6	S3	nr (nutrient retention)
U9	S2	nr, eh (nutrient retention, erosion hazard)
U14	S3	nr (nutrient retention)

Remark: U0= under oil palm 0 years old; U1= under oil palm 1 years old; U3= under oil palm 3 years old; U6= under oil palm 6 years old; U9= under oil palm 9 years old; U14= under oil palm 14 years old; S2 = moderately suitable; and S3 = marginally suitable.

The limiting factors can be minimized by soil and water conservation techniques application. The soil compaction and erosion can be decreased by intensive or minimum tillage according to contour with mulching and organic fertilizer application. Furthermore, the nutrient retention can be decreased by organic and inorganic fertilizer application. Sudaryono *et al.,* (2011) showed that technology component that can be applied for soybean farming was soil ameliorant (dolomit or zeolite) application, organic fertilizer (for examples manure and compost), inorganic fertilizer (NPK fertilizer). Effendi & Suwardi (2009) showed that land clearing with soil conservation technique has positive effect on soil organic matter, infiltration, and crop production increasing, erosion mitigation, and soil moisture maintenance. The organic fertilizer also serves the soil compaction decreasing and inorganic fertilizer effectivity in soil. Sarno (2009) also showed that application of 5-15 tons/ha manure can decrease NPK fertilizer dosage 25-75% and Widowati *et al.,* (2009) found that the best dosage for organic and inorganic fertilizer combination for caisim on Inceptisol Bogor is 560 kg organic fertilizer/ha, 300 kg Urea/ha, 50 kg SP-36/ha, and 50 kg KCl/ha.

Conclusion

1. The compaction soil under several age-gradient of oil palm plantation at Bungku Village was higher than bare land or the 0 years old of oil palm and it chemical fertility was very low to low. But the soil properties under oil palm were still suitable for soybean.
2. The land of oil palm plantation in Bungku Village (Jambi Province) has potency for soybean farming because soil under oil palm plantation (0, 1, 3, 6, and 14 years old) was marginally suitable with nutrient retention as limiting factor and under the 9 years old of oil palm was moderately suitable with nutrient retention and erosion hazard as limiting factors.
3. The utilization of soil under oil palm plantation potency for soybean farming development should be accompanied by soil and water conservation techniques included conservation tillage (intensive and minimum tillage with organic mulch) and organic and inorganic fertilizer application.

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