JOB OFFER

Postdoctoral position of 10 months
Epidemiological modelling of plant disease

The French National Research Institute for Agriculture, Food, and the Environment (INRAE) is a public research establishment. It is a community of 12,000 people with more than 200 research units and 42 experimental units located throughout France. The institute is among the world leaders in agricultural and food sciences, in plant and animal sciences, and is 11th in the world in ecology and environment. INRAE's main goal is to be a key player in the transitions necessary to address major global challenges. In the face of the increase in population, climate change, scarcity of resources and decline in biodiversity, the institute develops solutions for multiperformance agriculture, high quality food and sustainable management of resources and ecosystems.

SCIENTIFIC CONTEXT

Cultivated plants possess resistance genes that protect them from pathogen infections. However, pathogens adapt: resistance is often either overcome or eroded, leading to an increase in the proportion of virulent individuals able to infect resistant varieties. Some varietal deployment strategies can slow down this adaptive process. These strategies rely on diversifying host populations at different spatiotemporal scales: over time through crop rotations or in space, either at the field scale (varietal mixtures; Borg *et al.*, 2018) or at the landscape scale (mosaics of varieties; Rimbaud *et al.*, 2021). The demo-genetic model *Landsepi* (Rimbaud *et al.*, 2018a) was design to compare the performance of deployment strategies for qualitative or quantitative resistances and study the effect of landscape, epidemiological, and evolutionary parameters on disease control.

OBJECTIVES OF THE POSTDOCTORAL PROJECT

This postdoctoral project is part of the ANR COMBINE project. One objective is to evaluate multi-scale varietal diversification scenarios that enable effective and sustainable control of septoria leaf blotch caused by the fungus *Zymoseptoria tritici*. Previous results show that varietal mixtures enhance the durability of resistance through various demographic and genetic processes (Orellana-Torrejon *et al.*, 2022).

The *Landsepi* model, initially applied to cereal rusts (Rimbaud *et al.*, 2018a & 2018b), was adapted for grapevine downy mildew, caused by the oomycete *Plasmopara viticola*, by integrating a module that simulates the sexual phase of the pathogen's life cycle (Zaffaroni *et al.*, 2024a,b). A first parameterization of the model for *Z. tritici*, which also alternates between asexual and sexual reproduction phases, was carried out during a Master's internship (Sesia, 2024). You will first continue this parameterization using here key life-history traits of the pathogen and data available in the team then you will use *Landsepi* to simulate the effects of: (i) landscapes *sensu lato* composed of different resistant wheat varieties, and (ii) the introduction of varietal mixtures, themselves composed of resistant varieties, within these landscapes, on the evolution of epidemic intensity and the frequency of virulent strains in fungal populations.

You will test the hypothesis that the genetic diversity of wheat populations (number, frequencies, effects, and combinations of resistance genes) effectively contributes to disease reduction over multiple years. You will develop and evaluate scenarios in two contexts studied experimentally by the team: (i) in the French context, considering mixtures of wheat varieties possessing different resistance genes, based on ongoing micro-plot trials (Suffert et al., 2024); in the Tunisian context, considering wheat landrace populations that experience low disease incidence despite high pathogen pressure, based on an ongoing study aimed at characterizing the genetic architecture of resistance.

References:

Borg J, Kiær LP, *et al.* (2018). Unfolding the potential of wheat cultivar mixtures: A meta-analysis perspective and identification of knowledge gaps. *Field Crops Research*, 221: 298-313.

Orellana-Torrejon C, Vidal T, *et al.* (2022). Annual dynamics of *Zymoseptoria tritici* populations in wheat cultivar mixtures: A compromise between the efficacy and durability of a recently broken-down resistance gene? *Plant Pathol.* 71(2): 289-303.

Rimbaud, L, Papaïx J, *et al.* (2018a). Mosaics, mixtures, rotations or pyramiding: What is the optimal strategy to deploy major gene resistance? *Evolutionary Applications* 11(10): 1791-1810.

Rimbaud L, Papaïx J, *et al.* (2018b). Assessing the durability and efficiency of landscape-based strategies to deploy plant resistance to pathogens. *PLoS Computational Biology* 14(4): e1006067.

Rimbaud L, Fabre F, *et al.* (2021). Models of plant resistance deployment. *Annu. Rev. Phytopathol.* 59: 6.1-6.28.

Sesia M (2024) Première application du modèle *Landsepi* sur la septoriose du blé causé par *Zymoseptoria tritici* afin de comparer les stratégies de déploiement variétaux à une échelle paysagère. Rapport de stage de Master1 Biodiversité, Ecologie, Evolution.

Suffert F, Papin C, *et al.* (2024). Impact des mélanges sur l'évolution des populations de *Zymoseptoria tritici*. *Phytoma* 779-780: 26-30.

Zaffaroni M, Papaïx J, *et al.* (2024a). Combining single-gene-resistant and pyramided cultivars of perennial crops in agricultural landscapes compromises pyramiding benefits in most production situations. *Phytopathol.* 114: 2310–2321.

Zaffaroni M, Rimbaud L, *et al.* (2024b). Effects of pathogen reproduction system on the evolutionary and epidemiological control provided by deployment strategies for two major resistance genes in agricultural landscapes. *Evolutionary Applications* 17: e13627.

TRAINING AND SKILLS

- Recommended training: PhD in modelling for plant disease epidemiology.
- Knowledge required: Strong knowledge in epidemiology, mathematics and modelling. The candidate should have programming skills (at least R) and knowledge of data processing. An interest for applied question in agronomy.
- Skills sought: Proven skills in writing scientific publications, enthusiasm and team player attitude.

INRAE's life quality

By joining our teams, you benefit from (depending on the type of contract and its duration):

- up to 30 days of annual leave + 15 days "Reduction of Working Time" (for a full time);
- parenting support: CESU childcare, leisure services;
- skills development systems: training, career advise;
- social support: advice and listening, social assistance and loans;
- holiday and leisure services: holiday vouchers, accommodation at preferential rates;
- sports and cultural activities;
- collective catering.

↘ Offer reference

- Contract: postdoctoral position
- Duration: 10 months
- Beginning: second or third trimester 2025
- Remuneration: gross salary between 2900€ and 3200€ per month, adjustable according to the candidate's experience
- Location: INRAE Saclay-Palaiseau (UR 1290 BIOGER, 22 Place de l'Agronomie, 91120 Palaiseau)

Alternatively, INRAE Bordeaux (UMR 1065 SAVE, 71 Av. Edouard Bourlaux, 33140 Villenave-d'Ornon) may be considered if justified by the application.

↘ How to apply

- To apply : Please send your CV, cover letter, and references to Thierry Marcel (thierry.marcel@inrae.fr), Frédéric Suffert (frederic.suffert@inrae.fr), and Frédéric Fabre (frederic.fabre@inrae.fr).

- Deadline to postulate: the position will remain open until a suitable candidate is identified