Potential of crop mixtures to reduce pesticide use in France. A data analysis

Elodie Yan, Marco Carozzi, Nicolas Munier-Jolain, Philippe Martin

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Context

Agriculture specialisation and the massive use of pesticides on arable crops in France are major concerns. Systemic changes are needed to move towards pesticide-free agriculture.

Hypothesis

Crop diversification through crop mixtures effectively reduces pesticide use in arable crops.
Growing crop mixtures in arable crop systems is currently more challenging than in livestock systems.

Aims

- Assessing the reduction of pesticides enabled by crop mixtures in France
- Identifying the spatial and temporal dynamics of crop mixtures and associated drivers

Material & Methods: 2 databases

DEPHY: 3000 farmers voluntarily committed to reducing their use of pesticides

Treatment Frequency Index (TFI) as a proxy for pesticide use (Lechenet et al., 2017)

Data: DEPHY Farms Network — Scale: farm/crop

SELECTION

2139 cropping systems
42 agronomic variables

COMPUTATION

Distance matrix
Cropping systems with mixture * Cropping systems with pure crops

SELECTION

Pairs of CS
Most similar cropping systems (minimal distance)
in order to compare "all things being equal"

COMPUTATION

Pairwise t-tests
Comparison of Treatment Frequency Indexes (TFI):
Pure *vs.* Mixture for
Common wheat (44 pairs), Barley (16), Pea (84), Rapeseed (45)

French Land Parcel Identification System (LPIS): geographic information system for agricultural parcel identification

(Levavasseur et al., 2016)

Data: French LPIS — Scale: French departments*

SELECTION

- Crop mixtures (% on arable lands) → COMPUTATION
- Organic farming (% on arable lands) → COMPUTATION
- Arable crop and livestock systems (% on arable lands)

1 **Moran's I test for spatial autocorrelation**
Characterisation of crop mixtures spatial diffusion between French departments*

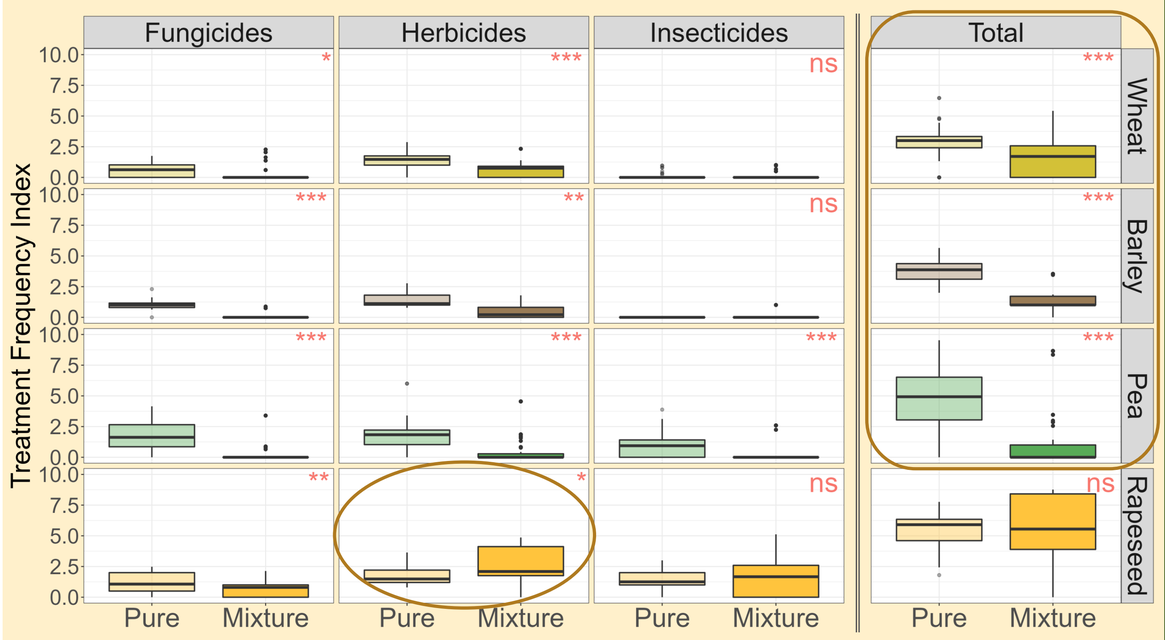
Taking autocorrelation into account

2 **Spatial lag model**
Test of drivers: organic farming, arable crop system, livestock system

