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# Disentangling the effects of genetic recombination and dormancy linked to pathogen sexual reproduction on the effectiveness and durability of resistance deployment strategies

Marta Zaffaroni, Jean-François Rey, Loup Rimbaud, Julien Papaïx, Frédéric Fabre

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## Petit Pois Dérivé 2022

30 mai-1 juin 2022 Villeneuve d'Ascq (France)

### **Disentangling the effects of genetic recombination and dormancy linked to pathogen sexual reproduction on the effectiveness and durability of resistance deployment strategies**

Zaffaroni, M., Rey, J.F., Rimbaud, L., Papaïx, J., Fabre, F.

The deployment of resistant cultivars in agricultural landscapes is an effective way to protect crops from plant pathogens. However, resistant cultivars can be quickly overcome by pathogens following their deployment. Several strategies have been proposed to promote more durable deployments of resistant cultivars. These strategies rely on the management of host genetic diversity with the aim to confront pathogens with eco-evolutionary challenges and thus avoid, or delay, their adaptation to plant resistance (evolutionary control), while maintaining effective disease protection (epidemiological control). Resistance genes can be *i*) combined in the same plant cultivar (pyramiding), *ii*) deployed in different plants sown in the same field (mixtures) or in different fields (mosaics), or *iii*) alternated across time (rotations). Previous theoretical studies have explored the evolutionary and epidemiological outcomes associated to different deployment strategies. These studies have focused on pathogens that reproduce purely asexually, although many plant pathogens includes in their life cycle at least one sexual cycle per growing season (mixed reproduction). At least two mechanisms linked to sexual reproduction could impact on deployment strategies. Genetic recombination may efficiently creates favourable gene combinations that would be accessible only through sequential mutation events in purely asexual reproduction, possibly favouring the emergence of pathogens able to overcome all the deployed resistance genes. Moreover, sexual reproduction often results in the formation of specialized structures that may persist in a state of dormancy and potentially survive in the soil for many years, possibly impacting the efficacy of crop rotation as a means of pathogen control. Here, we improved a spatially-explicit stochastic model to include different systems of pathogen reproduction (purely asexual vs mixed). We used the model to shed light on the effect of genetic recombination and dormancy on the evolutionary and epidemiological outcomes across the four main categories of deployment strategies. (295/300 words)

# Disentangling the effects of genetic recombination and dormancy linked to pathogen sexual reproduction on the effectiveness and durability of resistance deployment strategies

Marta Zaffaroni<sup>1\*</sup>, Jean-François Rey<sup>2</sup>, Loup Rimbaud<sup>3</sup>, Julien Papaix<sup>2</sup>, Frédéric Fabre<sup>1</sup>.

<sup>1</sup> INRAE – SAVE, 33882 Villenave d'Ornon, France, <sup>2</sup> INRAE – BioSP, 84914, Avignon, France,

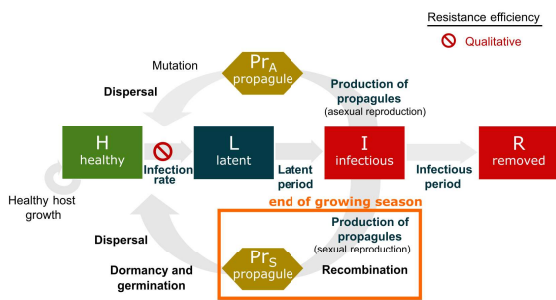
<sup>3</sup> INRAE – Pathologie Végétale, 84140, Montfavet, France. \*[marta.zaffaroni@inrae.fr](mailto:marta.zaffaroni@inrae.fr)

## 1 Introduction & objectives

- The deployment of resistant cultivars in agricultural landscapes is an effective way to protect crops from plant pathogens, but pathogens may quickly adapt to the deployed resistance. Many theoretical studies have considered the best way to deploy resistant cultivars in the landscape to delay pathogen adaptation, while maintaining effective disease protection. These studies have focused on pathogens that reproduce clonally, although many pathogens include in their life cycle at least one sexual cycle per growing season (**mixed reproduction**).
- We investigated the effect of **recombination** and **dormancy** linked to pathogen sexual reproduction on the evolutionary and epidemiological outcomes (respectively, *establishment of the super-pathogen SP* and *relative area under the disease progress curve AUDPC*, respectively), across four deployment strategies (pyramiding, mixture, mosaic and rotation).

