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Model-based estimation of aphid dispersal distances and its use to co-optimize sharka management strategies and the allocation of resistant cultivars

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Models can estimate epidemiological parameters, assess the effectiveness of different management strategies and optimize them. Here we present the PESO (parameter estimation–simulation–optimization) modelling framework (Picard et al., 2017), and we apply it to the management of sharka (caused by *Plum pox virus*), the most damaging Prunus disease. In a first step (Pleydell et al., 2018), using a spatially-explicit simulation model integrating disease dispersal, surveillance and control, we demonstrated that disease dispersal distances can be estimated accurately when disease control is ongoing. Applying this model to 15 years of sharka surveys in 605 orchards, we obtained the first estimate of aphid flight distances at the landscape scale. About 50% of aphid flights terminate beyond 90 m, and 10% exceed 1 km. By their impact on our quantitative understanding of winged aphid dispersal, these results can inform the design of management strategies for plant viruses, which are mainly aphid-borne. Indeed, we integrated these parameter estimates in an expanded version of the model, simulating sharka management options based on orchard surveillance, tree removal, plantation bans, and the replacement of at most half of the removed susceptible orchards with resistant cultivars. With this tool, we studied the spatial allocations of resistant orchards that minimize the direct and indirect economic impact of PPV epidemics in the landscape. We tested several allocations of resistant orchards for either emerging or established epidemics, on landscapes varying by their level of patch aggregation. This study (Picard, 2018) showed that the most promising allocations of durably resistant cultivars were (i) the regular mixing of susceptible and resistant orchards (in the absence of disease management), and (ii) any allocation of resistant orchards (under effective disease management). In addition, co-optimizing disease management and the spatial allocation of resistant cultivars slightly improved our economic criterion.

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