Sustainable plant resistance management in agricultural landscapes

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The deployment of virus resistant crops often leads to the emergence of resistance-breaking (RB) pathogens that suppress the yield benefit provided by the resistance. The theoretical model-based analyses presented here are designed to provide guidelines for farmers aiming altogether to optimise the deployment of a resistant cultivar in a landscape over several years. We consider management strategies willing either to minimise the overall yield losses due to the virus (economical strategy) or to keep the frequency of the RB virus in the reservoir hosts under a preset threshold (patrimonial strategy, preserving resistance durability).

Assuming a gene-for-gene type of interaction, virus epidemics are modelled in a landscape composed of a mosaic of resistant and susceptible fields, subjected to seasonality, and of a reservoir hosting viruses year round. The model links the genetic and the epidemiological processes shaping at nested scales the demo-genetic dynamics of viruses. Seasonality leads us to use a semi-discrete model, *i.e.* a hybrid dynamical system that undergoes continuous dynamics most of the time (describing the in-season epidemic dynamics in fields) and that experiences discrete dynamics at some time instants (mimicking pathogen overwintering in reservoirs).

We explored how time-constant optimal cropping ratio (i.e. the proportion of resistant cultivar deployed in a given landscape) defined according either to economical or patrimonial strategies depends on the choice of the resistant cultivar and on the epidemiological context. The epidemiological context is defined by the combination of a landscape structure (*i.e.* connectivity between the fields and the reservoir hosts) and an epidemic intensity (*i.e.* mean proportion of plants infected during a season in the absence of the resistant cultivar).

Analyses indicated that the choice of the resistance gene (characterized by the equilibrium frequency of the RB virus at mutation-selection equilibrium in a susceptible plant) is a major determinant of the optimal cropping ratio for both strategies. Epidemiological contexts are also important. For some of them, both strategies have close economical efficiencies (*i.e.* they provide close yield benefits), implying that patrimonial and economical strategies are compatible. For others, the patrimonial strategy has weak economical efficiency (*i.e.* lower yield benefits compared to those obtained with the economical strategy), meaning that the two strategies are incompatible in such epidemiological contexts.

Such an incompatibility can be lessened by using time-varying management strategies where the proportion of resistant fields in the landscape can change. We show that such strategies can comply with patrimonial objectives while substantially restoring the economical efficiency of time-constant strategies. They can even over-perform the time constant strategies in landscapes characterized by high between fields connectivity.

Reference : Fabre, F., Rousseau, E., Mailleret, L. & Moury, B. 2012. Durable strategies to deploy plant resistance in agricultural landscapes. *New Phytologist*, 193, 1064-1075.

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