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Soil CO_2 Emissions from a Rubber Plantation on Tropical Peat

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1. Introduction

High demand for food production has increased land clearing in Indonesian peatland, especially for plantation. Land-use change in peatland is usually related to high carbon dioxide (CO_2) emissions due chiefly to drainage, which lowers ground water level (GWL). Such CO_2 emissions potentially affect regional and global carbon balances. However, field experiments of soil CO_2 emission are still limited in tropical peatland. We focused on rubber plantation on peatland, which is one of major plantations in Indonesia. Using field data, we separately quantified total soil CO_2 efflux (total soil respiration: TR) and CO_2 efflux (heterotrophic respiration: HR) through oxidative peat decomposition. In addition, contribution of the peat decomposition to subsidence was assessed.

2. Methods

The field experiment was conducted in a rubber plantation (02°29′50″S, 114°11′20″E) in Jabiren, Central Kalimantan, Indonesia, from December 2014 to December 2015. A strong El Niño event occurred during the period. To exclude root respiration and directly measure HR, three trenching plots with an area of 1 × 1 m^2 (4 chamber bases each, totally 12 chamber bases) were established in June 2014. Also, to measure TR, 12 chamber bases were aligned outside of the trenching plots between tree rows. Soil CO_2 efflux was measured three times a day every month with a closed chamber system equipped with an infrared CO_2 analyzer (GMP343, Vaisala). In addition, soil subsidence was measured at 6 points simultaneously with CO_2 efflux and groundwater level (GWL) and soil temperature at 5-cm depth were monitored every hour.

3. Results and discussion

Soil CO_2 efflux varied seasonally with a peak in the dry season, when GWL was low. The averages (± 1 SD) of TR and HR were 8.22 ± 4.95 and 3.84 ± 3.77 μmol m^{-2} s^{-1}, respectively. Both TR ($p < 0.05$) and HR ($p < 0.001$) showed significant negative relationships with GWL. Using the linear relationships, annual CO_2 efflux was calculated from hourly GWL data, resulting in 3191 ± 814 (TR, n = 12) and 1522 ± 1219 (HR, n = 3) gC m^{-2} yr^{-1}; TR was significantly larger than HR ($p < 0.01$). The annual soil subsidence was -3.4 and -4.0 cm outside and inside the trenching, respectively. Using carbon content and bulk density of peat in the study site, subsidence from HR was estimated to assess the contribution of HR to total subsidence. The contributions of HR to TR and total subsidence was 47 and 36%, respectively.

4. Conclusions

Oxidative peat decomposition increased linearly as GWL lowered. Annual CO_2 efflux through peat decomposition in a rubber plantation was 1522 ± 1219 gC m^{-2} yr^{-1} in a strong El Niño year. The contribution of peat decomposition to total soil respiration was 47%. The peat decomposition accounted for 36% of subsidence on an annual basis.