** French departments = Level 3 of the EU Nomenclature of Territorial Units for Statistics (NUTS3)*

Results

Crop mixtures: a lever to reduce pesticide use…

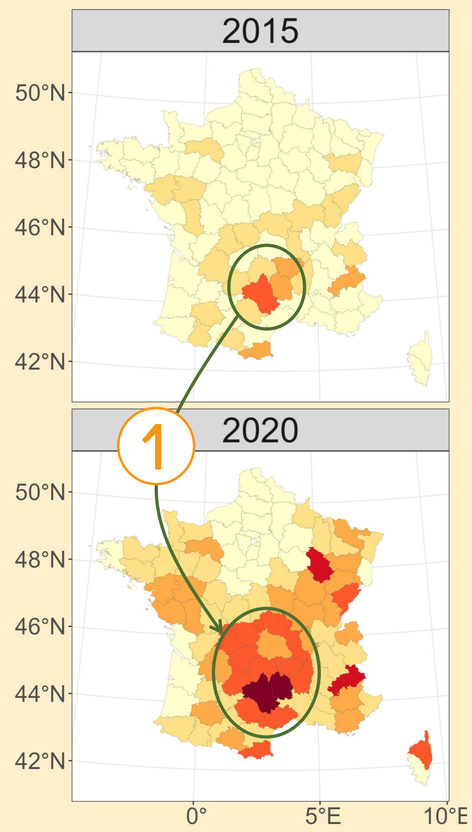


Comparison of pesticide use between pure crops and mixtures, for common wheat (44 pairs), barley (16), pea (84) and rapeseed (45)

"Total" = all pesticides included (fungicides, herbicides, insecticides and other pesticides not detailed here)
*ns = non-significant ; * = p-value ≤ 0.05, ** = p-value ≤ 0.01, *** = p-value ≤ 0.001*

- ↘ pesticide use for Common wheat, Barley, and Pea
- Rapeseed : ↗ herbicide to kill companion crops

… and diffusing according to specific drivers



1 Crop mixtures: **spatial diffusion** from hotspots **over time**
Moran's I test p-value: 0.0012 (**)

2 Organic farming, Livestock systems } = Strong drivers

Arable crop systems = Obstacles ?

Spatial lag model: coefficients

	Estimates	p-value
Organic farming	0.20	≤ 0.001 (***)
Livestock system	0.0067	≤ 0.001 (***)
Arable crop system	-0.083	≤ 0.001 (***)

Proportion of crop mixtures on arable lands (%)
0 - 0.74
0.74 - 1.7
1.7 - 2.9
2.9 - 4.8
4.8 - 7.2
7.2 - 10.6

- ↗ crop mixture areas over time and spatial diffusion
  - **Organic farming** ⇒ effect of crop mixtures on pesticide use
  - **Livestock systems** ⇒ crop mixtures used as fodder
- **Arable crop systems**: socio-technical lock-ins may hinder the development of crop mixtures

Conclusion

- DEPHY analysis showed that **crop mixtures are promising levers to reduce pesticide use in arable crops**. However, it is necessary to carefully **choose which crops to grow;** e.g. for rapeseed, companion crops may no longer be fully frost-shattered in some regions under climate change.
- LPIS analysis showed that **crop mixtures and organic farming are strongly linked**, confirming crop mixtures' ability to reduce pesticide use.
- Our analysis pointed out that it is currently **easier to grow mixtures in livestock systems than in arable crop systems**, as mixtures are used to feed animals (e.g. pea-based mixtures).

Perspectives

We will now further investigate the actual benefits of crop mixtures for farmers to better understand how to promote them.

Acknowledgements

This study is part of the MoBiDiv project, www.inrae.fr/cultiver-proteger-autrement_eng/Projects/MOBIDIV, funded by the French National Research Agency program "Investments for the Future" ANR-20-PCPA-0006