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Biological inputs in fertilizers drive soil microbiome assembly across a biodiversity gradient

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Soil microbial biodiversity is a key determinant of ecosystem stability, yet its interaction with mineral fertilizers remains poorly understood. This study evaluated how progressive biodiversity loss affects maize response to mineral fertilizer with or without biological activity (FA). A greenhouse experiment included three treatments (control – CT, mineral fertilization – FSA, and mineral fertilization with FA), using two soils (native forest and conventional). A biodiversity gradient was established through serial dilutions (10^0 , 10^{-1} , 10^{-3} , 10^{-6}) inoculated into sterile soils. Bacterial and fungal communities were analyzed by 16S rRNA and ITS sequencing, including alpha and beta diversity, co-occurrence networks, and Random Forest. FA altered microbial diversity and organization differently across soils and dilutions. In conventional soil, FA and FSA reduced bacterial and fungal richness and diversity, especially at lower dilutions (10^0 – 10^{-3}), whereas in native forest soil, these were maintained or increased under FA. Beta diversity showed FA effects persisted in native forest soil despite reduced biodiversity, while effects were weaker in conventional soil. Network analyses revealed biodiversity loss simplified microbial interactions in conventional soil, reducing connectivity, whereas native forest soil maintained structural complexity. Fungal networks were fragmented in both soils, but FA attenuated negative interactions, suggesting ecological reorganization. Random Forest identified key taxa: *Ralstonia* was associated with FA-treated conventional soil, whereas *Nocardioides* and *Lysobacter* remained dominant in native forest soil. For fungi, FA promoted *Trichoderma*, *Chaetomium*, and *Curvularia*, while *Fusarium* was associated with the control. Overall, soil microbial biodiversity regulates responses to biological inputs, influencing the magnitude and direction of FA effects. This process depends on soil history and microbial structure, indicating that fertilizer effects and performance of biological additives are conditioned by ecological context.

KEYWORDS: Co-occurrence networks, Soil history, Microbial interactions, Random Forest

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