Evaluation of peat soil properties for oil palm plantation in nine years of plant at Kubu Raya District, West Kalimantan, Indonesia

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Abstract. The aims of this research was to evaluate the nature of peat soil used for oil palm plantations in nine years of planting has been carried out in several private oil palm plantation companies in Kubu Raya District, West Kalimantan Province from May to June 2018. Research using survey methods with soil sampling was carried out intentionally (purposive sampling) in oil palm plantations planted on peatlands from 2009 to 2017. The results showed that the chemical properties of peat soils used for oil palm plantations in different planting years were qualitatively similar based on the assessment criteria of chemical properties. Quantitatively, some soil characteristics levels were very high. Mineral soil under peat at the study site cannot be used for ameliorant peat material because of pyrite compound. In order to maintain the quality of peat soils used for oil palm plantations, the application of ameliorant material which does not affect the acceleration of decomposition of peat soil material, must be continuously increased to the maximum extent possible.

1. Introduction
The use of peatlands for the cultivation of plantation crops, including for oil palm plantations is inevitable in line with population development and socio-economic development as well as the need for vegetable and non-fossil-based food and energy materials, both at local, national and international levels. Based on the report of the Indonesian Oil Palm Research Institute (IOPRI) Medan [1–3] the area of peatland in Indonesia used for oil palm plantations is around 1,705,912 hectares or only about 11.44% of the 14,905,574 hectares of peatland in Indonesia. Of the area of peatland used for oil palm plantations, approximately 1.4 million hectares are spread on the island of Sumatra and the rest are scattered on the island of Kalimantan.

As with oil palm cultivation on mineral land, oil palm cultivation in peatlands must also be oriented towards sustainable farming systems, which are not only aimed at achieving economic value, but also at sustaining social welfare and equality as well as remaining to guarantee the sustainability of natural and environmental resources (environmentally sound) [4, 5]. Oil palm cultivation on peatland can guarantee environmental sustainability or prevent land degradation, if carried out with cultivation techniques (agrotechnology) in relation to water management (water management). For example: management of land surfaces, management of soil enhancers (soil ameliorant or soil conditioner), and management of fertilizers [6, 7].
Drainage ditch construction for water management in peatlands is not intended to remove peat water from the land, but to reduce the surface of the peat water according to the optimal needs of the soil and plants (maintaining peat water levels above critical water content of at least 273%). Likewise, cover crops on peatlands must be consistent (there should be no fallow period) because land cover on peatlands is not intended to increase the biomass of peatlands, but rather is aimed at maintaining peat moisture [8–12].

Several private oil palm plantation companies in Kubu Raya District, West Kalimantan Province, have opened peatlands for oil palm plantations by implementing a portion of the environmentally-friendly technical culture described above, which has been carried out at least since 2009. On this basis it has been done a study to evaluate the nature of peat soil used for oil palm plantations in nine years of planting (from 2009 to 2017) in Kubu Raya District, West Kalimantan Province.

2. Materials and methods
The study was conducted in several private oil palm plantation companies in Kubu Raya District, West Kalimantan Province from May to June 2018. The study used a survey method with purposive sampling on soil samples collected from the oil palm plantations planted on peatlands since 2009 until 2017. Soil samples were analyzed at the Laboratory of Chemistry and Fertility of the Faculty of Agriculture, Tanjungpura University, Pontianak to obtain data on soil chemical properties consisting of pH H2O and pH KCl; nutrient content of N, P, K, Ca, Mg, and B; exchange bases; organic matter content; cation exchange capacity (CEC).

3. Results and discussion
The chemical properties and nutrient content of peat soil in oil palm plantations in Kubu Raya District, West Kalimantan for several years of planting was presented in table 1.

