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Actual agroecosystems mainly rely for their productivity on external inputs, as the use of agrochemicals and fossil fuels, that generate negative impact on the environment limiting their sustainability. A biodiversity-based agriculture, through i.e. crop mixtures, can promote ecosystem services by increasing biological interactions in agroecosystems to limit the dependency on external inputs (Duru et al., 2015). However, little is known about crop mixture design to promote these ecosystem services. We therefore aim to propose a generic method for designing crop mixtures based on a functional approach that takes into account the functioning of the mixtures in order to overcome the specificity of each species through a participatory approach with farmers, scientists and advisors.

To do so, we mobilized the trait-function-services functional ecology approach to identify in a generic way the plant traits as well as the functions that are important in a crop mixture to render ecosystem services, taking into account the pedoclimatic conditions. Indeed, the trait-function-services approach of functional ecology makes it possible to establish the links between functional traits and biological processes, which are themselves at the basis of ecosystem service production (Garnier & Navas, 2012; Damour et al., 2014; Mediène et al., 2016). The use of the trait-function-services model was done through participatory brainstorming workshops with scientists, farmers and advisors who are experts in the functioning of crop mixtures. In our study, we focused this approach on the ecosystem service of managing nitrogen nutrition in species mixtures that allow the reduction of synthetic nitrogen use.

Our results identified functional processes, plant traits, and agronomic and environmental characteristics important in a crop mixture to reduce fertilizer use. The main functions important for N management in mixtures were (i) functions that reduce N losses in the system, (ii) functions that contribute N inputs to the system, and (iii) functions that promote efficient N use by plants in the crop mixture. Traits such as root system, growth rate, nitrophile level of plant, height, biomass production capacity, cycle length, leaf area and orientation, and ramification rate were important for the realization of the above functions identified. On this basis, we were able to identify multifunctional traits, i.e. traits involved in the realization of several functions (e.g. root structure, height) and traits involved only in the realization of a single function (e.g. nitrophile level of plant, cycle length). We also showed that fertilization, initial nitrogen level and soil type mainly affected traits and functions related to weed reduction, establishment, development and competition between weeds and the crop of interest.

The conceptual method based on knowledge production through participatory brainstorming workshops focused on the functional relationships of crop mixtures lays the foundation for the design of operational crop mixtures. For example, the identification of important functions and

traits will allow us to assess the level of service provided by a crop mixture and to identify the crop mixtures most likely to reduce nitrogen use in a given agro-environmental context. Ongoing work takes into account other ecosystem services as well as the identification of assembly rules of plant traits in a crop mixture, which will allow the choice of species in the mixture according to the services sought.

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