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Effect of cultivation in different age's oil palm plantation on selected chemical properties of peat swamp soils

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Abstract: Large-scale land conversion of peat for agricultural purposes requires clearance, drainage, fertilizer application, and liming to increase the pH and boost microbial activity. The objective of this present study was to compare the soil chemical properties of oil palm plantation one-three years oil palm planted and mature oil palm that were previously a secondary tropical peat swamp forest. Soil samples were collected randomly at difference age's oil palm plantation from a Young Oil Palm Plantation (YOPP) in one year period of time at same place and Mature Oil Palm Plantation (MOPP) another place from oil palm plantation in Batang Igan, Sibu Sarawak, Malaysia. Approach: Forty eight soil samples were taken using a peat soil auger at 0-15 cm depths in every area. The samples were air dried and then sieved to pass 2 mm sieve. Soil pH in water and KCl, soil CEC, Organic Matter (OM), Organic Carbon (OC), Total Nitrogen (TN), Total Phosphorous (TP), Total Potassium (TK), carbon to nitrogen ratio and carbon to phosphorous ratio were determined using standard procedures. Statistical analysis showed that CEC, TC and OM content were statistically similar. Results: The soil pH_{water}, TN and C/N ration shows highly significant for all difference age's oil palm plantation. Difference with pH_{KCl} and TK content shows no significantly difference between YOPP 2 years and 3 years but both areas significantly higher with MOPP. For TP and C/P ratio content has no significant difference for YOPP (2 years) and MOPP but significantly difference with YOPP (3 years). Conclusion: Regardless of difference age's oil palm plantation, total carbon, organic matter and CEC was statistically similar to different ages of oil palm plantation, but soil acidity, nitrogen, phosphorus, potassium, C/N and C/P ratio was significantly higher between three areas weather YOPP (2 years), YOPP (3 years) and MOPP.

Keywords: Peat Swamp Forest, Soil Acidity, Soil Organic Matter, Total Carbon, Total Nitrogen, Total Phosphorus, Total Potassium, C/N and C/P ratio

1. Introduction

Land conversion with much of the available arable land on mineral soils already under cultivation, peat swamps are one of the last frontiers for production of food, pulp, and biofuels. Peat is considered a "problem" soil because its physical and chemical properties make the cultivation of many agricultural crops difficult [1]. Large-scale land conversion of peat for agricultural purposes requires clearance, drainage, fertilizer application, and liming to increase the pH and boost microbial activity [2]. Peat can also be defined as the accumulation of a 100% organic material and the distinction between soil and vegetative accumulation is not clear [1]. Peat as organic soils on the basis of mass composition for example soils that contain at least 65% organic matter or conversely and have less than 35% mineral content [3]. Peat is classified as highly organic and soft soils. Generally, peat is mainly composed of fibrous organic matters, which are partly decomposed plants such as leaves and stems. Most of peat is largely organic residues of plants, incompletely decomposed through lack of oxygen [4].

The soil division of Sarawak, Malaysia adopted a more recent definition which is based on soil partition, i.e. soils that have 50 cm or more Soil Organic Matter (SOM) within 100 cm or more than twice that of mineral soil materials overlying bedrock within 50 cm [5]. West Malaysia peats

have very low pH values ranging from 3.0 to 4.5, in some cases where sulphide materials are found within the profile, pH values can be below 3.0 [6]. Organic carbon (OC) and total nitrogen contents in peat soil are very high with the OC contents ranging from 12-60% [1]. The surface of peat soils contain more C compared to the subsoil with values such as 58% at the surface and 25% in the subsoil [7] and typical of deep peat soils. Organic nitrogen in shallow peat soils can range from 0.5-2.1% and in the deep peat soils the values can range from 1.1-1.7% [8] with N levels in the deep peat being higher compared to shallow peat soils [1].

There were large hectares of peat land being developed for agricultural uses due to high contents of C and N as well as other nutrients in peat soil. The objective of this study was to compare the soil chemical properties of oil palm plantation one and two years oil palm planted in the 1 year period time at same place and mature oil palm other place that were previously secondary tropical peat swamp forest.

2. Material and Method

The soil samples used in this study were taken from oil palm plantation in Batang Igan, Sibu Sarawak, Malaysia. The size of each experimental plot for the two locations was 20 x 50 meters. The ages of the oil palm plantations available sampled in young oil palm plantations were sample has collected in 1 year period time at same place and mature oil palm plantation another place. Forty eight soil samples were taken using a peat soil auger at 0-15 cm depths in every site. The samples were air dried and then sieved to pass 2 mm sieve.

