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Does diversity affect dynamics of agricultural system facing perturbations?

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1 Introduction

Agricultural systems are increasingly facing climatic and economic disturbances while they have to deal with food security, economic viability and environment quality issues. Several conceptual frameworks have been developed to analyze dynamics of such systems: resilience, vulnerability, robustness etc. However, there is still a challenge to propose operational methods and indicators to characterize dynamics of agricultural systems facing disturbance(s) and to identify system's properties that drive this dynamic.

Diversity in its various forms is commonly accepted as a strong determinant of resilience in agriculture. Benefits are supposed to arise from functional and spatiotemporal complementarity and redundancy. However, empirical evidences are scarce when analyzing positive effect of diversity on resilience. [1] provide systematic review of climate resilience of integrated agricultural system (i.e. diversified systems). It reveals supportive but not conclusive evidence on positive diversity role in resilience. Observed variability can be explained by specificities of agricultural systems: gradually artificialized (selected species, inputs) and driven by stakeholders from farm to regional and supra levels.

In this communication, we will present results of a systematic review of scientific studies assessing quantitatively the dynamics of agricultural systems in terms of vulnerability, resilience, robustness and other related concepts, hereafter VRR.

2 Materials and Methods

A generic request on Web of Science and a systematic sorting by co-occurrence of terms (with Vosviewer) enabled us to identify 37 papers dealing quantitatively with VRR of agricultural systems, in temperate zones, at different organizational levels: from field and farming system to food-chains and food systems. We analyzed results of each study through detailed characterization of VRR *of what* (the studied system: type of production and organization level), *to what* (hazards), *when* and *where* (spatiotemporal resolution and extend), *of which attribute(s)* (performance(s) to maintain) and *due to which property(ies)* (drivers explaining the observed dynamics of the attribute). This structured analysis enabled us to identify key diversity drivers of agriculture systems dynamics. When comparable, we synthetize studies results according to organization levels (plot, farm and territory), type of production (grassland or crop), system performance attribute and perturbation studied.

3 Results

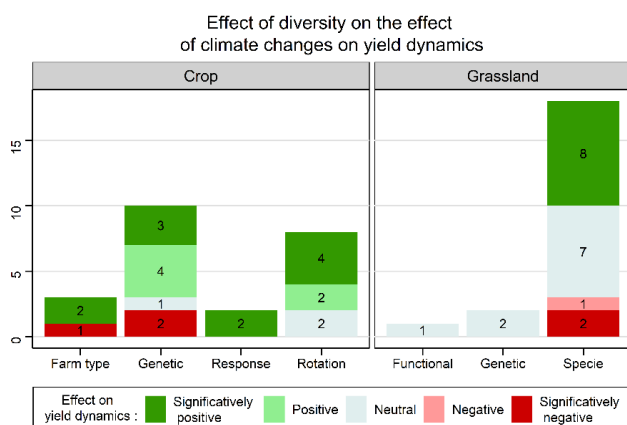


Figure 1. For crop and grassland at plot, farm and territory organization levels, effect of diversity (rotation diversity, farm type diversity, genetic (cultivar) diversity, response diversity, species diversity, genetic diversity and functional diversity) on the effect of climate change over studied indicators of yield dynamics: high level, high resistance, high or low risk of exceeding given threshold, increasing trend and low variability. Climate change is described as high, increasing trend and variable temperature or low, decreasing trend and variable precipitation. Light grey means no effect. Green/red means favorable/unfavorable effects of disturbed climate i.e. a lower/higher sensitivity of systems. Deep red/green represents significant results (at least p-value<0.1) and light red/green represent results where no statistical test is allowed by the method used.

A great majority of studies analyze effects of climate change on yield dynamics. They use a large range of dynamics indicators providing information on level, resistance, risk of exceeding given threshold, trend or variability of yields.

For grasslands, authors study mainly effects of taxonomic diversity in terms of specie (86%) and genetic (10%). For crop production systems, studies focus on effects of diversity of rotation at plot or farm level and farm type, cultivar or response (e.g. farm type, yield variability) at territory level. Our analysis shows that in only 38% of results there is a positive effect of diversity on dynamics of grassland yield considering climate change. In contrast, 74% of results shows positive effect of diversity on dynamics of crop yield (Figure 1).

In grasslands, at plot/field level, diversity of grassland species enhances levels of biomass produced when climate perturbation occurs [2]–[5]. Then, interestingly, and contrary to literature hypothesis, diversity of grassland species and root functional diversity doesn't [2], [6], [7] or negatively impact recovery ratio of productivity [3], typically use as indicator of resilience. Furthermore, variability, resistance and trend of yield is changeably affected by diversity of grassland species depending upon frequencies of climate perturbations and presence of legume or grass species [2].

In crop production system, at plot/field and farm system level, within farm biodiversity (i.e. taxonomic diversity) has a positive effect on level and dynamics of crop yield: high yield, low variability, low recovery time, positive trend [8], [9]. Particular negative response is explained by specificities of rice production (a composition effect) [10]. Besides, some authors show positive effect of farm type diversity in size and intensity of production on reduction of variability of yield when high temperatures occur [11].

4 Discussion and Conclusions

Our review highlights that majority of studies focus on field level, taxonomic diversity, yield performance and climate change. Diversity has variable effects on dynamics of agricultural systems. Effects differ from grassland to crop. Variability of diversity effect could be explained by composition effect (abundance of some species), i.e. in dynamics of biomass production (recovery after drought for example). Additional researches are needed on the role of associated diversity driven by agricultural practices and landscape configuration [12], [13]. Furthermore, research community has to go further than yield-centered studies and to address effect of diversity on dynamics of economic (by offering range of market opportunities), agronomic (by improving biological process [14]), or ecological (ecosystem services and biodiversity *per se*) performances.

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