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Model-based assessment of gene drive strategies to control pest populations in agricultural systems

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Agricultural systems throughout the world are threatened by a variety of pest species, including insects, pathogens and weeds. Conventional control methods often have limited success, notably in the case of pesticide use due to the ubiquitous development of resistance. Novel control approaches are therefore needed to improve management of these pest populations. Gene drive strategies, based on the use of genetic constructs with biased inheritance to drive traits into target populations, offer promising avenues for the development of such control methods, facilitated by the advent of CRISPR-Cas molecular tools. Implementation of such strategies in agrosystems, with actively managed populations and strict socioeconomic constraints, offers a specific set of opportunities and challenges. Here we present a newly developed modelling framework design to study the outcome of these genetic control strategies in a variety of agricultural systems. This framework is built as a modular toolset that can simulate a wide range of scenarios, including a diversity of pest species, in a biologically and ecologically detailed fashion. We detail here the ability of this modelling tool to take into account specific aspects of the life history, ecology and genetics of the target organism. We introduce results demonstrating how genetic strategies can be used to control pesticide resistance. Finally, we discuss the future avenues of research offered by this theoretical framework, notably in terms of optimising implementation and deployment of genetic strategies in specific agrosystems, as well as investigating potential approaches for spatial and temporal containment of the associated genetic constructs.

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