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Seasonal dynamics in rhizosphere effects of three temperate tree species

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Rhizosphere is the surrounding area of living roots, where the root–soil interactions can markedly change soil properties, microbial processes, and biogeochemical cycling compared to bulk soil. Such rhizosphere effect may change with season, particularly in temperate regions with remarkable seasonal variations in biotic and abiotic factors, such as temperature, moisture, microbial community, root activity, and belowground carbon allocation. However, seasonal dynamics of rhizosphere effects remain poorly understood.

In this study, we report the rhizosphere effects of three tree species (Betula platyphylla, Quercus liaotungensis, Pinus tabuliformis) in a temperate forest on Mt. Dongling, North China. We sampled paired rhizosphere and bulk soils of field-grown mature trees using the root adhering method in spring (May), summer (July), autumn (September) and winter (December) of 2017. We measured a number of variables including plant (leaf and root) traits, soil characteristics (pH, water content, total and available nutrients), microbial biomass, community composition (PLFA), enzyme activity, and potential carbon and nitrogen mineralization rates.

Our results showed that most variables (except soil total carbon and total nitrogen) changed significantly among seasons. Specifically, available nutrients (extractable organic carbon and inorganic nitrogen) and hydrolytic enzyme activities (involved in carbon and nutrient acquisition) peaked in summer, microbial biomass carbon and carbon/nitrogen ratio (particularly in rhizosphere) was highest in autumn. Moreover, the rhizosphere effects on microbial biomass, hydrolytic enzyme activity, and potential carbon mineralization rate varied significantly with season. For example, the rhizosphere effects on microbial biomass and potential carbon mineralization rate in autumn tended to stronger than those in spring and summer. Notably, we detected a strong positive relationship between root density and rhizosphere effect on soil carbon mineralization rate across seasons, within each species or across three species. Taken together, we showed that rhizosphere effects of the three temperate tree species showed remarkable seasonal variations.