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RESEARCH ARTICLE

ROLE OF COASTAL SEDIMENT ON SOIL NUTRIENT AVAILABILITY AND OIL PALM YIELD AT PEATLANDS

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ABSTRACT

Peatlands which is limited in chemical, physical and ecology require appropriate management for oil palm plantation. Coastal sediment as an ameliorant in peatlands increased productivity some crops. This study aims determining the effect of the doses of coastal sediment as ameliorant on peatlands to the availability of N, P, K, Ca, Mg and Na oil palm plantations. This research was performed in the area of oil palm plantation in Kubu Raya district, Borneo, Indonesia. Experimental design employed randomized block design with 4 levels of coastal sediment doses (L), i.e. L0 = 0 t ha^{-1}; L1 = 20 t ha^{-1}; L2 = 40 t ha^{-1}; L3 = 60 t ha^{-1} with three replication. The results showed that the application of coastal sediment at 40 t ha^{-1} in oil palm plantations significantly increased soil pH, availability of N, K, Ca and Mg, while P was not significantly different.

Keywords: ameliorant, Kubu Raya, oil palm, peat, soil nutrient

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INTRODUCTION

The palm oil has risen to become the most produced and consumed vegetable oil in the world (Hansen et al., 2015). As a major contributor to the economies of several developing countries, the expansion of oil palm cultivation is now a government priority throughout the humid tropics (Sayer et al., 2012). Oil palm plantation was emphasized in Master Plan for Acceleration and Expansion of Indonesia Economic Development (MP3EI) as one of the potential sectors in agriculture (Alwarritzi et al., 2015).

Expansion plans for oil palm plantations in Indonesia have become the subject of political and environmental debates (Obidzinski et al., 2012). Cultivation of oil palm on peat soil has greatly affected the environment in recent time, especially when such practice has been on for several years (Adesiji et al., 2014).

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Utilization of peatlands into oil palm plantation requires appropriate management because it has high acidity, high organic matter, but low nutrient content (Istina et al., 2015). Additionally, peat has limitations with consider to the unavailability of potassium (K), sulphur (S), zinc (Zn), and copper (Cu) (Masud et al., 2011; Abat et al., 2012). These conditions do not support the growth and yield plant and supply of adequate nutrient needs for plants, especially alkaline cations such as K, Ca and Mg (Hartatik et al., 2004; Suswati et al., 2011).

Coastal sediment is a natural resource that is quite large and potential to improve the productivity of the poor soil, especially in the peat soil (Suswati et al., 2014). Coastal sediment can be derived from the results of erosion on upland and transported by river flow result of coastal erosion and sea water transported and then deposited on the shoreline (shoreline). Seawater influence on material properties of coastal sediment resulted rich in salts such as NaCl, Na_2SO_4, $CaCO_3$ and $MgCO_3$ (Tan, 2011). High content of Na caused suppressing acid phenol. According Gogo and Pearce (2009) the cations were strongly bound to the negative exchange sites within fungsional groups of peat.

One effort to improve peatlands fertility and productivity is by adding ameliorants (Nurzakiah et al., 2013). The alternative amelioration applied to oil palm farms in West Kalimantan peatlands is coastal sediment which is easy to obtain and relatively cheap. Coastal sediment as ameliorant had been shown to increase productivity and production plants in peatland (Suswati, 2009). It application of coastal sediment with chemical properties such as pH neutral, containing the base cations (K, Na, Ca, Mg) and high micro elements (Cu, Zn, Fe, Mn), high Base Saturation (BS) and low CEC, can increase soil pH and BS and reduce CEC in peat soil simultaneously (Suswati, 2012).

