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SHORT COMMUNICATION

Potential of a strain of the entomopathogenic fungus *Beauveria bassiana* (Hypocreales: Cordycipitaceae) as a biological control agent against western flower thrips, *Frankliniella occidentalis* (Thysanoptera: Thripidae)

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Five *Beauveria bassiana* strains were evaluated for control of western flower thrips. Strain RSB was the most virulent, causing 69–96% mortality at concentrations of 1×10^4–1×10^7 conidia mL^{-1}, 10 days after inoculation of first instars. In greenhouse trials, RSB applied to broccoli foliage significantly reduced adult and larval populations.

Keywords: Beauveria bassiana; Frankliniella occidentalis; *broccoli*; *integrated biological pest control*

The western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), is an important pest of ornamentals and vegetables that causes significant economic losses in greenhouses and open-field plant production (Morse and Hoddle 2006; Reitz, Gao, and Lei 2011). This study investigates the activity of several novel strains of the entomopathogenic fungus *Beauveria bassiana* against *F. occidentalis* to provide a basis for development of a biological control technique.

A colony of western flower thrips was maintained as described by Liang, Lei, Wen, and Zhu (2010). Briefly, thrips colonies were reared in 0.5 L tube-shaped glass jars containing green bean pods. Rearing jars were kept at 26 ± 2°C, 60–70% RH and L13:D11 photoperiod. After 4–5 days, the beans were transferred to fresh glass jars. Eggs that were laid within a maximum period of 48 h were used to obtain first instar thrips, for experimental use.

The origin and source of the five fungal isolates are as follows: (1) NA, derived from *Ostrinia furnacalis* (Lepidoptera: Pyralidae) collected in Jilin (2010); (2) SZ, derived from *Ostrinia nubilalis* (Lepidoptera: Pyralidae) collected in Suizhong, Liaoning (2010); (3) TL, derived from *O. furnacalis* (Lepidoptera: Pyralidae) collected in Tieling, Liaoning (2009); (4) HS, derived from *Locusta migratoria manilensis* (Orthoptera: Acrididae), collected in Hebei (2009); and (5) RSB, derived from *Chilo*

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suppressalis (Lepidoptera: Pyralidae) collected in Beijing (2007). All isolates were maintained, and conidia were produced on Sabouraud dextrose agar (SDA) at $26 \pm 1^{\circ}C$ under continuous darkness. Conidial concentrations were determined with a haemocytometer and adjusted with 0.05% Tween-80 in sterile H_2O. Viability was confirmed on SDA (Wen et al. 2003) and was $>90\%$ for all strains.

The effect of the *B. bassiana* strains on *F. occidentalis* mortality was evaluated by treating first instars with five to seven concentrations of conidia for each. A control consisted of Tween-80 at 0.05% v/v in sterile H_2O. Individual *F. occidentalis* larvae were dipped for 10 s in the appropriate conidial suspension. Larvae were allowed to dry on filter paper and were transferred to Petri dishes (3.5 cm) lined with bean leaves, and stored in a humid plastic box. The status of individuals was determined 10 days after treatment. The presence of fungal mycelia was used as an indication of mycosis. Each replicate consisted of 30 larvae and was performed by triplicate, using different insect lots.

Strain RSB was identified as the most virulent strain and was selected for further evaluation in a greenhouse experiment on broccoli (*Brassica oleracea* L.) naturally infested with *F. occidentalis*. Broccoli was planted on 25 March 2010 in the six replicate blocks of a 648 m^2 greenhouse. Each block measured approximately 10×9 m. The experiment comprised two treatments laid out in a randomised complete block design across the six blocks: (1) *B. bassiana* strain RSB; and (2) control. Suspensions of fungal conidia (1×10^7 mL^{-1}) and the control solution were prepared as described above for the screening bioassays.

Treatments were applied to runoff on foliage, using a 50 L hand held sprayer. The experiment was started on 17 July 2010. The mean temperature in the greenhouse during this period was 36°C and ranged from 33 to 38°C. Ten plants were sampled in each of the plots for the numbers of live adult and larval thrips present. Three marked leaves per plant, one at the top, middle and bottom of each plant, were sampled at 1, 2, 4, 6, 8, and 10 days after treatment.

For the screening test, mortality data were corrected for control mortality (Abbott 1925) which were normalised using arcsine transformation and subjected to analysis of variance (ANOVA), with means separated by the Tukey's mean separation test at $\alpha = 0.05$ to determine significance. For the greenhouse trial, abundances of thrips were first compared over all sample dates by ANOVA. Data were then analysed separately for each date by ANOVA, using $P < 0.05$ to determine significance. All analyses were conducted using the SAS statistical software (SAS Institute 1988).

