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学位論文内容の要旨

博士の専攻分野名称：博士（農学）　　氏名：Nur Wakhid

学位論文題名

Soil CO_2 emissions and net primary production in agricultural plantations on tropical peat

（熱帯泥炭地の農業プランテーションにおける土壌 CO_2 放出量と純一次生産）

Land conversion from tropical peat swamp forest to plantations potentially results in a large amount of carbon dioxide (CO_2) emissions through oxidative peat decomposition because of lowered groundwater level (GWL) by drainage. Moreover, the land conversion would decrease carbon (C) sequestration through net primary production (NPP) because of vegetation change. Two major agricultural land uses in Indonesia's tropical peatland over the past decade are oil palm and rubber plantations. However, information on their C balance based on field studies is still limited. The objectives of this study were to (1) separately investigate the seasonal variations of total soil respiration (SR) and peat decomposition (PD) in a rubber plantation and determine the contribution of PD to total subsidence, (2) quantify the above- and belowground NPP of mature oil palm plantations and determine how much CO_2 is emitted through pruned frond decomposition (LD_{frond}), (3) quantify SR, PD and NPP of a young oil palm plantation, and (4) investigate the C balance and C dynamics of agricultural plantations on tropical peat.

First, soil CO_2 efflux was measured monthly using a closed chamber system from December 2014 to December 2015, in a rubber plantation on peat soil in Central Kalimantan, Indonesia. SR and PD were separately quantified by trenching. Also, peat surface elevation was measured to determine annual subsidence. With GWL, SR showed a negative logarithmic relationship ($p < 0.01$), whereas PD showed strong negative linearity ($p < 0.001$). Using the significant relationships, annual SR and PD were calculated from hourly GWL data to be 32.9 ± 10.4 and 14.1 ± 2.14 Mg C ha^{-1} yr^{-1} (mean $\pm$ 1 standard deviation), respectively. From the PD and peat properties, annual subsidence

only through peat oxidation was estimated at 1.50 cm yr^{-1}, which accounted for 25% of total subsidence (5.96 cm yr^{-1}) on average.

Second, above- and belowground NPP and CO_2 emissions through LD_{frond} were assessed in two different mature oil palm plantations established on peat, an industrial plantation in Riau and a smallholder plantation in Jambi, Sumatra, Indonesia from February 2018 to July 2019. Aboveground NPP (ANPP) arises from the production of trees, pruned fronds, fruit bunches, and understory vegetation, whereas belowground NPP (BNPP) consists of the production of coarse roots including trunk bases and fine roots. Annual total NPP (ANPP + BNPP) was 17.3 and 13.5 Mg C ha^{-1} yr^{-1}, in the industrial and smallholder plantations, respectively. ANPP accounted for 81 and 73% of total NPP in the industrial and smallholder plantations, respectively. Using a negative exponential equation determined by the litter bag method, annual CO_2 emissions through LD_{frond} was estimated at 1.48 and 1.12 Mg C ha^{-1} yr^{-1}, respectively, in the industrial and smallholder plantations.

Third, soil CO_2 emissions and NPP were measured in a young oil palm plantation on peat soil in South Kalimantan, Indonesia from September 2018 to March 2020. SR and PD were separately quantified by measuring at near (SR) and far (PD) positions from tree bases. Total NPP was estimated at 10.9 Mg C ha^{-1} yr^{-1}, of which ANPP accounted for 78%. Annual SR and PD were 23.1 and 15.4 Mg C ha^{-1} yr^{-1}, respectively. Annual subsidence through peat oxidation was 2.33 cm yr^{-1}, which accounted for 14% of total subsidence (17.2 cm yr^{-1}). Annual LD_{frond} was estimated to be 0.38 Mg C ha^{-1} yr^{-1}. Therefore, heterotrophic respiration (HR) as a sum of PD and LD_{frond} was 15.8 Mg C ha^{-1} yr^{-1}, resulting in a net C source of 4.9 Mg C ha^{-1} yr^{-1} (= NPP – HR).

Comparable PD (14.1 and 15.4 Mg C ha^{-1} yr^{-1}) at similar mean GWL (-0.69 and -0.74 m), in rubber and young oil palm plantations, indicates that GWL can be used as a proxy for peat decomposition even at different land uses. Besides tree age, plantation management significantly affected NPP. A young oil palm plantation in South Kalimantan was a CO_2 source, resulting from lower NPP due to immaturity.