Application of coastal sediment at a dose of 40 tons ha^{-1} of peatlands for production of hybrid corn produced 12 ton ha^{-1} (Suswati, 2012). Besides high polyvalent cations by the complexation process simple organic compounds into complex compound can reduce toxic organic acids and cations to form a bridge that is highly resistant to decomposition so that the CO_2 emissions can be reduced (Husen et al., 2013). However, excessively addition of coastal sediment as ameliorant can inhibit plant growth because the soil becomes alkaline, it can increase the osmotic pressure in plant root tissues resulting in plasmolysis. While giving too little ineffective due to its ability to reduce soil acidity is low (Sabiham, 1996). The study aims is to determine the effect of coastal sediment dosage to the availability of soil N, P, K, Ca, Mg and Na in peatlands soil at oil palm plantations.

MATERIALS AND METHODS

The research was conducted at oil palm plantation in Rasau Jaya III subdistrict in Kubu Raya District of West Kalimantan, from May to Augustus 2014. Coastal sediment (water content 37.49%) used were obtained from Kijing Beach, Mempawah regency. The experiment was conducted by using randomized block design, with triplicates (Gomez and Gomez, 2007). The treatment was the application of coastal sediment for ameliorant which consisted of 4 levels, namely C_0: Control (without coastal sediment), C_1: coastal sediment of 20 Mg ha^{-1}, C_2: coastal sediment of 40 Mg ha^{-1}, and C_3: coastal sediment of 60 Mg ha^{-1}. They were 12 experimental plots with a plot size of 18 x 54 m; each plot consisted of 6 plants (in 2 rows planting) with a spacing of 9 m x 9 m, thus the area of each experimental plot 972 m^2.

Macro and micro nutrients (N, P, K, Ca, Mg, Na and which micro Zn, Bo and Cu) content were recognized after one g of plant samples (previously dried at 60 °C for 24 h) was digested with concerted H_2SO_4 (for determination of N element) and a combination of concentrated HNO_3 and $HClO_4$ (for determination other than N), after which the extraction was adjusted using deionized water up to 50 mL. Determination of N was done using semi-micro Kjedahl, P with vanadomolybdate yellow with wavelength 889 nm, while K with the atomic absorption spectrophotometry (AAS) method (Temminghoff and Houba, 2004).

Some physical and chemical properties of ameliorants and soil were performed in the laboratory of soil fertility and chemistry. The coastal sediment texture was carried out using the pipette method (Sarkar and Haldar, 2005). The ameliorants and soil pH were determined in a 1: 2.5 soil: distilled water suspension using a glass electrode. The content of organic carbon was measured using the Walkley and Black method. Ameliorant and soil cation exchange capacity (CEC) were determined by leaching with 1M ammonium acetate buffer adjusted to pH 7.0 followed by steam distillation (Pansu and Gautheyrou, 2006). Available phosphorus in ameliorants and soil extracted with $NaHCO_3$ (0.5 M) at pH 8.5 and determined colorimetrically after treating with ammonium molybdate and stannous chloride at a wavelength of 660 nm. The exchangeable base cations were extracted with 1.0 mol L^{-1} ammonium acetate (Pansu and Gautheyrou, 2006). After extraction, the cations were measured using the atomic absorption spectrophotometry (AA-6200 SHIMADZU).

The data obtained were subjected to a two-way analysis of variance (ANOVA) followed by a Duncan's test at 5% level. For some parameters the correlations were computed. The data were analyzed using the Statistical Analysis System package (SAS Institute, 2003).

RESULTS AND DISCUSSION

The characteristic of peat soil and coastal sediment

The soil characteristics of the peat can be seen in Table 1. Based on the standards of determining soil chemical properties (Hazelton and Murphy, 2007), this soil had a very acidic (pH 3.34), high organic-C (37.30 %) and total N content 2.30 %. Mostly peat is acidic to very acidic and naturally accumulated under anaerobic conditions (Sabiham et al., 2012).

The available P was low (9.51 ppm), according to Bjorn et al., (2008) that Phosphate elements in peat lands were fixated by Fe or Al causing, not available and only 30% of them can be up taken by crops.

