Mathematical Methods and Models in Biosciences
June 15–20, 2025, Sofia, Bulgaria
https://biomath.math.bas.bg/biomath/index.php/bmcs

Application of mathematical biology in agriculture: The case of the Soybean Aphid

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Soybean Aphids have changed Soybean agriculture by acting as an invasive pest. A genetic modification was developed in the Soybean plant to make it resistant to Aphids. Colonization and feeding by an Aphid can alter the plant's physiology, favouring the subsequent colonization of additional conspecifics. There are two mechanisms by which this susceptibility can be induced: feeding facilitation and the obviation of resistance. The results can be seen in soybean fields and is a seasonal phenomenon.

We develop a non-local population model that holds the dynamics of the mechanisms seen biologically. We consider the effect of non-smooth Allee-type mechanisms on the two species Lotka-Volterra competition model. This mechanism can alter classical competitive dynamics in the ODE setting.

In particular, an Allee effect present in the weaker competitor could lead to bi-stability dynamics and competitive exclusion reversal. We discuss applications of our results to pest management strategies for soybean aphids in the context of a changing climate. We validate the model dynamics with on-field dynamics and analyse them using numerical simulations.

Keywords: soybean, biotype, insecticide-resistant management, nonlocal ODE model, Allee effect, bi-stability, bifurcations, finite time extinction, differential fitness, soybean aphid control, climate change

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