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Seasonal dynamics of CO_2 efflux in soils amended with composted and thermally-dried sludge as affected by soil tillage systems in a semi-arid agroecosystem

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In semi-arid agricultural soils, seasonal dynamic of soil CO_2 efflux (SCE) is highly variable. Based on soil respiration measurements the effects of different management systems (moldboard plowing, chisel and no-tillage) and the application of composted sludge (CS) and thermally-dried sewage sludge (TSS) was investigated in a long-term field experiment (28 years) conducted on a sandy-loam soil at the experimental station "La Higueruela" (40^o 03'N, 4^o 24'W). Both organic amendments were applied at a rate of 30 Mg ha^{-1} prior to tillage practices. Unamended soils were used as control for each tillage system. SCE was moderate in late spring (2.2-11.8 μmol CO_2 m^{-2} s^{-1}) when amendments were applied and tillage was performed, markedly decreased in summer (0.4-3.2 μmol CO_2 m^{-2} s^{-1}), following a moderate increase in autumn (3.4-14.1 μmol CO_2 m^{-2} s^{-1}), rising sharply in October (5.6-39.8 μmol CO_2 m^{-2} s^{-1}). In winter, SCE was low (0.6-6.5 μmol CO_2 m^{-2} s^{-1}). In general, SCE was greater in chisel and moldboard tilled soils, and in CS and particularly TSS-amended soils, due to the addition of labile C with these amendments, meanwhile no-tillage soils exhibited smaller increases in C efflux throughout the seasons. Soil temperature controlled the seasonal variations of SCE. In summer, when drought occurs, a general decrease of SCE was observed due to a deficit in soil water content. After drought period SCE jumped to high values in response to rain events ("Birch effect") that changed soil moisture conditions. Soil drying in summer and rewetting in autumn may promotes some changes on the structure of soil microbial community, affecting associated metabolic processes, and enhancing a rapid mineralization of water-soluble organic C compounds and/or dead microbial biomass that acts as an energy source for soil microorganisms. To assess the effects of tillage and amendments on SCE, Q_{10} values were calculated. Data were grouped into three groups according to soil moisture (0.03-0.10 m^3m^{-3}, 0-11-0.21 m^3m^{-3}, 0.22-0.30 m^3m^{-3}). In general, Q_{10} values were lower at elevated temperatures when soil moisture contents decreased, confirming that SCE is less sensitive to soil temperature during drought periods. Q_{10} values were higher in moldboard and chisel tilled soils, possibly due to the incorporation of residues into soil and the increase of soil C substrate, meanwhile in no-tillage part of the organic C pools are likely protected from microorganisms by physico-chemical mechanisms. TSS-amended soils exhibited higher Q_{10} values than CS, pointing that the biochemical lability of the organic C added with amendments exerts an influence on SCE.

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