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Nitrogen transformations in a Vertisol under long-term tillage and no tillage management in dryland agricultual systems: key genes and potential rates

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The impact of tillage practices on microbial N transformations in semiarid regions is poorly understood and data from long-term field experiments are scarce. In this study, we evaluated the effects of traditional tillage (TT) vs no-tillage (NT) on key processes of the N cycle such as nitrification and denitrification in a long-term field experiment under a rainfed crop rotation system (cereal-sunflower-legumes) on a vertisol (SW Spain). Besides general soil chemical and biological parameters, we quantified the size of the ammonia oxidizing and denitrifying bacterial populations via real-time PCR (amoA, nirS and nosZ genes), and measured potential nitrification and denitrification rates. Soil was sampled at two depths (0-30, till layer; and 30-50 cm), once during the growing period of the crop (wheat) and another time after harvesting. Conservation tillage slightly increased total organic carbon and microbial biomass C content, whereas no effect on nutrient availability (C and N) was observed, likely due to the fertilization regime and the textural characteristics of the soil type (Vertisol). Gene abundance and potential rates were influenced by the interaction between tillage treatment and sampling period, mainly at 0-30 cm depth. In general, ammonia oxidizers and potential nitrification were enhanced under TT, particularly after harvesting. By contrast, higher abundance of denitrifiers, as reflected by both nirS and nosZ gene copy numbers and larger potential denitrification rates were found under NT during the growing period, but not after harvesting. Results also showed that the N2O/N2 ratio was constant throughout the experiment and thus was affected more significantly by environmental parameters such as the availability carbon than by changes in denitrifier abundance. Our results stress the importance of quantifying microbial populations to address the impact of agricultural practices on N transformations in soil. Furthermore, results suggest that the spatial and seasonal variability of tillage practices need to be taken into account as they can substantially influence the size and activity of microbial communities involved in nitrification and denitrification.