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## Seasonality drives arbuscular mycorrhizal (AM) fungal community responses while future climate alters AM fungi-mediated phosphorus uptake in plant functional groups

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Arbuscular mycorrhizal (AM) fungi form symbiosis with most terrestrial plants, facilitating nutrient and water uptake while contributing to ecosystem services such as nutrient cycling, soil carbon sequestration, and plant resilience to abiotic stressors. As such, these fungi hold significant potential in advancing climate-change-resilient agriculture. However, their effectiveness in supporting agricultural resilience depends on their own responses to global change, which remain poorly understood due to species-specific and context-dependent variability across agricultural systems and climate scenarios.

To address this knowledge gap, we investigated AM fungal community responses at the Global Change Experimental Facility (GCEF) in Bad Lauchstädt, Germany. Established in 2014, the experiment consists of 5 blocks assigned to ambient climate and 5 to a future climate scenario, simulating the expected climate in Central Germany for 2070-2100, based on the consensus of several climate models. The future climate scenario simulates changes in temperature and precipitation patterns. Within each block, we focused on two distinct land-use types, extensive mowing or grazing, typically used for supporting livestock production. The meadows were mown or grazed one to three times annually, depending on plant biomass production. AM fungal community data from 160 soil samples, collected across eight time points spanning two years (mid-2020 to mid-2022) and differentiated by the two land-use types, were analysed using DNA metabarcoding. Additionally, plant biomass and nutrient concentrations were assessed.

Hierarchical Modelling of Species Communities (HMSC) revealed that, across land-use types and climate scenarios, seasonality was the dominant driver of AM fungal variance in the abundance

and occurrence model. Plant growing season spring was the primary influence on AM fungal responses, particularly regarding alpha indices and phylogeny. In addition, Glomeraceae abundance increased in spring ( $p: 0.043$ ), potentially highlighting its role in providing fast nutrient supply for host plants. However, future climate scenarios dampened these seasonal patterns, particularly in mowed systems, suggesting a shift in the dynamics of AM symbiosis. Additionally, we observed plant functional group-specific effects: under future climate, phosphorus uptake by grasses ( $p: 0.11$ ) and forbs ( $p: 0.027$ ) correlated with AM fungal phylogenetic clustering, while legumes exhibited an opposite pattern, with phosphorus uptake correlating with phylogenetic dispersion ( $p: 0.021$ ). We speculate that this might be due to the dual symbiosis of legumes with AM fungi and nitrogen-fixing bacteria. Thus, these findings contribute to providing insight into the functional roles of AM fungal communities under future climate and suggest that considering plant functional group composition may become more critical for managing these systems in the future.