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Influence of pore size distributions on decomposition of maize leaf residue: evidence from X-ray computed micro-tomography

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Soil's potential to sequester carbon (C) depends not only on quality and quantity of organic inputs to soil but also on the residence time of the applied organic inputs within the soil. Soil pore structure is one of the main factors that influence residence time of soil organic matter by controlling gas exchange, soil moisture and microbial activities, thereby soil C sequestration capacity. Previous attempts to investigate the fate of organic inputs added to soil did not allow examining their decomposition in situ; the drawback that can now be remediated by application of X-ray computed micro-tomography (μ-CT). The non-destructive and non-invasive nature of μ-CT gives an opportunity to investigate the effect of soil pore size distributions on decomposition of plant residues at a new quantitative level. The objective of this study is to examine the influence of pore size distributions on the decomposition of plant residue added to soil. Samples with contrasting pore size distributions were created using aggregate fractions of five different sizes (<0.05, 0.05-0.1, 0.10-05, 0.5-1.0 and 1.0-2.0 mm). Weighted average pore diameters ranged from 10 μm (<0.05 mm fraction) to 104 μm (1-2 mm fraction), while maximum pore diameter were in a range from 29 μm (<0.05 mm fraction) to 568 μm (1-2 mm fraction) in the created soil samples. Dried pieces of maize leaves 2.5 mg in size (equivalent to 1.71 mg C g-1 soil) were added to half of the studied samples. Samples with and without maize leaves were incubated for 120 days. CO_2 emission from the samples was measured at regular time intervals. In order to ensure that the observed differences are due to differences in pore structure and not due to differences in inherent properties of the studied aggregate fractions, we repeated the whole experiment using soil from the same aggregate size fractions but ground to <0.05 mm size. Five to six replicated samples were used for intact and ground samples of all sizes with and without leaves. Two replications of the intact aggregate fractions of all sizes with leaves were subjected to μ-CT scanning before and after incubation, whereas all the remaining replications of both intact and ground aggregate fractions of <0.05, 0.05-0.1, and 1.0-2.0 mm sizes with leaves were scanned with μ-CT after the incubation. The μ-CT image showed that approximately 80% of the leaves in the intact samples of large aggregate fractions (0.5-1.0 and 1.0-2.0 mm) was decomposed during the incubation, while only 50-60% of the leaves were decomposed in the intact samples of smaller sized fractions. Even lower percent of leaves (40-50%) was decomposed in the ground samples, with very similar leaf decomposition observed in all ground samples regardless of the aggregate fraction size. Consistent with μ-CT results, the proportion of decomposed leaf estimated with the conventional mass loss method was 48% and 60% for the <0.05 mm and 1.0-2.0 mm soil size fractions of intact aggregates, and 40-50% in ground samples, respectively. The results of the incubation experiment demonstrated that, while greater C mineralization was observed in samples of all size fractions amended with leaf, the effect of leaf presence was most pronounced in the smaller aggregate fractions (0.05-0.1 mm and 0.05 mm) of intact aggregates. The results of the present study unequivocally demonstrate that differences in pore size distributions have a major effect on the decomposition of plant residues added to soil. Moreover, in presence of plant residues, differences in pore size distributions appear to also influence the rates of decomposition of the intrinsic soil organic material.