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Microbial and mineral interactions decouple litter quality from soil organic matter formation

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Mineral-associated organic matter (MAOM) forms from plant or microbial-derived compounds and comprises the largest reservoir of soil organic carbon (SOC) globally. Most SOC is associated with soil minerals and mineralogy is considered a primary control on SOC persistence due to variations in mineral reactivity. However, most mineral-associated SOC is microbial in origin thus microbial residue formation, through the processing of plant inputs, may also control SOC dynamics. Current understanding suggests that litter quality controls the formation of MAOM with high-quality litter producing more microbial residues which are then stabilised on mineral surfaces. We hypothesized that inputs of high-quality litter would lead to a net increase in MAOM stocks, relative to low-quality litter, through more efficient formation of MAOM and less priming of existing SOC. We also hypothesised that soil mineralogy would act as the primary control on the formation of MAOM relative to litter quality. To test our hypotheses, we amended an agricultural soil with common soil minerals (Kaolinite, Montmorillonite and unamended control) and incubated these amended soils in the laboratory with two surface-applied ^{13}C labelled litters of contrasting qualities (high quality - White Clover and low quality - Winter Wheat). During the incubation, litter decomposition and priming were quantified by $\delta^{13}CO_2$ analysis. After 4 months, mineral stabilisation of litter-C, the amounts of particulate organic matter (POM) remaining and litter-C assimilated into microbial biomass were all quantified, along with characterisation of the soil microbial communities. Soil mineralogy strongly influenced the efficiency of MAOM formation, with Montmorillonite-amended soils respiring less litter-C and stabilising more as MAOM. High quality litter led to less (not more) efficient production of MAOM due to soil microbial community shifts associated with lower carbon-use efficiency. Low-quality litter enhanced priming of pre-existing SOC, counterbalancing the effect of litter quality on MAOM stocks. Taken together, our findings demonstrate that soil mineralogy was the primary control on MAOM formation and that litter-microbial interactions determine the effect of litter quality on MAOM. These findings refute the hypothesis that high-quality plant litters form MAOM most efficiently and demonstrate that mineral and microbial interactions regulate the formation of stable SOC.