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Linking plant identity and interspecific competition to soil nitrogen cycling through ammonia oxidizer communities

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ABSTRACT

Both plants and microbes influence soil nutrient cycling. However, the links between plants, microbes and nutrient cycling are poorly understood. In this study, we investigated how plant identity and interspecific competition influence soil nitrogen cycling and attempted to link plant identity and interspecific competition to community structures of bacterial and archaeal ammonia oxidizers based on terminal restriction fragment length polymorphism analysis (T-RFLP) of bacterial and archaeal ammonia monooxygenase (*amoA*) genes. Faba bean and maize monocultures and a faba bean/maize mixture were planted with two nitrogen levels (0 and 100 mg N kg^{-1} soil as urea). Soil mineral nitrogen, ammonia oxidizer function (potential nitrification activity, PNA) and community structures were measured 28 and 54 days after plant emergence. Faba bean and maize substantially differed in their influences on mineral nitrogen concentrations and PNA in rhizosphere soils. Soil mineral nitrogen and PNA in the rhizosphere soils of the faba bean/maize mixture were closer to those of the maize monoculture than to those of the faba bean monoculture. T-RFLP with restriction enzymes BsaJI and Hpy8I distinguished variations in bacterial and archaeal ammonia oxidizers community structure, respectively, and detected both between-cluster and within-cluster variations in bacterial ammonia oxidizers. T-RFLP data showed that nitrogen addition favored part of a *Nitrosospira* cluster 3b sequence type and suppressed part of a cluster *Nitrosospira* 3a sequence type of bacterial ammonia oxidizers, while it had no influence on the archaeal ammonia oxidizer community structure. Although multivariate analysis showed that the function and community structure of bacterial ammonia oxidizers were significantly correlated, plant species and interspecific competition did not significantly change the community structure of bacterial and archaeal ammonia oxidizers. These results indicate that plant species and interspecific competition regulate soil nitrogen cycling via a mechanism of other than alteration in the community structure of ammonia oxidizers as investigated by DNA based methods.

1. Introduction

The regulation of soil nutrient cycling by plants is important in that, through forming negative or positive plant–soil feedbacks, the sustainability of ecosystem functioning is impacted (Chapman et al., 2006; Ehrenfeld et al., 2005; Hooper and Vitousek, 1998; van der Heijden et al., 2008). Soil nutrient cycling is influenced more by the composition of plant function groups than by their richness, due to differences in rates of nutrient uptake, quality of litter input, nutrient use efficiency and, most importantly, the controls over plant-microbial loops (Chapman et al., 2006; Hooper et al., 1998; Knops et al., 2002; van der Heijden et al., 2008). Among the plant function groups, C4 grasses and legumes are specific contributors to positive diversity-function relationships of plant communities in natural ecosystems and are traditionally used (as intercropping) to enhance productivity in agricultural ecosystems, suggesting their significance in sustaining soil nutrient cycling (Fornara and Tilman, 2009; Li et al., 2007; Spehn et al., 2002; Tilman et al., 1997). While the interspecific facilitation between C4 grasses and legumes via stimulating symbiotic dinitrogen fixation is fully recognized, other microbially-associated nitrogen transformation processes associated with the combination of these two plant function groups remain largely unexplored (Fan et al., 2006; Spehn et al., 2002). Furthermore, while nitrogen cycling is mediated by soil microbes (Kowalchuk and Stephen, 2001; Prosser, 1989; van der Heijden et al., 2008), the link of plant identity to soil microbially-oriented

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