Table 1. The chemical characteristics of peat and coastal sediment

Parameter	Peat	Coastal sediment
Texture		
Sand (%)		5.31
Silt (%)		38.22
Clay (%)		56.47
pH	3.34	7.72
Organic -C (%)	37.30	1.18
Total N (%)	2.30	0.9
Available P (ppm)	9.51	10.2
Exch. K(cmol(+)kg^{-1})	0.52	5.01
Exch. Ca (cmol(+)kg^{-1})	3.85	65.10
Exch. Mg (cmol(+)kg^{-1})	1.83	10.24
Exch. Na (cmol(+)kg^{-1})	0.50	36.03
Exch. Al (cmol(+)kg	1.21	0.00
Exch. H (cmol(+)kg	5.51	0.25
CEC (cmol(+)kg^{-1})	67.31	15.82
Base Saturated (%)	9.96	>100

Less nutrient of P uptake resulted in abnormal growth and low crop production (Istina et al., 2015). Table 1 showed that the content of potential K, Ca and Mg was low, each 0.52, 3.85 and 1.83 Cmol(+) kg^{-1}) respectively. CEC value was very high (67.31 cmol(+)kg^{-}1) but bases saturity (BS) was very low (9,96%). It might inhibit equilibrium of nutrients, especially K, Ca and Mg. Content of K, Ca and Mg nutrients were low, which was resulting in the plant deficiency of macro nutrient. The characteristics of peat such as low pH (acidic), poor nutrient, irreversible drying caused low productivity for agriculture (Masril et al., 2014).

Coastal sediment was analyzed for chemical properties (Table 1). It had high pH value (7.72) and very high base saturation (>100%). It consists of 5.31% sand, 38.22% silt and 56.47% clay (clay texture). It had very low available P and potential K with 10.20 mg P_2O_5 kg^{-1} and 5.01 (cmol(+)kg^{-1}), respectively. The addition of coastal sediment on peat soil might raise soil pH due to neutralization reaction of H^+ ions from peat soil by OH^- ions from coastal sediment (Suswati et al., 2014).

The effect of coastal sediment application to the properties of peat soil

Properties of peat soil after application of coastal sediment at variety of doses are shown in Table 2. Results of analysis of variance of soil pH at one month after treatment showed that the coastal sediment treatments significantly affected soil pH. Table 2 shows that application of coastal sediment can increase soil pH after incubation. Dosing coastal sediment up to 60 tons ha^{-1}, can increase soil pH after incubation significantly. Seawater influence on material properties of coastal sediment so that the resulting sediment is rich in salts NaCl, Na_2SO_4, $CaCO_3$ and $MgCO_3$ (Tan, 2011) which can neutralize organic acids (Stevenson, 1994) so as to increase the soil pH. In addition, the cations will increase the percentage of base saturation (BS) colloidal complex and directly contributed to the increase in soil pH.

Table 2 shows that the addition of coastal sediment 20 tons ha^{-1} on peat soil can reduce soil organic C when compared with no addition of coastal sediment. Value of C-organic peat soil decreased with the addition of coastal sediment up to the dose of 60 tons ha^{-1}. Coastal sediment contains a low organic-C 1.18% compared with the untreated peat organic C is 37.30%. Therefore, the addition of increasing coastal sediment up to 60 tons ha^{-1} would decrease C-organic peat after incubation.

Addition of coastal sediment up to 20 tons ha^{-1} can lower soil CEC after incubation when compared to no provision of coastal sediment, but with the addition of coastal sediment up to 60 tons ha^{-1} was able to significantly lower soil CEC. Soil CEC decreased by increasing of dose coastal sediment up to 60 tons ha^{-1}. This is due to the coastal sediment has a low CEC is 15.82% cmol (+) kg^{-1} compared CEC peat ranged from 67.31 cmol (+) kg^{-1}. Giving ameliorant material which has a lower CEC of peat peat will lower CEC. The decrease caused by the increased soil CEC increased coastal sediment with low organic-C (1.18%) can reduce soil organic-C.

