PLANT HEALTH

Modeling the impact of an exotic parasitoid *Diadegma, semiclausum*, on the diamondback moth, *Plutella xylostella*, in Kenya, using the Lotka-Volterra model

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Introduction

Integrated pest management systems utilising the use/release of the parasitoid *D. semiclausum* have been developed to replace the pesticides only approach to diamondback moth control which is the major pest for crucifers worldwide. Consequently the impact of this strategy using mathematical model is paramount.

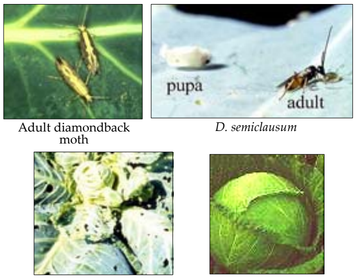

Figure 1. Diamondback moth and damage Cabbage + *D. semiclausum* and healthy cabbage

Objectives

1. **To fit mathematical model with field time series datasets.**
2. **Study the impact of biological control of the diamondback moth using the exotic parasitoid *D. semiclausum.***

Methods

The Lotka-Volterra model model (Wangersky, 1978)

$$\frac{dx}{dt} = \alpha_1 x - \beta_1 x^2 - \gamma_1 xy$$

$$\bar{x} = \frac{\alpha_1\beta_2 + \alpha_2\gamma_1}{\gamma_1\gamma_2 + \beta_1\beta_2} \qquad x(0) = x_0 \geq 0$$

$\bar{x}$: DBM population steady-state

X(t), y(t): DBM, Parasitoid population density at time t

X(0), y(0): DBM, Parasitoid initial population density

α_1: DBM growth rate α_2: DBM natural death rate

β_1, β_2: DBM, Parasitoid self-regulation coefficient

γ_1: DBM/Parasitoid interaction coefficient

γ_2: Parasitoid/DBM interaction coefficient

$$\frac{dy}{dt} = -\alpha_2 y - \beta_2 y^2 + \gamma_2 xy$$

$$y(0) = y_0 \geq 0 \qquad \bar{y} = \frac{\alpha_1 - \beta_1\bar{x}}{\gamma_1}$$

$\bar{y}$: Parasitoid population steady-state point

Model parameters were estimated from the minimisation of the loss function made of the sum squared deviations between theoretical and field data following the Nelder-Mead method. The diamondback moth steady-state values for pre- and post-release period were calculated and compared. With this method, numerical reduction of this quantity stipulates a positive impact of *D. semiclausum*.

Results

Estimated parameters	Pre-release	Post-release
α_1	27.76	27.76
α_2	33.28	1.80
β_1	1.40	1.40
β_2	2.04	0.43
γ_1	35.14	145.19
γ_2	7.07	0.95
$\bar{x}$	**4.86**	**2.17**
$\bar{y}$	0.60	0.17
x_0	1.91	8.48
y_0	0.05	0.15

Table 1. Estimates Lotka-Volterra model parameters and values of statistical criteria fitted to an empirical times series of the diamondback moth and its parasitoids before and after the release of the exotic parasitoid species

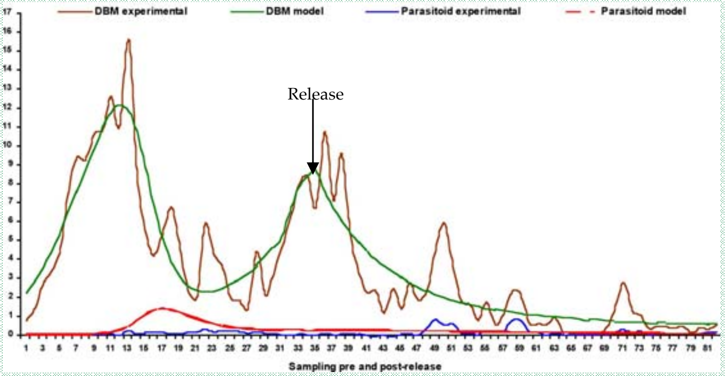

Figure 2. Empirical population trajectories of the diamondback moth and its parasitoids and predictions of the Lotka-Volterra model before and after the release of the exotic parasitoid species

Impact

The classical biological control method has had a positive impact in suppressing DBM pest population.

Conclusion

The project should be expanded to neighbouring countries with similar natural conditions to help farmers manage diamondback moth and consequently minimise the use of insecticides.

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References/acknowledgements

Wangersky J. P. (1978) Lotka-Volterra population models. *Annual Review of Ecology and Systematic*, 9, 189–218.

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