The mortality of *F. occidentalis* 10 days after treatment as first instars with the various strains of *B. bassiana* is shown in Figure 1. Overall, strain RSB was the most pathogenic causing from 69% mortality at 1×10^4 conidia mL^{-1} to 96% mortality at 1×10^7 conidia mL^{-1}. The other strains produced significantly lower mortality than the *B. bassiana* strain RSB (fungal conidia 1×10^4 mL^{-1}: $F = 136.01$; df = 4,14; $P < 0.001$; 1×10^5 mL^{-1}: $F = 295.35$; df = 4,14; $P < 0.001$; 1×10^6 mL^{-1}: $F = 201.32$; df = 4,14; $P < 0.001$; 1×10^7 mL^{-1}: $F = 236.92$; df = 4,14; $P < 0.001$).

In the greenhouse experiment, a significant reduction in thrips population density was observed in fungal − treated plots as compared with the control plots: larvae ($F = 13.13$; df = 1,35; $P < 0.001$) and adult ($F = 13.72$; df = 1,35; $P < 0.001$) (Figure 2). Specifically, although no significant differences between the treatments

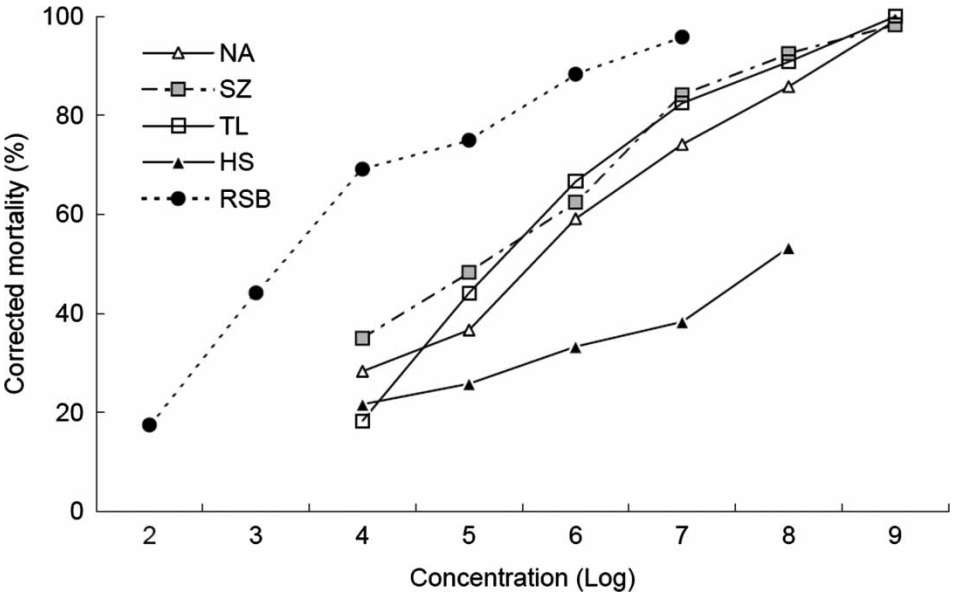

Figure 1. Corrected mortality of *Frankliniella occidentalis* 10 days after inoculation, as first instars, with various *Beauveria bassiana* fungal isolates (fungal conidia concentrations tested ranged from 1×10^2 to 1×10^9 mL^{-1}).
Note: Not all strains were tested at each concentration.

were observed for larvae and adults at 2 days ($F = 1.05$; df = 1,5; $P = 0.37$ and $F = 3.64$; df = 1,5; $P = 0.129$, respectively) and 4 days ($F = 2.26$; df = 1,5; $P = 0.068$ and $F = 1.23$; df = 1,5; $P = 0.330$, respectively), there was a significant difference between treatments for larvae and adult at 6 days ($F = 8.55$; df = 1,5; $P = 0.043$ and $F = 27.58$; df = 1,5; $P = 0.006$, respectively), 8 days ($F = 21.40$; df = 1,5; $P < 0.01$ and $F = 27.04$; df = 1,5; $P = 0.007$, respectively) and 10 days ($F = 13.27$; df = 1,5; $P < 0.01$ and $F = 17.78$; df = 1,5; $P < 0.01$, respectively).

Our results indicate that *B. bassiana* strain RSB is highly virulent to *F. occidentalis* and significantly reduces its survival. The RSB strain produced greater mortality than observed in laboratory trials for strain 5492 (Gouli, Gouli, Skinner, and Shternshis 2009) and strain GHA (Shipp, Zhang, Hunt, and Ferguson 2003), although differences in experimental protocols cannot be discounted. Likewise, strain RSB produced comparable mortality to a highly virulent strain of *Metarhizium anisopliae* (Sorokin)Metchnikoff (Gouli et al. 2009). The greenhouse experiment further supports our laboratory studies regarding the virulence of the RSB strain. The results are especially encouraging in that strain RSB was effective as a foliar application against the mobile life stages of *F. occidentalis*, and that the strain was effective even though greenhouse temperatures reached 33–38°C. Declines in thrips abundance were not evident until 6 days after treatment, but this time lag in the onset of mortality is comparable for other studies with *B. bassiana* (Jacobson, Chandler, Fenlon, and Russell 2001; Abe and Ikegami 2005).