Soil CEC values are directly related to the amount of soil organic matter. The smaller the proportion of peat in mixing with minerals due to the depletion of the peat layer, the more it will reduce the source of the negative charge of the soil layer (Fahmi et al., 2012). One source of negative charge soil is organic matter; the charge comes from the

Table 2. Peat soil properties with application coastal sediment (CS)

Observation periode	Dose of CS (ton ha^{-1})	Variables					
		pH	C-org (%)	CEC	Exch-Al	Exch-H	BS (%)
				Cmol(+) kg^{-1}			
after Incubation (2 weeks)	0	3.58d	36.32a	67.86a	0.23b	1.25a	9.89d
	20	4.47c	29.61b	56.90b	0.22b	0.62b	44.83c
	40	5.16b	25.11c	49.82c	0.20b	0.37c	68.82a
	60	5.50a	19.20d	46.47c	0.01c	0.29d	61.15b
	Mean	4.68	27.56	55.26	0.22	0.63	46.17
The end of experiment	0	3.51d	35.94a	64.34a	0.62a	1.02a	9.323c
	20	4.40c	28.28b	56.28b	0.31b	0.28b	106.46b
	40	5.15b	24.80c	45.28c	0.03b	0.32b	165.73a
	60	5.49a	18.52d	45.28c	0.03b	0.31b	156.20a
	Mean	1133.75	26.89	52.80	0.25	0.48	109.43

Remarks : the value in the column followed by the same letters and the same treatment groups was not different by Duncan's test 5%.

dissociation of functional groups of organic acids. In addition, Wulandari *et al*. (2014) explain that Na from seawater can decrease the CEC value of peat. Salampak (1999) stated that the addition of cations in peat soil will decrease the activity of organic acids, especially phenolic acids. CEC on peat soil is largely determined by the phenolic and carboxylic acids, phenolic acids; the decrease will cause a reduction in CEC of peat.

Table 2 shows that the application of coastal sediment up to 20 tons ha^{-1} can increase BS after incubation when compared to without of coastal sediment. The addition of coastal sediment 40 tons ha^{-1} and 60 tons ha^{-1} were able to increase the available BS significantly. This is due to the coastal sediment containing alkaline cations such as K, Ca, Mg and Na; it can increase BS of peat reached 44.83 – 68.82%, meanwhile without addition coastal sediment only 9.89% of BS. At the end of the study soil BS tends to increase due to the release of base cations cations such as K, Ca, Mg and Na optimally so that soil BS tends to rise in soil.

Results of analysis variance of exch-Al soil after incubation showed that coastal sediment treatment significantly affected soil exch-Al. Table 2 shows that application of coastal sediment at doses 20 ton ha^{-1} increase availability exch-Al soil after incubation and decreased compared to without giving coastal sediment. At the end of the study of exch-Al soil tends to decrease as soil pH and increase availability of base cations. Table 2 showed that the coastal sediment treatment significantly affected soil exch-H after incubation. Application of coastal sediment at all doses could decrease exch-H compared with control (without coastal sediment). This is due to increased soil pH, thereby increasing OH- ions in the soil solution to neutralize exch-H (H^+). At the end of the study exch-H soil tends to decrease as soil pH and availability of base cations also increased.

The effect of coastal sediment application to the availability of nutrient inpeat soil

Table 3 shows that the application of coastal sediment at 20 tons ha^{-1} on peat soil has been able to increase the total soil N after incubation compared to without of coastal sediment. N-total in peat increased significantly with the addition of coastal sediment at 40 tons ha^{-1}. Increasing of N-total derive from decomposition of organic matter, N is an element that largely sourced from the decomposition of organic matter. The contribution of N from the decomposition process is highly dependent on the quality and quantity of organic matter. One of the factors that affect the rate of decomposition is an increase in soil pH (Reddy and Delaune, 2008). Increasing soil pH would increase activity of soil microorganisms, which are active at pH range 6-7 or around neutral soil. Due to the increased activity of microorganisms in the soil, it would lower ratio of C/N in peat soil, so that N would be available to plants. According to Kakei and Clifford. (2000), liming can increase the pH in peat, N avaibility in the peat were increased by liming. N-total at the end of experiment tends to decrease as compared with soil N-total after incubation, it used by plants for growth and development, although the availability of soil N total tends to decline but still in conditions not unlike the N soil total after incubation.

