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Legumes preserve recalcitrant soil organic matter by decreasing microbial priming effect

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Grasslands are an important reservoir for biodiversity and soil organic carbon (SOC) storage. The different plant species deposit different amounts of fresh organic matter-called rhizodeposition- according to their functional traits. This rhizodeposition is fresh source of energy for microbes which can then mineralize recalcitrant SOC through a co-metabolism, a phenomenon called as priming effect (PE) in soil science. This PE may have major consequences on soil C budget and induce a negative C balance, that is, C input to soil may decrease soil C content. The present study aims at finding effect of different plant species on SOM mineralization (PE) and soil C loss.

Seven plant species that are common to permanent temperate prairies Trisetum flavescenes (Tf), Poa trivialis (Pt), Lolium perenne (Lp), Festuca arundinaceae (Fa), Bromus erectus (Be), Brachypodium pinnatum (Bp) and Trifolium repens (Tr) were established in monocultures. All monocultures were continuously exposed to $^{13}$C-labelled CO$_2$ to trace the incorporation of new C fixed by the plant and the fate of old pre-existent SOC. For $^{13}$C labelling, outdoor air was scrubbed from H$_2$O and CO$_2$, which was then replaced by fossil-fuel derived CO$_2$ depleted in $^{13}$C. Non-destructive respiration measures of monocultures were taken in completely sealed dark chambers at 130, 155 and 172 days after their germination.

Mineralization of unlabelled soil-originated C was significantly higher in planted than in non-planted control soils, indicating that all the species induced PE. The minimum amount of PE was induced by Fa at day 172 (92% above the control non-planted soil) whereas the maximum was caused by Tr (271% above the control). The mineralization of SOM in all grasses was statistically similar but was much lower than that induced by Tr for all measures. According to the existing theory (Fontaine et al. 2003) Tr should have mineralized less SOM owing to its fixation of N thus deviating microbes’ attention from SOM. However, this apparent contradiction between theory and experimental results vanishes when the difference in fresh C supply between plant species is taken into account. The more the rhizodeposition is, higher will be the
stimulation of microbes and the PE. Trifolium (Tr) deposited $942_{\pm 37} \text{ mg kg}^{-1}$ of fresh particulate organic matter (POM) whereas the most productive gramineae deposited maximum $648_{\pm 60} \text{ mg kg}^{-1}$ of POM. When rhizosphere PE is expressed per unit of fresh carbon respired it is the ‘Leg’ that induces minimum SOM mineralization, that is, 0.26 mg soil C primed per mg of fresh C respired in the Tr treatment versus a mean of 0.56 in the gramineae treatments.

This study provides important information on the potential of different grassland species to mineralize the stable SOM. This also suggests that Tr can induce long-term C accumulation in ecosystems by decreasing the microbial mining of nutrients in soil organic matter.