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Soil C saturation does not seem to influence short-term decomposition of maize residues

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Accumulation of organic C in agricultural soil has the potential to mitigate the increasing CO_2 content of the atmosphere, but as a soil reaches C saturation, its ability to retain additional organic C might be limited. As such, the amount of clay and silt particles and the initial organic C content of the soil are believed to influence the decomposition of plant residues and their stabilization as soil organic C (SOC). A soil with SOC content far below its theoretical C storage potential (C saturation limit), i.e. a soil having a high C saturation deficit, would have much capacity to sequester additional C. The objective of this study was to evaluate, under controlled condition, the effects of soil C saturation deficit and level of C input on corn residue decomposition in topsoil and subsoil of a cultivated heavy clay soil from the St. Lawrence lowlands, Eastern Canada. Comparison of this topsoil and subsoil, which had similar texture (941 g clay + silt kg^{-1} soil) and mineralogy (> 40% illite + chlorite in the clay fraction) but contrasting SOC contents, should allow for a clear evaluation of the effect of C saturation deficit on residue decomposition. We incubated topsoil (31.3 g C kg^{-1} soil) and subsoil (4.5 g C kg^{-1} soil) samples with ^{13}C-^{15}N-labelled corn residues at rates of 0, 2.5, 5, 10, 20, and 40 g C kg^{-1} soil under laboratory conditions for 51 d. Temperature, soil moisture content and mineral N concentrations were adjusted to optimal levels for microbial activity. Whole soil SOC content increased linearly with increasing residue inputs and both soils responded similarly to increasing C additions. Such linear accumulation reflects non-saturation behaviour of the whole soil SOC pool during the short term incubation. The amounts of residue-C stabilized were not statistically different between the two soils for each residue addition rate, despite the much greater C saturation deficit in the subsoil than in the topsoil. Even when the residue C input greatly exceeded the amount that would be added to soils under field conditions (e.g., > 20 g C kg^{-1}), whole soil SOC (27.2 g C kg^{-1} soil) in the subsoil did not reach the theoretical C storage capacity limit. However, the expected C storage capacity was greatly surpassed in the topsoil (50.0 g C kg^{-1} soil) with the same amount of residue-C added. Results presented here do not support the hypothesis that whole soil C accumulation is limited with respect to residue C inputs, at least in the short-term. Residue-induced cumulative C-CO_2 lost was positively correlated with the amount of C added and was greater in topsoil than subsoil within each C input rate. The linear increase in total respiration with application rates implies that for the 51 d of incubation, no limitation or levelling off of soil decomposition activity occurred in the topsoil or the subsoil. Despite differences in C mineralization, similar amounts of residue-C were stabilized in both soils. This suggests that the increased C mineralization observed in the topsoil could be attributable to the mineralization of native SOC and thus that a priming effect could have occurred in our study. However, if a priming effect occurred in the topsoil, its magnitude was small when compared to the high levels of SOC measured at the end of the experiment. Soil C saturation deficit did not influence residue-C stabilization in this study and the linear accumulation of residue-C tends to show that whole soil SOC accumulation is not limited with respect to C inputs in the short term in this heavy clay soil.