論 文 の 内 容 の 要 旨

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論文題目 Dynamics of turnover of active-biological and stable-mineralogical soil organic carbon resulting in CO_2 evolution
(有機態炭素および無機態炭素を起源とする
土壌からの CO_2 ガス発生機構に関する研究)

Deduced from the literature, the soil carbon associated with the silt and clay particles is the mineral-associated organic carbon (MAOC), the measurable fraction of the stable soil organic matter (SOM) pool, having turnover of centuries to millennial time scales. The fumigated soil microbial biomass carbon (SMBC) is the measurable fraction of the active SOM pool, having turnover times of hours to months. SMBC is the active-biological fraction, and MAOC is the stable-mineralogical soil organic carbon.

This 110-day constant temperature laboratory incubation experiment investigated the kinetics and effects of fresh organic matter (FOM) application: No organic matter (No OM); leaf litter (1.81 g C kg^{-1}); and chicken manure (2.12 g C kg^{-1}) in the carbon dioxide (CO_2) evolution rate and cumulative CO_2 evolution, SMBC, and MAOC of the 0–5- and 5–20-cm layers of two Asian soils: Bagabag, Nueva Vizcaya, Philippines ((121°15’ E, 16°35’ N) and Tsumagoi, Gunma Prefecture, Japan (138°30’ E, 36°30’ N).

Specifically, this study was conducted to (1) determine the effect of FOM application and time on the CO_2 evolution rate and cumulative CO_2 evolution of two typical Asian soils; (2) investigate the short-term influence of FOM application on the dynamics of the active-biological soil organic carbon (SOC) (i.e. SMBC); and (3) determine the short-term influence of FOM application on the dynamics of the stable-mineralogical SOC (i.e. MAOC).

In the Bagabag soil, CO_2 evolution rate was significantly higher in the 0–5- than in the 5–20-cm layer. Leaf litter application did not significantly increased CO_2 evolution rate but chicken manure application significantly increased CO_2 evolution rate both in the 0–5- and 5–20-cm layers. CO_2 evolution rate significantly decreased with time in both soil layers.

Chicken manure application caused significant increase in the cumulative CO_2 evolution in both the 0–5- and 5–20-cm layers. Cumulative CO_2 evolutions in the leaf litter-applied and control soils were comparable.

SMBC was significantly higher in the 0–5- than in the 5–20-cm layer. Chicken manure application caused a significant increase in SMBC as compared to control and leaf litter-applied soils. Soil microbial biomass was higher at two particular time periods – 13 and 70 days after incubation in both 0–5- and 5–20-cm layers regardless of FOM treatment indicating readily-available sources of energy for microorganisms in those specific periods.

MAOC was significantly higher in the 0–5- than in the 5–20-cm layer. FOM application significantly improved MAOC in a 110-day period. MAOC did not change significantly in the 0–5-cm layer within 110 days. However, this was not the case in the 5–20-cm layer, where MAOC significantly decreased after 110 days.

In the Tsumagoi soil, CO_2 evolution rate was significantly higher in the 5–20-cm layer than in the 0–5-cm layer. FOM application caused highly significant increases in the CO_2 evolution rates both of the 0–5- and 5–20-cm layers as compared to the control. CO_2 evolution rate decreased with time, and highest during the first 3 days of incubation. Chicken manure application caused significant increase in the cumulative CO_2 evolution in both 0–5- and 5–20-cm layers. Cumulative CO_2 evolutions in the leaf litter-applied and control soils were statistically comparable.

SMBC was significantly higher in the 5–20- than in the 0–5-cm layer. Chicken manure application caused significant increase in SMBC. The SMBC in leaf litter-applied soils were statistically comparable with the control. SMBC was significantly highest at two particular periods - 13 and 85 days after incubation. A two-peak SMBC scenario was consistent with the results obtained from the Bagabag soil, where the second peaks occurred 70 days after incubation.

MAOC was significantly higher in the 5–20- than in the 0–5-cm layer. Fresh organic matter application improved MAOC in the 0–5-cm layer, but not in the 5–20-cm layer, where MAOC significantly decreased after 3 days of incubation.

The higher CO_2 evolution rate and cumulative CO_2 evolution in the Bagabag soil than in the Tsumagoi soil was due to the ability of SOC to form Al-humus complexes in volcanic ash soils like Tsumagoi soil. This renders a major part of the SOC to become more resistant to microbial attack.

The first peak in SMBC is FOM-induced while the second peaks suggest a shift in the microbial community structure as the readily-available substrates from FOM became exhausted a few days after application. Although microbial structure was not examined, soil microbial biomass growth at that stage was due to activity of the microbial population utilizing stable SOC.

The significant turnover in the stable mineral-associated organic carbon fraction found in this study was of profound magnitude and importance and could have significant influence on our conventional understanding of the contribution of the various conceptual soil organic matter pools from terrestrial ecosystems, particularly soils, to the atmospheric CO_2 evolution. It challenges conventional knowledge that stable SOC is not a source of CO_2 evolution and microbial energy in the short term time scale.