Effects of ecological intensification on soil nutrient availability, microbial functions, and soybean production in organic grain systems in the Upper Midwest

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Soil health and microbial functions are the foundation of successful organic production. Current organic grain systems in the Upper Midwest are usually simplistic and tillage-intensive, which may limit soil organic matter building and microbial functions therefore constraining crop productivity. The ecological intensification of such organic system, by treating crop seeds with N-fixing inoculants and reducing tillage, may improve organic crop production by enhancing soil health and microbial functions. Empirical evidence regarding this subject, however, is lacking. The objective of this study is to evaluate how such ecological intensification affects various soil health parameters and in-season nutrient availability, soybean nutrient uptake, and soybean yield in organic grain production systems in the Upper Midwest. Field trials are being conducted in three midwestern states: Indiana, Illinois, and Wisconsin with treatments comparing a standard organic (SO) system and an eco-intensive organic (EIO) system. In the SO system, tillage is used to terminate cereal rye cover crops and multiple cultivation are employed to control weeds. In the EIO system, a roller-crimper is used to terminate rye and the crimped rye residues act as a barrier to suppress weeds, whereas soybean seeds are inoculated with B. Bassiana. In 2023, soybean is present in one of the entry points of the SO and EIO systems, creating an opportunity to compare the treatment effects on the same cash crop (i.e., soybean) in a single season. EIO will lead to lower soil nutrient (NH4 and NO3) availability and lower soybean leaf nutrient content compared to the SO system, because of reduced tillage and reduced SOM decomposition. EIO will increase soil aggregate stability and soil microbial parameters (microbial respiration, ACE protein, enzyme activities, etc.) compared to the SO system, especially in the mid-late growing season. Soybean yield is more closely related to weed pressure. When there is enough weed suppression supported by sufficient rye cover crop residues, soybean yield in the EIO system can outperform the SO system. It is expected that while ecological intensification through inoculation and tillage reduction, although will result in lower short-term nutrient availability (NH4 and NO3) and nutrient uptake, but will can improve soil aggregate stability and biological soil health parameters. However, soybean yield may be more closed related to the weed pressure rather than short-term soil health or nutrient availability. When adequate weed control is provided by sufficient rye cover crop biomass, soybean yields in the EIO system will match or outperform the SO system. This study reveals how ecological intensification, an important step to more optimized and sustainable organic systems, can improve soil health and maintain or improve soybean yields in a single season. Future research should examine the integrated ecological intensification practices can impact sustainability and productivity of the entire crop rotation such organic systems.