The determination of soil pH was done by using a ratio of 1:10 soil to distilled water suspension (pH in water) and 1 M of KCl (pH in 1 M potassium chloride) using a glass electrode (Tan, 2005). The loss on ignition method was used to determine soil organic matter (SOM) and total C (TC) [9]. Soil CEC was determined by leaching method 1M ammonium acetate buffer adjusted to pH 7.0 followed by steam distillation technique. Total nitrogen (TN) was determined by the Kjeldahl method followed by steam distillation technique [10]. Total phosphorus (TP) and total potassium (TK) was extracted by the aqua regia method [11]. TP was determined by blue method followed measured using spectroscopy at wavelengths 882nm [12] and the cation of TK was measured using atomic absorption spectrophotometry (Analyst 800, Perkin Elmer Instruments, Norwalk, CT).

Data was analyzed using the Statistical Analysis System (SAS) by means of ANOVA and means separation was done using the Tukey's test [13].

3. Result

The soil pH_{water} of Young Oil Palm Plantation (YOPP) (2 years), Young Oil Palm Plantation (YOPP) (3 years) and Mature Oil Palm Plantation (MOPP) were significantly difference between three areas where MOPP pH 4.06, followed YOPP (2 years) pH 3.70 and YOPP (3 years) pH 3.20. The soil pH_{KCl} of YOPP (2 years) and YOPP (3 years) showed no significant difference but for mature site shows significant difference (Table 1). The soil CEC, soil organic matter and total carbon showed no significant difference between the three areas (Table 2).

Table 1. *Mean comparison soil pH and soil CEC of different ages of oil palm plantation*

Location	Means	
	pHwater	pHKCl
YOPP (2 years)	3.70b	2.71a
YOPP (3 years)	3.20c	2.52a
MOPP	4.06a	2.85b

Note: Means within column with same alphabets are not significantly different at p = 0.05 using Tukey's test

Table 2. *Mean comparison soil organic matter and total carbon of oil palm plantation*

Location	Means		
	CEC (meq 100-1)	Total C (%)	SOM (%)
YOPP (2 years)	72.96a	55.62a	95.89a
YOPP (3 years)	82.19a	55.67a	95.99a
MOPP	83.21a	54.73a	94.36a

Note: Means within column with same alphabets are not significantly different at p = 0.05 using Tukey's test

Total N shows significant higher between three areas where YOPP (3 years) is higher than MOPP and YOPP (2 years) are the lowest value. Total P showed no significant difference between YOPP (2 years) and matures oil palm but significantly difference for YOPP (3 years), where YOPP (2 years) is the higher than other two sites. For the total K, shows highly significant between sites but for the YOPP 2 and 3 years shows no significant where MOPP is the higher value followed YOPP (3 years) then YOPP (2 years) (Table3).

The C:N ratio shows significant higher between three areas where YOPP (2 years) has the highest value and YOPP (3 years) has the lowest value. Different with C:P ratio, there were no significant difference between YOPP (2 years) and matures oil palm but has significantly difference for YOPP (3 years), where YOPP (3 years) has the higher value while MOPP and YOPP (2 years) have the lower value (Table 4).

Table 3. *Mean comparison soil organic matter and total carbon of different ages of oil palm plantation*

Location	Means		
	Total N (%)	Total P (%)	Total K (%)
YOPP (2 years)	0.8210c	0.0194a	0.0097b
YOPP (3 years)	1.7183a	0.0135b	0.0107b
MOPP	0.9650b	0.0188a	0.0883a

Note: Means within column with same alphabets are not significantly different at p = 0.05 using Tukey's test

Table 4. *Mean comparison C:N and C:P ration of different ages of oil palm plantation*

Location	Means	
	C:N ratio	C:P ratio
YOPP (2 years)	67.77a	2874b
YOPP (3 years)	33.50c	4240a
MOPP	59.90b	3190b

Note: Means within column with same alphabets are not significantly different at p = 0.05 using Tukey's test

4. Discussion

Paul and Clark [18] found that, the standard typical range SOM in peat soil is more than 90 percent. Total carbon consists of organic and inorganic carbon where total carbon is much related with soil organic matter. This present study recorded that total carbon of the peat soil is not changed for difference age's oil palm cultivation. The range value of total carbon is from 55.67 to 54.73 percent where it is in the range between 12 – 60% as reported by Andriesse [1].

