

When competitors join forces: using consortia of entomopathogenic *Pseudomonas* bacteria, nematodes and fungi for pest control

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Introduction

- To increase reliability and efficacy of biocontrol measures, we combined **plant disease-suppressing and insecticidal *Pseudomonas chlororaphis* bacteria (P)** with **entomopathogenic nematodes (N)** and **entomopathogenic fungi (F)**.
- We built a triple consortium to fight the cabbage maggot *Delia radicum* which causes increasing losses in the production of Brassicacean crops and for which no satisfactory control measures exist.
- To exclude negative effects for biocontrol, we studied the interaction between **pseudomonads, nematodes** and **fungi** under laboratory conditions in *Pieris brassicae* and *Diabrotica balteata* larvae.

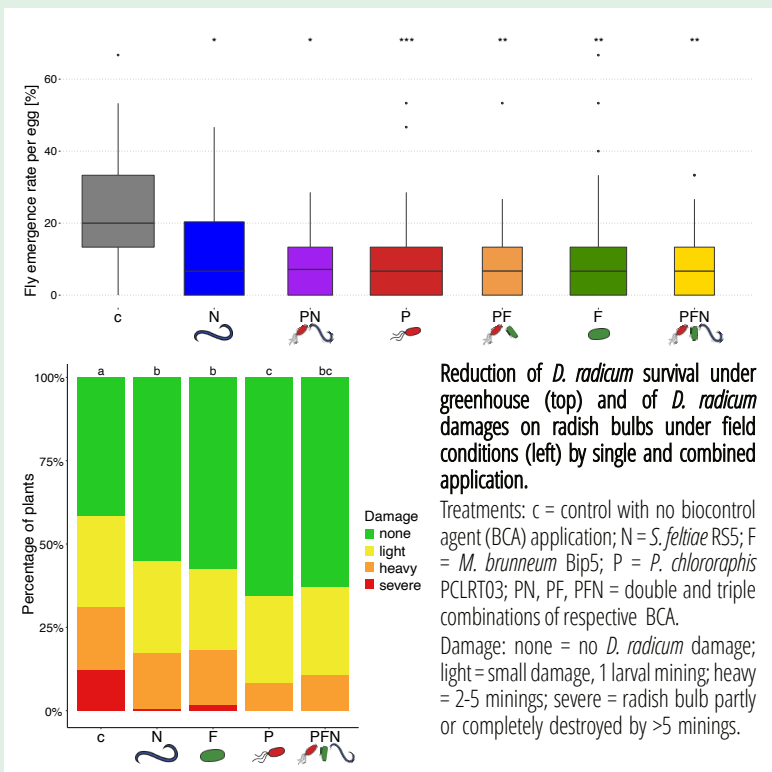


Conclusion

All three chosen biocontrol agents reduce *Delia radicum* survival and damage alone and in combination. Combinations increase killing speed and mortality in *Pieris brassicae* and *Diabrotica balteata* larvae.

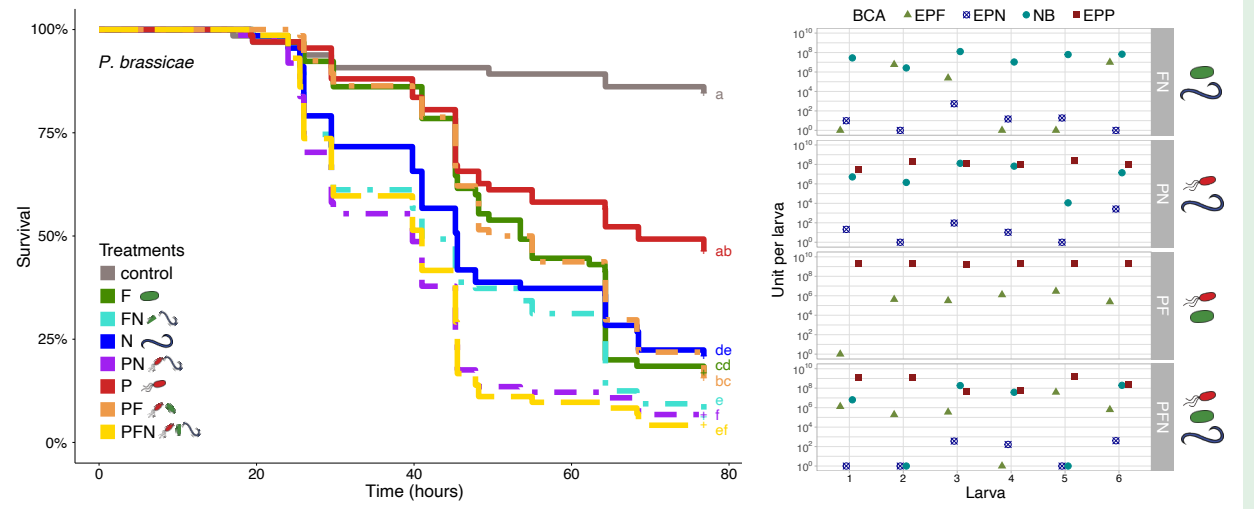
Results

- Single and combined application of all three biocontrol agents reduced *D. radicum* survival in greenhouse trials and *D. radicum* damage, e.g. feeding tunnels in produce, in a field trial, by 50%.
- Combined application increased killing speed and mortality in *P. brassicae*. After 5 days, pseudomonads co-colonised the larvae with nematodes and fungi, while fungi were inhibited by nematodes in double combinations.



Survival of *P. brassicae* larvae after infection with single and combined applications (left) and proliferation of biocontrol agents (BCA) inside *P. brassicae* larvae after five days (right).

Treatments: control = no BCA application, P = *P. chlororaphis* PCLRT03, N = *S. feltiae* RS5, F = *M. brunneum* Bip5, FN, PN, PF and PFN = double and triple combinations of respective BCA. BCA: EPF = Bip5, EPN = RS5, NB = N-associated bacterium *Xenorhabdus bovienii* SM5, EPP = PCLRT03. Survival curves represent pooled data from four independent repetitions with 18 larvae per treatment and repetition. Colonisation of six individual larvae by BCA after simultaneous application at 5 days post infection. Colonisation was assessed by qPCR and colonisation values are displayed in units per larva (relative to bacterial cells, fungal spores and nematode IJ). For improved readability, BCA that are not part of a double combination were removed in this plot.



Study systems

Delia radicum: screening, greenhouse and semi-field trials with artificial inoculation of *D. radicum* eggs and a field experiment with a heavy natural infestation were conducted.



Pieris brassicae & *Diabrotica balteata*: larvae were placed in multi-well plates and infected with BCA. Survival was recorded and larvae extracted to quantify BCA colonisation.

