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Plant–mycorrhizae association affects plant diversity, biomass, and soil nutrients along temporal gradients of natural restoration after farmland abandonment in the Loess Plateau, China

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The interaction between plants and arbuscular mycorrhizal fungi in the rhizosphere plays a vital role in driving vegetation recovery and restoration of soil nutrients. However, how this interaction affects vegetation succession and how soil nutrient recovery is driven by vegetation restoration and rhizosphere processes are still largely unknown. In this study, a well-documented grassland restoration chronosequence on the Loess Plateau, China (fields at 0, 7, 12, 17, 22, and 32 years after farmland abandonment and a natural grassland reference) was selected. The species richness and diversity reached maximum values between 17 and 22 years after farmland abandonment, whereas the plant total above and belowground biomasses simultaneously peaked at 22 years and then remained stable. In the dominant plant rhizosphere and bulk soil concentrations of total glomalin-related soil protein (including both old and recently produced fungal proteins) substantially increased from 3.58 to 4.87 g kg^{-1} and from 2.67 to 3.86 g kg^{-1}, respectively, between 12 and 32 years after farmland abandonment. The concentrations of soil organic carbon (SOC) and total nitrogen (TN) in the plant rhizosphere and bulk soil significantly increased between 17 and 32 years and reached the levels of the natural grassland. The aboveground plant biomass, soil SOC, and TN concentrations were positively correlated with the glomalin-related soil protein (GRSP) concentration ($p < 0.05$). Our study suggested that interactions among plant–mycorrhizae association, plant diversity, and biomass promote GRSP and nutrient accumulation in the plant rhizosphere and bulk soil, and GRSP largely contributes to SOC stabilization and the accumulation of SOC and TN.