Seasonal variations in soil CO_2 concentrations and fluxes at two different soybean fields

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Agricultural field is one of the important sources of greenhouse gas emissions. It is known that CO_2 emissions from soils are influenced by environmental factors such as soil moisture, soil temperature, and organic matter content. These factors are variable with different soil types, therefore it is essential to understand the relationship between soil type and soil CO_2 dynamics. Previous studies have also shown that continuous monitoring is required to accurately understand the effects of soil moisture on CO_2 gas emissions. In this study, we aimed to clarify the effect of soil types on CO_2 dynamics in soybean fields. Measurements were conducted in two different soybean fields; volcanic ash soil and lowland soil located in Fukushima City and Koriyama City in Japan, respectively. Each field consisted of three treatments: unplanted (NC), cow manure (CM), and chemical fertilizer (CF). $O_2$and CO_2 concentrations were monitored at two depths (10 cm, 25 cm) at one-hour intervals during the soybean growing season from June to October in 2021. At both sites, volumetric water content, soil temperature, electrical conductivity, and water potential at four depths (2 cm, 10 cm, 18 cm, and 25 cm) were measured at 30-minute or 1-hour intervals. Basic physical properties, gas diffusion coefficient, air permeability, and water retention curves were measured using undisturbed samples collected at four depths (5 cm, 10 cm, 18 cm, and 25 cm). The measured CO_2 concentrations and gas diffusion coefficients were used to calculate the CO_2 fluxes at depths of 0-10 cm and 10-25 cm. The rate of CO_2 production was evaluated by subtracting CO_2 flux at 10-25 cm depth from the one at 0-10 cm depth.

The difference in time-series variations of CO_2 concentration among soils was small at 10 cm depth, while CO_2 concentration at 25 cm depth was higher in lowland soil than in volcanic ash soil. This was because of the smaller air-filled porosity (i.e., lower gas diffusion coefficient) in the lowland soil than in volcanic ash soil. For the CM plot, the rate of CO_2 production was higher in the volcanic ash soil. Because during the monitoring periods, volcanic ash soil showed higher air-filled porosity than lowland soil, especially at 0-10 cm depth, larger oxygen supply from the atmosphere to soil enhanced soil respiration in the volcanic ash soil. Relations between CO_2 flux at 0-10 cm depth and volumetric water content showed an optimum volumetric water content that maximized CO_2 flux in each field. The optimum water content ranged from 0.5 to 0.6 as water saturation, regardless of the soil type and treatment.

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