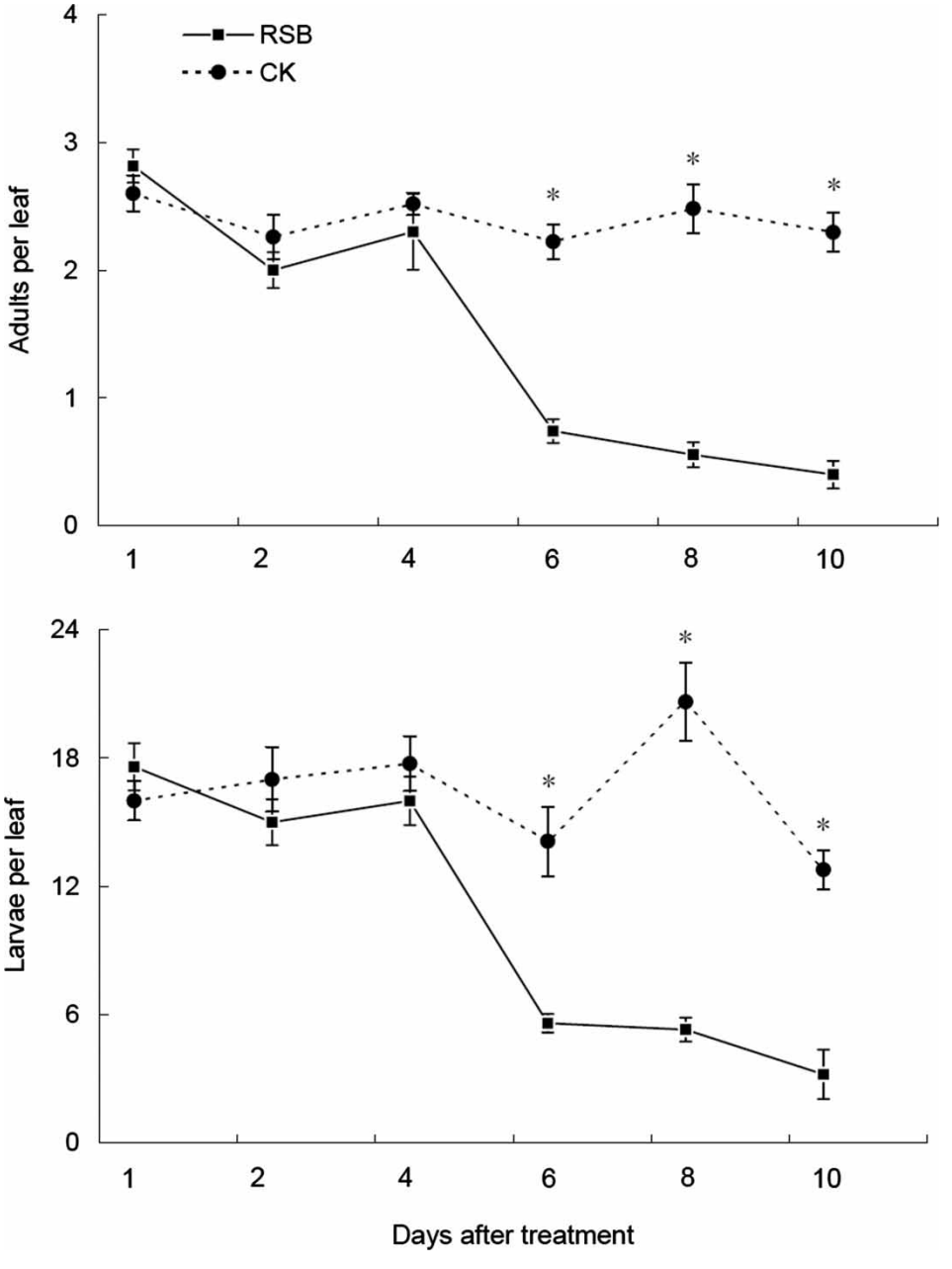

Figure 2. Effect of *Beauveria bassiana* strain RSB application (1×10^7 conidia mL^{-1}) on the abundance of larval and adult *Frankliniella occidentalis* compared with the control (CK) on broccoli foliage at different days after treatments were applied. Bars represent the standard errors of the means.

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