Addition of coastal sediment until the dose of 60 tons ha^{-1} of coastal sediment commonly tends to decrease the available soil P after incubation (Table 3). The decline in available soil P occurs due to the condition of the soil pH also increased to 5:50, so that in these conditions the solubility of base cations

Table 3. Nutrients content in peat soil with application of coastal sediment (CS)

Observation periode	Dose of CS (ton ha^{-1})	Variables							
		pH	N (%)	P (ppm)	K	Ca	Mg	Na	S
					Cmol(+)kg^{-1}				ppm
After Incubation (2 weeks)	0	3.58d	1.57a	23.44a	0.54d	3.89d	1.81c	0.55d	585.19b
	20	4.47c	1.26b	23.40a	0.58c	19.38c	3.55b	2.08c	1238.53a
	40	5.16b	1.19c	23.32a	0.68a	24.77b	4.09a	2.27b	1351.32a
	60	5.50a	0.93d	22.39a	0.64b	30.16a	4.07a	2.43a	1369.06a
	Mean	4.68	1.24	23.14	0.61	19.55	3.38	1.83	1136.03
The end of experiment	0	3.51d	1.55a	23.28a	3.56c	3.27c	1.78c	0.54b	585.19b
	20	4.40c	1.24b	22.74a	4.50b	45.17b	9.83ab	4.43a	1238.53a
	40	5.15b	1.16b	21.35ab	5.24a	56.16a	10.34a	4.56a	1351.32a
	60	5.49a	0.94c	19.70b	5.33a	56.57a	9.06b	4.11a	1359.96a
	Mean	4.66	1.22	21.77	4.66	40.29	7.75	3.41	1133.75

Remarks : the value in the column followed by the same letters and the same treatment groups was not different by Duncan's test 5%.

Ca ions increased primarily. This allows the binding of phosphate ions by Ca ions are poorly soluble, the higher the Ca^{2+} or Ca carbonate will be higher the more embedded phosphate so that P is not available (Tisdale et al., 1990). Beside, P is an element that is susceptible to leaching if high concentrations in the soil solution (Sapek et al., 2009) and according to Kurnain (2005) peat soils do not have a strong enough tread sorption binding P so easily leached.

Table 3 shows that the provision of coastal sediment at 20 tons ha^{-1} on peat soil can increase the available of K peat soil when compared to without coastal sediment. Addition of coastal sediment of 40 tons ha^{-1} still increase available of K significantly, but at the dose of 60 tons ha^{-1} where a decline in available K. Increasing available of K by application coastal sediment was up to 40 tons ha^{-1} caused the coastal sediment containing K, so that when added to the soil will increase soil K availability. Besides coastal sediment was as a source of nutrients K, a high proportion of clay at coastal sediment is added gives a great potential to soil K availability.

Available of K decreased at doses of 60 tons ha^{-1}, this is possible because the C-organic soil also decreased at doses increasing coastal sediment. According to Havlin et al. (2005), dissolved K in the soil is proportional to the organic matter added to the soil. Potassium is mainly contained in the organic matter as dissolved inorganic K so as to supply the K available to plants. At the end of the study soil K tends to decrease as compared with soil K after incubation, as used by plants for growth and development, although exchangeable soil K availability tends to decrease but still in conditions not unlike soil K after incubation. This is due to soil organic C also decreased at the end of the study.

