Relative influence of agricultural systems, pathogen pressures and soci-economic drivers on spatio-temporal changes of cultivated bread wheat varietal and genetic diversity over recent decades in France

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Introduction

To deal with climate instability and recurrence of new pest pressures, enhancing within-crop cultivated diversity has been regarded as a relevant way to ensure yield inter-annual stability while reducing the usage of synthetic inputs. However, a detailed knowledge of the main drivers of within-crop cultivated diversity and their relative influences is still lacking. In this study, we focused on bread wheat varietal and genetic diversity in France, an important production area known to be characterized by temporal changes in diversity between contrasted agricultural production regions. We defined an extensive list of potential drivers that could be grouped into three main categories: agricultural systems, pathogen pressures and socio-economic drivers.

We addressed two questions :

1- Does the combination of drivers identified presented a higher explanatory power for varietal rather than genetic diversity?

2- Does the drivers associated with agricultural systems were more explanatory of the level of varietal rather than genetic diversity?

Materials & methods

Characterization of bread wheat diversity (1981-2006):

- ❑ systematic surveys of wheat acreages for 54 districts (FranceAgriMer)
- ❑ 35 microsatellite markers
- ❑ 709 genotyped varieties
- ❑ indicators of diversity:
  - o spatial varietal diversity N_2
  - o spatial genetic diversity H_T*

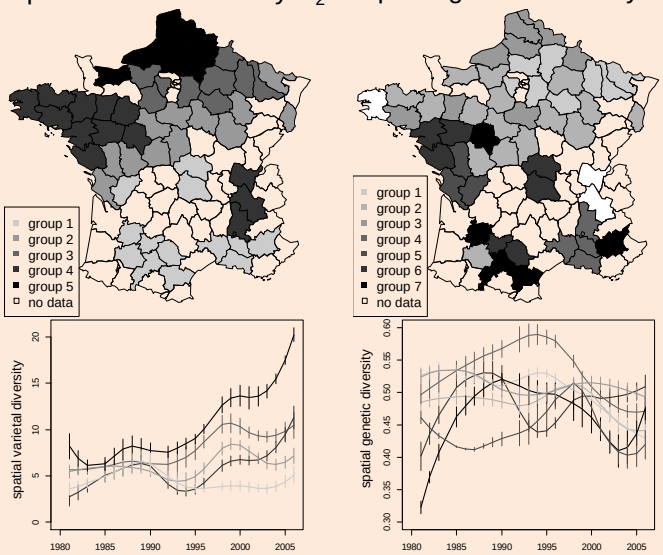
Characterization of potential drivers:

- ❑ the total production area of bread wheat (Agreste – SAA)
- ❑ the relative proportion of maize and wheat as preceding crops, the diversity of preceding crops (Agreste – Teruti)
- ❑ the number of agricultural cooperatives (Coop de France)
- ❑ the level of risk for five foliar pathogens (PESTOBSERVER database)

Statistical analyses: DAPC, linear models (choice of the best model based on AICc)

Main results and interpretation

spatial varietal diversity N_2 | spatial genetic diversity H_T*

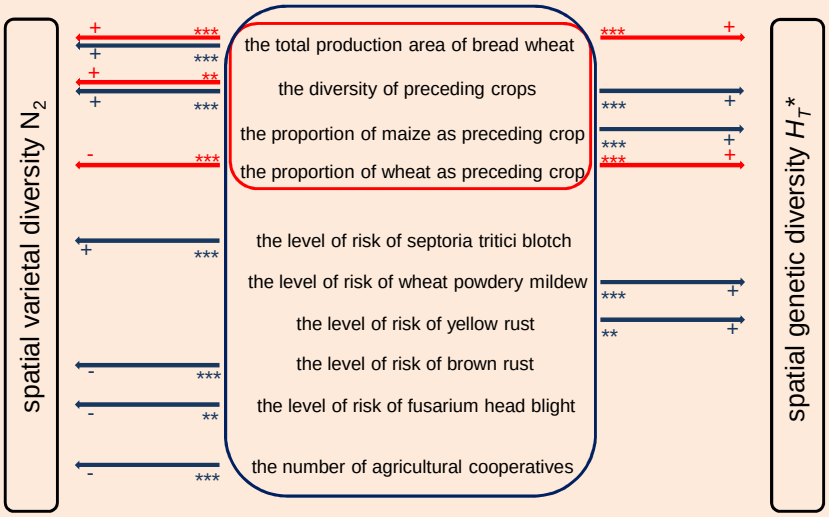


Geographical representation (top) of the mean temporal evolution (bottom) of groups of districts characterized by different temporal trends over the period 1981-2006 for the spatial varietal diversity (left) and the spatial genetic diversity (right) based on a DAPC procedure (for more details on these results, see Perronne et al. 2017)

- ✓ substantial differences of temporal changes of bread wheat diversity were highlighted between agricultural regions
- ✓ the spatial varietal diversity partly varied along a south-north gradient (substantial increase in the north, relative stability in the south)
- ✓ the spatial genetic diversity showed a more complex spatial structure (substantial decrease in the north, complex patterns in the south)

⇨ hypothesis: several drivers could potentially explain these spatio-temporal structures of bread wheat diversity

Influence of a set of potential drivers of within-crop wheat diversity



Schematic representation of the influence of different potential explanatory drivers of the spatio-temporal structure of the spatial varietal diversity N_2 (left) and the spatial genetic diversity H_T* (right). Two best models were chosen based on AICc: (1) the best model integrating only the four drivers related to the agricultural system (in red, 25 years × 53 districts considered) and the best model accounting for the ten drivers (in blue, 9 years × 48 districts). Only significant effects were shown *P < 0.05; **P < 0.01; ***P < 0.001. The sign of the relationship was also indicated.

- ✓ **the main explanatory drivers explained the spatio-temporal structure of the spatial varietal diversity more than the genetic one** (only potential drivers related to the agricultural systems R^2_{adj} = 21.0% vs 3.5%, all potential drivers R^2_{adj} = 48.8% vs 18.5%)
- ✓ **the drivers associated with agricultural systems explained more the spatial varietal diversity than the genetic diversity**, in contrast with the effects highlighted for the level of risk of some pathogens
- ✓ the total production area of bread wheat and the diversity of preceding crops both positively influence the varietal and genetic diversity

Conclusion

The spatio-temporal structure of bread wheat diversity differed between varietal and genetic diversity over the period 1981-2006 in France. **These contrasted patterns could be due to different drivers affecting these varietal and genetic diversity.** As an example, the varietal diversity was mainly positively affected by the total production area of bread wheat and by the diversity of preceding crops that could be associated with different sowing dates, while negatively associated with pressures of some pathogens, sometimes due the nature of the preceding crop increasing the severity of diseases. In contrast, the genetic diversity appeared to be as much affected by the drivers of the agricultural system as the level of risk of pathogens.

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Literature reference: Perronne, R., Makowski, D., Goffaux, R., Montalent, P. & Goldringer, I. 2017. Temporal evolution of varietal, spatial and genetic diversity of bread wheat between 1980 and 2006 strongly depends upon agricultural regions in France. Agriculture, Ecosystems & Environment 236: 12-20