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Master thesis

Soil aggregate formation following plant residue addition of different qualities to low fertility sandy soils in north eastern Thailand

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Abstract

In tropical sandy soils of typically low soil organic matter (SOM) contents, regular organic matter (OM) inputs may help to conserve or improve soil fertility and SOM through soil aggregate formation. As soil aggregate formation is promoted by microbial biomass (MB), the quality of OM input as the source of MB growth may have a strong impact. However, in contrast to the effect of residue quality on MB growth and decomposition patterns, the effect that residue quality exerts on aggregate formation is incompletely understood. In this study, we therefore examined MB in parallel with carbon (C) and nitrogen (N) contents of four soil fractions, including aggregates, in a time series of 30 weeks after application of four different qualities of organic residues.

The examined soil was a sandy loam from a long-term experiment of Khon Kaen university, Khon Kaen, Thailand, receiving annual residue application of different qualities since 25 consecutive years. Treatments were: no application/control (CT), rice (Oryza sativa) straw (RS), groundnut (Arachis hypogaea) stover (GN), tamarind ((Tamarindus indica) litter (TM), dipterocarp (Dipterocarpus tuberculatus) leaf litter (DP). Organic residues differed chemical composition of N, polyphenols (PP) and lignin (L), and therefore in quality. GN is considered a high-quality residue (high N, low PP and L); TM is of medium quality (medium N, PP and L); DP (low N, high PP and L) and RS (low N, PP and L) are of low quality. We hypnotized that different qualities of organic residues affect the MB development, which then translates into different patterns of aggregation and SOM stabilization. Soil samples were taken before and 2, 4, 8, 16 and 30 weeks after residue application and then analyzed for MB C and N. Further, four size classes determined by physical separation: large macroaggregates (LMA, >2 mm), small macroaggregates (SMA, 2-0,25 mm), microaggregates (MI, 0,25-0,053 mm) and the silt and clay sized fraction (SICL, <0,053 mm). SMA and MI were separated from free OM by density fractionation in a solution of 1,6 g ml^{-1} before, together with SICL and bulk soil, analyzed for organic C and N contents.

MBN increased from 8-9 mg kg^{-1} soil initially to highest values of 24-45 mg kg^{-1} soil week 4. In week 8 and 16 MBN values were 16-25 mg kg^{-1} soil in RS and DP and 25- 43 mg kg^{-1} soil in TM and GN and after which MBN values decreased towards initial levels in all treatments. MBN values were significant higher in TM and GN compared to CT. Residue application led to significant increases of the mass of LMA, but not in other fractions possibly due to high sand contents of the soil. MI was the largest fraction (62,9-64,9 %), followed by SMA (17,3–23 %), SICL (13,9-18 %) and LMA (0,1-0,75 %). During the whole sampling period, bulk soil C was significantly increased by residue application compared to CT (av. 600 mg kg^{-1} soil) and further significantly higher in TM (av. 1570 mg kg^{-1} soil) and GN (av. 1330 mg kg^{-1} soil) than RS (av. 930 mg kg^{-1} soil) and DP (av. 980 mg kg^{-1} soil). Additionally, TM and GN contained significantly higher amounts in bulk soil N than CT. Main proportion of C and N measured in fractions were found in SICL (47-80 %), followed by MI (17-39 %) and SMA (3-15 %). No residue application lead to significantly lower amounts of C in all fractions, except in RS in SICL. Further C and N content in MI and SICL were temporally significant higher in TM and GN than RS and DP.

Application of organic residues improves stabilized SOM, as a result of increased formation of aggregates and organomineral complexes. Organic residues with higher N contents (GN, TM) led to increases in MB and C stored in bulk soil, MI and SICL fraction. Therefore, it is arguable that high and medium quality residues promote SOM stabilization, because N content of residues allows the MB to process higher quality litter more efficiently. Further, the efficiency of N seems to increase in combination with recalcitrant compounds (L and PP), because N mineralization is delayed, which may reduce the amount of leached N. Applications of high-quality residues should be synchronized with plant uptake.