The application of coastal sediment of 20 tons ha^{-1} can increase the availablity of Ca when compared with control and no different with the addition of coastal sediment at the dose of 40 t ha^{-1} (Table 3). This is due to the coastal sediment containing high Ca is 3.85 cmol (+) kg^{-1}, higher than the content of other base cations (K, Mg, Na), so it can act as a source of Ca. Very important factor in determining of available Ca is soil pH and CEC (Havlin et al., 2005).

Available Mg increased with the addition of coastal sediment 20 tons ha^{-1} compared to without coastal sediment and no different with dosage 40 tons ha^{-1} and 60 ton ha^{-1} (Table 3). This was caused by the coastal sediment containing Mg so it can act as a source of Mg. Addition of coastal sediment will reduce the availability of Mg because it tends to accumulate in soils rich in Clay (Bohn et al., 2001). At the end of the study Mg tended to decline as oil palm crops used for growth and development. Table 3 shows that Na lowest available soil after incubation without coastal sediment treatment. Sodium available was increased by application of coastal sediment up to doses of 60 tons ha^{-1}. This is due to the salty coastal sediment containing Na so it can act as a source of Na.

Palm Oil Production

The responses of yield of oil palm were varied from one treatment to another. All of doses of ameliorant gave a better yield than control (without coastal sediment).Average yield of oil palm until the end of the study can be seen in figure 1. The highest increasing of yield oil palm was application of coastal sediment at dose of 40 tons ha^{-1}. This is possible because in these conditions the availability of macro nutrients are in a state of sufficient and balanced, making it possible to absorb oil palm plants.

The application of coastal sediment at the dose of 60 tons ha^{-1}, it production tends to decline. Oil palm plant production depends on the supply of nutrients from the soil,

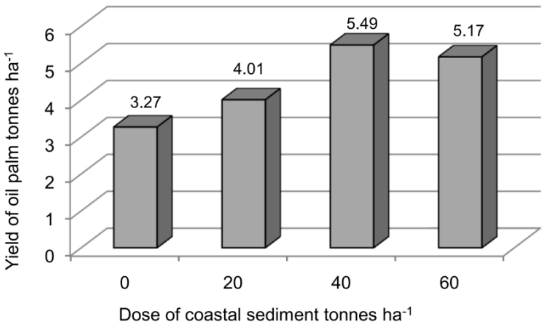

Figure 1. Average yield of oil palm which was add coastal sediment at some doses.

supposedly with the availability of some macro nutrients (N, P, K and Mg) which also tends to decrease at dose of 60 tons ha^{-1}, so that the uptake of macro nutrients also declined. Nutrition is crucial production of oil palm fruits, the nutrients needed different numbers from different parts of the plant (roots, stems, leaves, fruit bunches) (Salmiyati et al., 2014). Such as nitrogen generally has no effect on oil palm yield components, but giving P lowered fruit production, fertilizer Potassium deficiency tends to reduce the mesocarp: fruit ratio, while Mg considerable increase palm oil (Goh et al., 2003).

CONCLUSIONS and SUGGESTION

Conclusion

1. Application of coastal sediment can improve some chemical properties of peat shown by pH and base saturation.
2. Nutrients availability in peat increased by application of coastal sediment.
3. Doses of coastal sediment of 40 tons ha^{-1} is optimal dose for increase yield of oil palm in peat, which attain 5.49 tons ha^{-1}.

Suggestion

It was shown that application of coastal sediment had positive effect to some peat chemistry properties and nutrients availability in peatlands, which could be potentially, exploited in various soils amelioration strategies without risk to a sustainable agriculture in the tropics area.

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REFERENCES

Abat. M.. M.J. Mc Laughlin, J.K. Kirby and S.P. Stacey. 2012. Adsorption and desorption of copper and zinc in tropical peat soils of Sarawak. Malaysia. Geoderma. 176: 58-63.