**Table 1.** Chemical properties and nutrient content of peat soil in oil palm plantations for several years of planting.

| Years of planting | Soil chemical properties |
|-------------------|--------------------------|
|                   | pH H2O | C-org. (%) | N-total (%) | P2O5 (ppm) | Exchange bases [cmol (+) kg⁻¹] | CEC [cmol (+) kg⁻¹] | Base saturation (%) |
| 2009 (VA) (VH)   | 3.35   | 20.49      | 1.48        | 46.71      | 1.17 (L) 0.32 (L) 0.25 (L) 0.43 (L) | 6.53 (L) 33.23 (L) | 2009 (VA) (VH)   | 3.56   | 15.27      | 1.98        | 34.63      | 2.33 (L) 1.64 (L) 0.30 (L) 0.49 (L) | 7.57 (L) 62.88 (L) | 2009 (VA) (VH)   | 3.63   | 41.18      | 2.01        | 53.40      | 4.53 (L) 0.43 (L) 1.20 (L) 2.02 (L) | 15.18 (L) 53.89 (L) | 2009 (VA) (VH)   | 3.81   | 44.66      | 2.07        | 34.92      | 1.40 (L) 0.46 (L) 0.13 (L) 0.20 (L) | 13.37 (L) 16.38 (L) | 2009 (VA) (VH)   | 3.60   | 49.69      | 2.09        | 63.86      | 3.39 (L) 0.86 (L) 0.40 (L) 0.67 (L) | 21.38 (L) 24.88 (L) | 2009 (VA) (VH)   | 3.56   | 46.79      | 1.91        | 66.56      | 1.33 (L) 0.48 (L) 0.24 (L) 0.40 (L) | 4.10 (L) 59.76 (L) | 2009 (VA) (VH)   | 4.34   | 56.26      | 1.41        | 66.58      | 1.54 (L) 0.30 (L) 0.21 (L) 0.35 (L) | 7.85 (L) 30.57 (L) | 2009 (VA) (VH)   | 3.60   | 56.26      | 1.94        | 88.25      | 2.00 (L) 1.17 (L) 0.65 (L) 1.14 (L) | 6.17 (L) 80.39 (L) | 2009 (VA) (VH)   | 3.16   | 57.23      | 1.94        | 165.17     | 2.53 (L) 0.71 (L) 0.57 (L) 0.98 (L) | 7.06 (L) 67.85 (L) |

Note: VA = very acid; VH = very high; H = high; M = medium; L = low; VL = very low

Based on table 1, the pH H2O tends to be very acidic. In accordance with the previous research [13, 14] mention that the peat soils generally have relatively high levels of acidity with a pH range of 3-4. Others research [15, 16] mention that oligotropic peat (Quartz sand substratum in Berengbengkel),
Central Kalimantan has a pH range of 3.25-3.75. The level of acidity of peat soil is closely related to the content of organic acids, namely humic acid and fulvic acid. Organic materials that have undergone decomposition have carboxyl and phenol reactive groups which are weak acids. It is estimated that 85-95% of the acidity of peat soil is caused by the two carboxyl and phenol groups. The acidity of peat soil tends to decrease along with the depth of peat. The upper layer of shallow peat tends to have a higher pH than thick peat [17].

Potential acidity as well as 25% HCl P and K extraction nutrient levels on peat soil in oil palm plantations in Kubu Raya District, West Kalimantan for several years of planting as shown in table 2. For nutrient content of 1N HCl extraction on peat soil at oil palm plantations in Kubu Raya District, West Kalimantan for several years of planting was presented in table 3.

Table 2. Potential acidity as well as 25% HCl P and K extraction nutrient levels on peat soil in oil palm plantations for several years of planting.

| Years of planting | Soil chemical properties | Ekst. KCl 1N (cmol (+) kg⁻¹) | Ekst. HCl 25% (mg/100g) |
|-------------------|--------------------------|-------------------------------|--------------------------|
|                   | pH.KCl                   | Al-dd                        | H-dd                     | P₂O₅         | K₂O         |
| 2009              | 2.88 (A)                 | 3.20                          | 1.17                     | 31.17        | 397.23      |
| 2010              | 2.16 (VA)                | 0.88                          | 1.92                     | 68.26        | 599.94      |
| 2011              | 2.45 (VA)                | 2.81                          | 4.19                     | 91.31        | 620.62      |
| 2012              | 2.61 (A)                 | 1.26                          | 1.69                     | 20.82        | 353.76      |
| 2013              | 2.43 (VA)                | 1.50                          | 2.19                     | 77.87        | 481.14      |
| 2014              | 2.53 (A)                 | 1.07                          | 0.58                     | 76.78        | 474.46      |
| 2015              | 3.41 (A)                 | 2.13                          | 3.31                     | 32.30        | 387.45      |
| 2016              | 2.16 (VA)                | 1.03                          | 1.77                     | 113.36       | 392.40      |
| 2017              | 1.96 (VA)                | 0.86                          | 1.40                     | 109.83       | 508.98      |