## 2 A demo-genetic spatially-explicit temporal stochastic model

### Pathogen epidemic and evolutionary dynamics



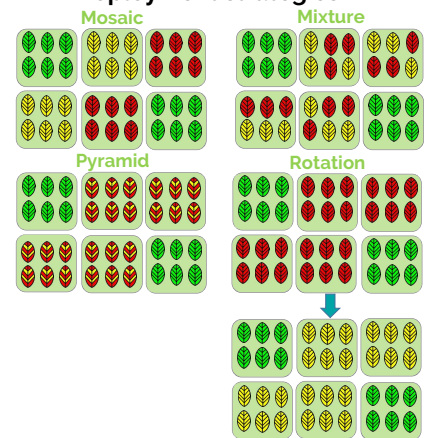
### Gene-for-gene interaction

Pathogens	Cultivars			
	S	R <sub>1</sub>	R <sub>2</sub>	R <sub>12</sub>
wt	✓	✗	✗	✗
mut1	✓*	✓	✗	✗
mut2	✓*	✗	✓	✗
SP	✓*	✓*	✓*	✓*

\* Possible fitness cost

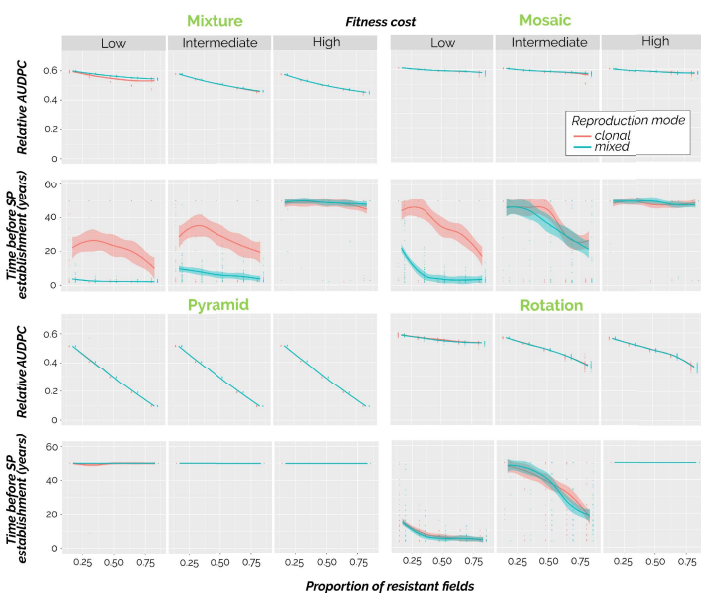
### Epidemics in a diversified landscape

#### Deployment strategies:



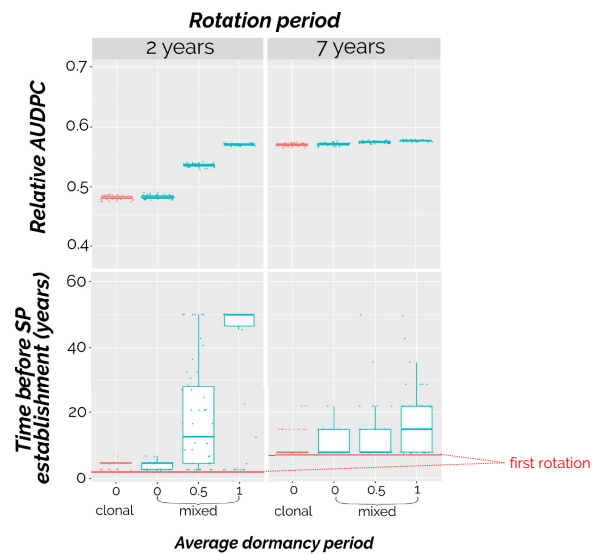
The R package *landsepi* provides a general modelling framework to help compare plant resistance deployment strategies and understand the impact of epidemiological, evolutionary and genetic factors for a wide range of pathosystems.

## 3 Recombination fosters the establishment of super-pathogen (SP) for mosaic and mixture.



- Pathogen's reproduction mode marginally affects disease control (*relative AUDPC*) provided by resistant cultivars.
- SP establishment is fostered by:
  - Emergence of the simple mutants (fosters in mosaic and mixture).
  - Recombination between simple mutants (provided by sexual reproduction at the end of the growing season).

## 4 Dormancy increases durability for rotation, but reduces disease control.



- Dormancy creates a pool of pathogens genotypes able to infect resistant cultivars, reducing the disease control provided by rotation.
- SP establishment is fostered by:
  - Available host to infect (provided by cultivar rotation).
  - A population size large enough to compete with simple mutants (hampered by dormancy diluting in time pathogens emergence).

## ACKNOWLEDGEMENTS

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## LINKS

Web app: [https://shiny.biosp.inrae.fr/app\\_direct/landsepi/](https://shiny.biosp.inrae.fr/app_direct/landsepi/)

R package: <https://cran.r-project.org/web/packages/landsepi/index.html>