iCASE Project / AY 2026 -2027

Modelling Fungicide Resistance in Monocyclic Plant Pathogens

Project Reference: ICS-PLA-NC26

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Industrial Partner: ADAS

Main BBSRC strategic theme: Bioscience for sustainable agriculture and food

Secondary BBSRC strategic theme: Transformative technologies

Overview:

Fungicide resistance is a growing threat to sustainable crop production. Chemical control remains a cornerstone of plant disease management, but the evolutionary pressure it exerts on pathogen populations can lead to the rapid emergence of resistance. While substantial progress has been made in modelling resistance management for *polycyclic* pathogens—those with multiple infection cycles per season—very little is known about how best to manage resistance in *monocyclic* systems.

This PhD project will address this gap by developing mathematical models of fungicide resistance in monocyclic plant pathogens. The work builds on earlier modelling efforts within the group (e.g., Elderfield et al., 2018; Taylor et al., 2023a,b) but shifts the focus to pathogens with very different epidemiological characteristics. The outcomes of this research will be relevant to the optimisation of current fungicide strategies and could have long-term implications for agricultural disease control.

Scientific Background

Existing theory for resistance management is almost entirely based on diseases that cycle repeatedly during a growing season. However, many important pathogens—including *Sclerotinia sclerotiorum* (affecting vegetable crops) and *Oculimacula yallundae/acuformis* (causing eyespot in cereals)—are monocyclic, completing only one infection cycle per season. These diseases are typically managed using fungicides, yet the dynamics of resistance development in these systems remain poorly understood.

Excitingly, initial modelling work (van den Bosch et al., 2014) suggests that applying standard modelling approaches to monocyclic pathogens may produce significantly different results. Notably, assumptions underpinning current management strategies—such as the benefits of fungicide mixtures—may not hold under monocyclic dynamics. This project will explore these questions in greater depth.

Project Structure

The student will adapt and extend existing fungicide resistance models to reflect the biology of monocyclic pathogens, incorporating within-season pathogen development and other relevant features. The work will use case study systems informed by data and expertise from our project partners at ADAS, the UK's largest independent provider of agricultural and environmental consultancy. The student will also spend six months working on-site at the ADAS research station in Boxworth (near Cambridge).

Supervision and Training

The project will be based in the Theoretical and Computational Epidemiology Group at the University of Cambridge, led by Prof. Nik Cunniffe. The student will be co-supervised by Drs. Corkley, Grimmer and van den Bosch at ADAS, who are all actively engaged in fungicide resistance research (e.g., van den Bosch et al., 2014, 2020; Grimmer et al., 2015; Corkley et al., 2025). Dr Grimmer also serves as Secretary of FRAG-UK (Fungicide Resistance Action Group UK), providing a direct link to national-level guidance and impact.

The successful candidate will receive training in:

- Mathematical modelling of biological systems
- Simulation and analysis of epidemiological models
- High-performance computing (HPC)
- Data integration and model fitting
- Collaboration across academic and applied research contexts

Candidate Profile

Applicants with a background in mathematics, physics, engineering, or theoretical ecology are particularly encouraged to apply. Prior experience with programming is beneficial but not essential. Candidates from experimental or biological backgrounds with a strong interest in modelling are also welcome.

References

- Elderfield et al. (2018). Using epidemiological principles to explain fungicide resistance management tactics: why do mixtures outperform alternations? *Phytopathology*, 108:803–817.
- Taylor et al. (2023a). Modelling quantitative fungicide resistance and breakdown of resistant cultivars: designing integrated disease management strategies for Septoria of winter wheat. *PLOS Computational Biology*, 19:e1010969.
- Taylor et al. (2023b). Optimal resistance management for mixtures of high-risk fungicides: robustness to the initial frequency of resistance and pathogen sexual reproduction. *Phytopathology*, 113:55–69.
- van den Bosch et al. (2014). Mixtures as a fungicide resistance management tactic. *Phytopathology*, 104:1264–1273.
- Corkley et al.(2025). Dose splitting increases selection for both target-site and non-target-site fungicide resistance – a modelling analysis. *Plant Pathology*, 74:1152–1167.
- Grimmer et al. (2015). Fungicide resistance risk assessment based on traits associated with the rate of pathogen evolution. *Pest Management Science*, 71:207–215.
- van den Bosch et al. (2020). Identifying when it is financially beneficial to increase or decrease fungicide dose as resistance develops: an evaluation from long-term field experiments. *Plant Pathology*, 69:631–641.