Note: A = acid; VA = very acid

Table 3. Nutrient content of 1N HCl extraction on peat soil at oil palm plantations for several years of planting.

| Years of planting | Nutrient content [Ekst. HCl 1N (%)] | P (%) | K (%) | Mg (%) | B (ppm) |
|-------------------|--------------------------------------|-------|-------|--------|---------|
| 2009              | 0.54                                 | 0.69  | 0.44  | 2.53   |
| 2010              | 0.61                                 | 0.64  | 0.43  | 2.41   |
| 2011              | 0.58                                 | 0.57  | 0.44  | 3.65   |
| 2012              | 0.53                                 | 0.44  | 0.53  | 3.20   |
| 2013              | 0.49                                 | 0.40  | 0.54  | 3.15   |
| 2014              | 0.42                                 | 0.37  | 0.45  | 2.53   |
| 2015              | 0.45                                 | 0.52  | 0.47  | 3.06   |
| 2016              | 0.43                                 | 0.99  | 0.42  | 2.58   |
| 2017              | 0.58                                 | 0.89  | 0.42  | 2.37   |

The results showed that the chemical properties of peat soils used for oil palm plantations in different planting years (2009-2017) based on criteria for assessing soil chemical properties, were qualitatively similar (table 1−3). Quantitatively, some soil characteristics, especially C-organic and P₂O₅ levels were very high (table 1 and table 2).

At present, amelioration of oil palm plantations at this location has not yet been implemented. For this reason, amelioration using acidic mineral soils that were widely available around the garden and estimated to be cheaper, was recommended (figure 1).

Mineral soil under peat from the study site cannot be used as an ameliorant for peat soil at the site of this study, because it was indicated to contain high pyrite (FeS). Fertilizing oil palm cultivated on peatland will be more effective and will not stimulate/accelerate the decomposition of peat soil material when combined with the administration of mineral soils as ameliorant material on the plate (figure 1). Thus, the fertilizer provided will not be easily lost due to high washing on peat soil [18].
Amelioration on peat soil is intended to suppress the toxic properties of organic acids, especially monomeric organic acids. Giving dolomite on peat soil functions more as fertilizer (source of nutrients) calcium (Ca) and magnesium (Mg), as well as balancing nutrient potassium (K), phosphorus (P) and micro nutrients. Dolomite addition to peat soils for increasing pH was not effective, because Al levels in peat were low. Oligotrophic peat, found in Kalimantan, has alkaline cation content, such as: Ca, Mg, K, and Na were very low, especially in thick peat. The thicker the peat, the bases it contains were lower and the soil reaction becomes more acidic [19].

The thicker the peat, the lower the ash content, decreased Ca and Mg content and the soil reaction becomes more acidic [20]. A low alkaline content accompanied by a high value of cation exchange capacity (CEC) causes low alkaline availability. The level of fertility of peat soil depends on several factors, namely: the thickness of the peat soil layer and the level of decomposition, the composition of plants composing peat, and mineral soils that are below the peat soil layer [15].

4. Conclusions
The chemical properties of peat soils used for oil palm plantations in different planting years were qualitatively similar. Quantitatively, some soil characteristics, especially C-organic and P$_2$O$_5$ levels were very high. Mineral soil under peat at the study site cannot be used for ameliorant peat material because it contains pyrite compounds. Fertilizing oil palm cultivated on peatland will be more effective and will not stimulate/accelerate the decomposition of peat soil material when combined with the addition of mineral soils as ameliorant material on the plate.

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