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Growth rates of rhizosphere microorganisms depend on competitive abilities of plants for nitrogen

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Rhizosphere - one of the most important 'hot spots' in soil - is characterized not only by accelerated turnover of microbial biomass and nutrients but also by strong intra- and inter-specific competition. Intra-specific competition occurs between individual plants of the same species, while inter-specific competition can occur both at population level (plant species-specific, microbial species-specific interactions) and at community level (plant – microbial interactions). Such plant – microbial interactions are mainly governed by competition for available N sources, since N is one of the main growth limiting nutrients in natural ecosystems. Functional structure and activity of microbial community in rhizosphere is not uniform and is dependent on quantity and quality of root exudates which are plant specific. It is still unclear how microbial growth and turnover in the rhizosphere are dependent on the features and competitive abilities of plants for N. Depending on C and N availability, acceleration and even retardation of microbial activity and carbon mineralization can be expected in the rhizosphere of plants with high competitive abilities for N. We hypothesized slower microbial growth rates in the rhizosphere of plants with smaller roots, as they usually produce less exudates compared to plants with small shoot-to-root ratio. As the first hypothesis is based solely on C availability, we also expected the greater effect of N availability on microbial growth in rhizosphere of plants with smaller root mass. These hypothesis were tested for two plant species of strawberry: Fragaria vesca L. (native species), and Duchesnea indica (Andrews) Focke (an invasive plant in central Europe) growing in intraspecific and interspecific competition.

Microbial biomass and the kinetic parameters of microbial growth in the rhizosphere were estimated by dynamics of CO2 emission from the soil amended with glucose and nutrients. Specific growth rate (μ) of soil microorganisms was estimated by fitting the parameters of the equation: CO2(t) = A + B $\times$ exp($\mu\times$t), to the measured CO2 production rate (CO2(t)) after glucose addition, where A is the initial respiration rate uncoupled from ATP production, B the initial rate of the growing fraction of total respiration coupled with ATP generation and cell growth, and t time.

Our study revealed the linkage between growth strategies of rhizosphere microorganisms and different adaptation strategies of F. vesca and D. indica to N limitation. Plant – strong competitor for N (D. indica) did not change root mass under N limitation causing the deficit of N in the rhizosphere and altering the structure of rhizosphere microbial community. Benefiting of slow growing microorganisms with K-strategy under N limiting conditions was indicated by strong decrease in specific microbial growth rates in the rhizosphere of D. indica. Root mass of the plant with weak competitive abilities for N (F. vesca) increased under lack of N to compensate the lack of nutrients. The increase in root mass and possible increase in amount of root exudates coincided with no structural changes in microbial community in rhizosphere of F. vesca.

By intraspecific competition at low N level a 2.4-fold slower microbial specific growth rates were observed under D. indica (0.09 h-1) characterized by smaller root biomass and lower N content in roots compared with F. vesca. The generation time of actively growing microbial biomass was for the 6 hours longer in rhizosphere of D. indica than under F. vesca (10.7 to 4.6 h, respectively). Thus, under N limitation the strong competition for N between plant and microorganisms decreased microbial growth rates and carbon turnover in rhizosphere.

By interspecific competition of both plants at low N level, microbial growth rates were similar to those for D. indica indicating that plant with stronger competitive abilities for N controls microbial community in the rhizosphere.

At high N availability the root biomass did not differ significantly between both plants. This resulted in similar

microbial growth rates for intra- and interspecific plant competition. Since high N level smoothed the differences between plant species in root and microbial biomass as well as in microbial growth rates, we conclude that competitive abilities of plant species were responsible for microbial growth in rhizosphere only under N imitation. As it is common that fine root proliferation and root exudation decrease at high N level, N addition smoothed the differences in microbial growth independently on plant competitive abilities.