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Plant diversity drives positive microbial associations in roots enhancing carbon use efficiency in agricultural soils

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Soils are the largest and most dynamic terrestrial carbon (C) pool, storing 2000 Pg of C – more than the atmosphere and biosphere combined. However, agriculture has caused the loss of approximately 60 Pg soil C since the beginning of industrial period. Despite this, improving agricultural practices can also be used to counteract rising CO2 levels. As agroecosystems represent over 40% of earth surface today, they must be part of the solutions put in action to mitigate climate change. The utility of management practices to maximize soil carbon storage – is currently limited by a poor understanding of how plants which input carbon to soil, and the microbes which determine its fate there interact with one-another. We sampled a recently stablished plant diversity experiment (TwinWin, University of Helsinki, Finland) to evaluate the influence of ecological intensification within agroecosystems. Toward this end, barley is planted in monoculture, as well as under increasing levels of undersown plant diversity: barley plus 1 undersown species, barley plus 4 undersown species and barley plus 8 undersown species. As microbial carbon use efficiency (CUE) plays a central role in regulating the flow of carbon through soil, the overall aim of this study is to provide empirical evidence for the response of soil microbial community carbon use efficiency (CUE) to a plant diversity gradient in agricultural soils. We measured CUE with the 18O–H2O substrate-independent method, sequenced bacterial and fungal communities and determined the soil C quantity and quality. Using network analysis in combination with structural equation modeling we distinguished between the direct and indirect drivers of CUE. We observed that increasing plant diversity within agricultural soils strengthen positive interactions within the soil microbial community in relation to the negative interactions. Further, these enhanced positive interactions influenced positively microbial community carbon use efficiency. These results unveils the mechanisms by which increasing plant diversity yields higher C content in soils. Thus, suggesting that

management should consider, when possible increasing biodiversity in agriculture as a strategy to enhance the potential of carbon retention in agricultural soils.