



Coordinated application of phytoseiids and other biological control agents on management of different pest insect species: a case of ecostacking*

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Ecostacking, maximising the benefits of ecosystem services, implies to combine in an additive or synergistic manner the beneficial services of functional biodiversity from all levels and types (Hokkanen and Menzler-Hokkanen, 2018). Historically, studies of biological control focused on interactions between different prey species and shared predators, or that among target prey and different predators (El-laithy *et al.*, 2021; Hao *et al.*, 2021). *Amblyseius swirskii* was a predominant predator against small sap-sucking pests including whiteflies and thrips (Rahimi *et al.*, 2022). In this study, we conducted a coordinated management strategies utilizing the phytoseiid mite *A. swirskii*, the predatory bug *Eocanthecona furcellata* and the entomopathogenic fungi *Beauveria bassiana*, to control the major pest insects of tobacco planting areas in Southwestern China, including *Bemisia tabaci*, *Thrips tabaci*, *Spodoptera litura* and *Helicoverpa assulta*.

A laboratory study indicated that *B. bassiana* sprayed at 8.0×10^7 spores per mL resulted in a low mortality on *A. swirskii* (13.4% in 7th d) and *E. furcellata* (15.6% in 7th day), whereas *S. litura*, *H. assulta*, *B. tabaci* and *T. tabaci* were sensitive to *B. bassiana* (68% to 85% mortality in 7th d). The predatory mites and bugs, inoculated seven days after the *B. bassiana* spraying, held a relatively high survival rate (88% to 92%) once the prey were supplied *ad libitum*. Besides, intraguild predation did not occur when predatory mites and predatory bugs coexisted. Field trials showed that the control efficiency of coordinated application of *B. bassiana* (0.30 g/m²), *A. swirskii* (15 individuals/m²) and *E. furcellata* (0.06 individuals/m²) was 81% on lepidoptera pests and 86% on the small sap-sucking pests, which was in the approximate level of strategies of spraying three times chemical pesticides. These results built a good case that the utilization of multi-biocontrol agents increased the level and efficiency of integrative, sustainable, and eco-friendly control strategies.

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Keywords: ecostacking, *Amblyseius swirskii*, *Eocanthecona furcellata*, *Beauveria bassiana*, sustainable management strategy

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