Responses of soil ammonia oxidizers to a nitrification inhibitor, 3,4-dimethylpyrazole phosphate (DMPP)

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Ammonia-oxidizing archaea (AOA) and bacteria (AOB) play a critical role in mediating the rate-limiting step of nitrification. The nitrification inhibitor 3,4-dimethylpyrazole phosphate (DMPP) is a strategic approach to mitigate nitrogen losses by inhibiting nitrification and promote nitrogen use efficiency in agricultural production. However, the responses of ammonia oxidizers to DMPP amendment and their impact on the variable efficiency of DMPP across different soils are poorly understood. Here we compared the effects of DMPP on the abundance, community structure and metabolic activity of ammonia oxidizers using quantitative PCR, terminal restriction fragment length polymorphism (T-RFLP) and 13CO2-DNA-stable isotope probing (DNA-SIP) with an acidic (pH 5.7) pasture soil and an alkaline (pH 7.2) vegetable soil. We further tested the findings from the two soils in another eight soils collected across three land uses with soil pH ranging from 5.4 to 8.0. Quantitative PCR results showed that DMPP significantly inhibited nitrification in the alkaline vegetable soil only, and this was accompanied by a significant decrease in AOB abundance. Results of T-RFLP revealed that the community composition of ammonia oxidizers maintained invariably the same in presence and absence of DMPP amendment. The 13CO2-DNA-SIP results indicated both AOA and AOB as active nitrifiers in both soils, but DMPP amendment only inhibited the assimilation of 13CO2 into the amoA gene of AOB in the alkaline vegetable soil. Consistent with prior results, the investigation with more soils found the same trend that the AOB abundance, rather than AOA showed significant and positive correlation with nitrate content across three land uses and was significantly minimized by DMPP amendment. DMPP had higher efficacy in neutral and alkaline wheat and vegetable soils, compared with pasture soils. Collectively, our findings demonstrated that DMPP could effectively inhibit nitrification through impeding the abundance and metabolic activity of AOB in the alkaline soils, but not in the acidic pasture soils. The information of microbial dynamics is highly desirable to be incorporated in future predication for the effectiveness of DMPP in wider farming systems.