Adesiji, R.A., T.A. Mohammed, N.N. Daud, and S. Mustapha. 2014. Impacts of Oil Palm cultivation on soil chemistry in a Malaysian Tropical Peatland. Adv. Environ. Biol. 8: 369-373

Alwarritzi, W., T. Nanseki and Y. Chomei. 2015. Analysis of the factors influencing the technical efficiency among oil palm smallholder farmers in Indonesia. Procedia Environmental Sciences. 28:630 – 638.

Bjorn, B., and C. Mc Claugherty. Plant litter. decomposition humus formation, carbon sequestration. Springer, Verlag Berlin Heisenberg. (2008).

Bohn, H.L., B.L. Mc Neal and G.A. O'Connor. 2001. Soil Chemistry. 3rd edition. John Wiley and Sons. New York USA. 307 p.

Fahmi, A., B. Radjagukguk, B.H. Purwanto and E. Hanudin. 2012. The influnece of peat layer on hidrogen and aluminium concentration originating from the substratum sulphidic materials. J Trop Soils. 17: 197-202.

Gogo. S. and D.M.E. Pearce. 2009. Carbon. Cation dan CEC : Interactions and Effects on Microbial Activity in Peat. Geoderma. Journal. 153 : 76-86.

Goh, K.J. and Hardter, R. 2003. General Oil Palm Nutrition. In: Fairhurst, T.H. and Hardter, R. (eds.) Oil Palm: Management forLarge and Sustainable Yields. PPI, Switzerland, pp. 191-230.

Gomez, K.A. and A.A. Gomez.2007. Statistical procedures for agricultural research. Second edition, an International Rice Research Institute Book. A wiley Interscience Publication. P. 1-15; 97-116; 121-156.

Hansen, S.B., R. Padfield, K. Syayuti, S. Evers, Z. Zakariah and S. Mastura. 2015. Trends in global palm oil sustainability research. Journal of Cleaner Production. 100: 140-149.

Hartatik, W.,K.Idris, S. Sabiham, S. Djuniwati, and J.S.Adiningsih.2004.The effect of natural phosphate and SP-36 on peat soil that was given to the mineral soil material ameliorant P uptake and fertilizer efficiency P. Proceedings of the National Congress VIII HITI. Universitas Andalas. Padang. (in Indonesian).

Havlin, J.L., J.D. Beaton, S.L. Tisdale and W.L. Nelson, 2005. Soil Fertility and Fertilizers. An Introduction to Nutrient Management. Pearson Education. Inc., Upper Saddle River, New Jersey. 515 p.

Hazelton, P.A. and B. Murphy. 2007. Interpreting soil test results: what do all the numbers Average? (2nd ed.). CSIRO Publishing, Australia.

Husen, E., S. Salma and A. Fahmudin. 2013. Peat emission control by groundwater management and soil amendments: evidence from laboratory experiments. Mitig. Adapt. Strateg. Glob. Change 1381, 1-9.

Istina, I.N., H. Widiastuti, B.Joy and M. Antralina. 2015. Phosphate-solubilizing microbe from saprists peat soil and their potency to enhance oil palm growth and p uptake. Procedia Food Science. 3: 426 – 435.

Kakei, M. and P.E. Clifford. 2000. Long-term effects of lime application on 15 N availability to Sitka spruce seedlings growing in pots containing peat soils. Forestry 73, 4. 393 – 401.

Kurnain, A. 2005. Activity impact on agriculture and fire ombrogen peat. Dissertation Study Program of Agricultural Sciences. Interest in Soil Science. Graduate program. Yogyakarta.

Masril, R., E. Munaf, H. Nurdin, H. Suyani and T. B. Prasetyo. 2014. Research Journal of Pharmaceutical, Biological and Chemical Sciences. RJPBCS 5: 1823 – 1830.

Masud. M.M., M. Moniruzzaman and M.M. Rashid. 2011. Management and conservation of organic peat soils for sustainable crop production in Bangladesh. Bull. Inst. Trop. Agr. 34. 93-101.