Generally, total nitrogen contents in peat soil are high than compared with mineral soil. Normally in peat soil, most of the nitrogen is in the organic form but small quantities of nitrate are usually present in better drained soils in which organic materials oxidize rapidly. This present study shows there is highly significant difference of total nitrogen contents between three areas. The higher total nitrogen content in oil palm plantation could be related to the origin of the parent material and the water management. Cultivation with oil palm required the soil to be much drain. Agricultural practices such as initial land clearance, water table management, liming and fertilizer application caused the total nitrogen content decreased [19]. These will increase peat soil pH and boost microbial activity which would degrade or mineralize nitrogen in peat.

Total phosphorus of soil in oil palm cultivation result a small changes where there is slightly decrease in YOPP (3 years). Total P in YOPP (2 years) and MOPP was slightly higher than YOPP (3 years) where the value of mean is 0.0194 % YOPP (2 years), 0.0188 % MOPP and 0.0135 % YOPP (3 years). Total phosphorus of soil in oil palm cultivation result a small changes where there is slightly decrease in YOPP (3 years).

Generally, peats are in an acidic condition and the pH value often lies between 4 to 7 [14]. The pH values of this study were typical of tropical peat soils, which has very low pH values range from 3.20 to 4.06 pH_{water} and 2.52 to 2.85 pH_{KCl}, and existing of sulphide materials within the profile makes pH values can be below 3.0 [6]. The acidity of peat is decrease with depth and the decreasing may be large near the bottom layer depending on the type of the underlying soil [15].

Caution exchange capacity (CEC) in peats is very high and pH dependent. Soil CEC of this study was no significantly difference between three areas, where soil CEC range is 72.96 to 83.21 meq 100^{-1}. Tie (1988) found that, the standard range of soil CEC is 40 – 135 meq 100^{-1}. CEC will increase as long as increase in pH value and the exchangeable caution concentration [16]. Among the peats, the CEC for fibrous peat is larger than others.

Soil organic matter controls many of the chemical, physical and biological properties of the soil [17]. The accumulation of SOM is dependent on quantity and quality of organic residue inputs, largely as plant material, the rates of microbial decomposition, and the capacity of the soil to store organic matter. In this study, soil organic matter of the three areas shows no significant difference, which value range is 95.99 % to 94.36 %.

The result shows that total P lower compared to standard range 0.04 to 0.1 percent [1]. When rapid decomposition occur due to the changed of environment after oil palm cultivation, the more P are released into the soil [7].

Total K shows highly significant change, particularly MOPP. Total K in YOPP (2 years) and YOPP (3 years) MOPP was lowest than MOPP where the value of mean is 0.0097 % YOPP (2 years), 0.0107 % YOPP (3 years) and 0.0883 % MOPP. In YOPP area, the oil palm trees is still small thus, leaves has not been able to cover the entire land area when rainy day so K can be lost through the leachate. Andriesse [1] reported that, peat soil in open condition without forest cover, in tropical peats, with high rainfall, potassium will be strongly leached, meanwhile sufficient drainage system in oil palm plantation will increase potassium uptake that will led to decreasing of total potassium content in cultivated peat soil.

Andriesse [1] stated that, the C/N and C/P ratio indicates the degree of humification of the peat and the likelihood of nitrogen and phosphorus consumption by micro-organism when the peats are fertilized on reclamation. In this study, the C/N and C/P ratio for difference age's oil palm is statistically difference (Table 4). The reason of mean C/N and C/P ratio value for this area is very high because nitrogen and phosphorus was found to be very low instead of carbon. The C/N ratio is statistically not similar, the YOPP (3 years) showed lower mean C/N ratio compared to YOPP (2 years) and MOPP due to higher water table level likewise the C/P ratio is not uniform, the YOPP were found high value mean compared to MOPP and YOPP (2 years). This will caused a condition where microbes need longer time to decompose carbon, nitrogen and phosphorus in the soil. However, in oil palm plantation soil, the breakdown of nitrogen and phosphorus by microbes caused the mean C/N and C/P ratio is high [20].

5. Conclusion

Regardless of difference age's oil palm plantation, total carbon, organic matter and CEC was statistically similar to different ages of oil palm plantation, but for soil acidity, nitrogen, phosphorus, potassium, C/N and C/P ratio was significantly higher between three areas weather YOPP (2 years), YOPP (3 years) and MOPP. Studies on plantations must be do older than ten years (MOPP) as this could give more clear differences in results emanating from the prolonged land use change and management.

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References

[1] Andriesse, J.P., 1988. Nature and Management of Tropical Peats. FAO Soils Bulletin 59. FAO, Rome, ISBN: 92-5-102657-2.