Nurzakiah, S., Agus, F., and H. Syahbuddin. 2013. Ameliorant application on variation of carbon stock and ash content on peatland South Kalimantan. J.Trop. Soils 18, 11-16.

Obidzinski, R., R. Andriani, H. Komarudin and A. Andrianto. 2012. Environtment and social impact of oil palm plantations and their implacations for biofuel production in Indonesia, Journal Ecology and Society. 17: 25.

Pansu, M., Gautheyrou, J., 2006. Handbook of Soil Analysis: Mineralogical, Organic and Inorganic Methods. Springer-Verlag, New York.

Reddy, K.R. and R.D. DeLaune. 2008. The Biogeochemistry of Wetland; Science and applications. CRC Press. New York. USA. 779 p.

Sabiham. S., S.D. Tarigan, Hariyadi, I.las, F.Agus, Sukarman, P. Setyanto and Wahyunto. 2012. Organic Carbon Storage and Management Strategies for Reducing Carbon Emission from Peatlands: A Case Study in Oil Palm Plantations in West and Central Kalimantan. Indonesia. Pedologist: 426-434.

Sarkar, D., and A. Haldar. 2005. Physical and chemical methods in soil analysis. New Age International Ltd., New Delhi.

Salmiyati, A. Heryansyah, I. Idayu and E. Supriyanto. 2014. Oil Palm Plantations Management Effects on Productivity Fresh Fruit Bunch (FFB). APCBEE Procedia 8: 282 – 286.

Sapek, A. B. Sapek, S. Shrzanowski and M. Urbaniak. 2009. Nitrient mobilization and losses related to the groundwater level in low peat soils. International Jurnal of Enviroment and Pollution. 37 (4); 398-408.

SAS [Statistical Analysis System] Institute, 2003. The SAS system for windows. Release9.1. SAS Inst. Inc., Cary, NC.

Sayer, J., J. Ghazoul, P. Nelson and A. K. Boedhihartono. 2012. Oil palm expansion transforms tropical landscapes and livelihoods. Global Food Security. 1:114–119.

Sabiham S. 1996. Utilization of tidal bog sediment as one of the alternatives in decrease methane and phenolic acids in peat soil thickness. Proceedings of the National Seminar on Peat II, HGI and BPPT, Jakarta (in Indonesian).

Salampak,1999. Increased production peat which made rice field with providing material mineral land ameliorant high abundance of iron. Dissertation. Bogor Agricultural University Graduate Program. Bogor.

Suswati, D. 2009. The effect of coastal sediment to some chemincal of peat soil. Jurnal Agripura1: 643-653.

Suswati, D., Sunarminto, B.H., Shiddieq and D. Indradewa, D., 2011. Characteristics and suitability of peatlands for maize development in Rasau Jaya III, Kubu Raya District. Journal of Agripura 7: 984-990 (in Indonesian).

Suswati,D. 2012. Utilization of some ameliorant to increase peat land suitability in development of Jagung in Rasau Jaya III, Pontianak. Dissertation of agriculture science. Graduaded UGM, Yogyakarta.

Suswati, D. B.H. Sunarminto, D. Shiddieq and D. Indradewa. 2014.Use of Ameliorants to Increase Growth and Yield of Maize (Zea mays L.) in Peat Soils of West Kalimantan. J Trop Soils, Vol. 19, No. 1:35-41.

Stevenson, F.J. 1994. Humus chemistry, genesis, compasition and reactions. Chichester Brisbane. John Wiley and Son. New York. Xii.

Tan ,K.H. 2011. Principles of Soil Chemistry, Fourth Edition. Marcell Dekker. Inc. New York and Basel. 362 p.

Temminghoff, E.J.M. and V.J.G. Houba. 2004. Plant analysis procedures, 2nd. Kluwer Academic Publishers, London.

Tisdale, S. and W. Nelson, 1990. Soil Fertility and Fertilizers. Edisi Ketiga. MC. Millan Publishing Company, Inc. New York. 755p.