[2] Posa, M.R.C., L.S. Wijedasa and R.T. Corlett., 2011. Biodiversity and Conservation of Tropical Peat Swamp Forests. American Institute of Biological Sciences., 61(1): 49-57.

[3] Mohamed, M., E. Padmanabhan, B.L.H. Meiand and W.B. Siong. 2002. The Peat Soils of Sarawak. University Malaysia Sarawak.Malaysia. http://www.strapeat.alterra.nl/download/12%20peat%20soils%20of%20Sarawak.pdf

[4] Kazemian, S., V., Ghiasi and Bujang B.K. 2011. Huat, In *effect of cement on peat stabilization*, the proceeding if the first Iranian students scientific conference in Malaysia. April 9-10,.

[5] Tay, T.H., 1969. The distribution, characteristics, uses and potential of peat in West Malaysia. J. Trop. Geograph., 29: 58-63.

[6] Malaysian Agricultural Research and Development Institute, MARDI. 2009. Extent and Characteristic of Peat Soil. Agric. Res. Dev. Inst., pp. 3-25.

[7] Kanapathy, K., 1976. Fertilizer requirement on peat soils. Malaysian Agric. J., 50: 292-307 http://orton.catie.ac.cr/cgibin/wxis.exe/?IsisScript=CATALCO.xis&method=post&formato=2&cantidad=1&expresion=mfn=046312

[8] Tie, Y.L. and J.S. Lim, 1992. Characteristic and classification of organic soils in Malaysia. In tropical peat. Proceedings of the International Symposium on Tropical Peatland, May 6-10, Malaysia Agricultural Research and Development Institute, Kuching, Sarawak, Malaysia, pp: 441.http://www.abebooks.co.u/9789679361278/Tropical-Peat-Proceedings-International-Symposium-9679361276/plp

[9] Fiala, K. and J. Krhovjakova, 2008. Application of lossof-ignition method to the soil organic carbon determination. Geophys. Res. Abstr., 10: 1-2.

[10] Jones, J.B., 2001. Laboratory Guide for Conducting Soil Tests and Plant Analysis., ISBN: 0849302064. CRC Press, USA, pp: 209-212.

[11] Zarcinas, B.A., B. Cartwright and L.R. Spouncer. 1987. Nitric acid degestion and multi-element analysis of plant material by inductively coupled plasma spectrometry. Common Soil Science Plant Analysis 18(1): 131-146. DOI: 10.1080/00103628709367806

[12] Bray, R.H. and L.T. Kurtz, 1945. Determination of total, organic and available forms of phosphorus in soils. Soil Sci., 59: 39-45. http://scholar.google.com.pk/scholar?hl=en&lr=&q=info:2cWp5lf_TuMJ:scholar.google.com/&output=viewport&pg=1

[13] SAS., 2001. SAS/STAT Software. SAS Institute, Cary, NC. ISBN: 10: 1580258506

[14] Lea FM. 1956. In the Chemistry of Cement and Concrete, ed. Lea and Desch, London: Edwar Arnold Ltd.

[15] Muttalib, A., Lim J.S., Wong M.H., Koonvai L. 1991. Characterization, distribution, and utilization of peat in Malaysia. In Proceedings of the International Symposium on Tropical Peatland, ed. Aminuddid, Kuching, Sarawak, pp. 7-16.

[16] Aho M. 1986. The ion exchange and adsorption properties of sphagnum peat under acidic conditions, Research report No. 24, University of Jyväskylä. ISBN 951-679-533-1, ISSN 0357-346X.

[17] Doran, J.W and T.B. Parkin, 1994. *Defining and assessing soil quality*. In Defining Soil Quality for a Sustanable Environment; Doran, J.W., Coleman, D.C., Bezdicek, D.F., Stewart, B.A., EDS; Soil Science. Society AM.: Madison, WI, 1994, pp. 3-24.

[18] Paul, E.A., and F.E. Clark, 1996. Soil Microbiology and Biochemistry, Academic Press, San Diego (1996) pp. 131–146.

[19] Tie, Y.L. and H.S. Kueh, 1979. *A review of lowland organic soils of Sarawak.* Department of Agriculture, Technical Paper 4, Research Branch, Sarawak, Malaysia.

[20] Muniandy, M., O.H. Ahmed, N.M.A. Majid and M.K. Yusop, 2009. Effects of Converting Secondary Forest to Oil Palm Plantation on Peat Soil Carbon and Nitrogen and other Soil Chemical Properties. Am. J. Environ. Sci., 5: 406-412. DOI:10.3844/.2009. 406-412E.A.