

Entomopathogenic nematodes for controlling *Lobesia botrana* in vineyards: fine-tuning of application, target area, and timing

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Abstract

Lobesia botrana (Lepidoptera: Tortricidae), also known as the European grapevine moth, is one of the major harmful pests detected in worldwide vineyards. The current control methods have limitations, and expanding the available biological control agents can provide new strategies in both IPM and organic viticulture. Entomopathogenic nematodes (EPN) are well-known biological control agents for numerous soil pests. Thanks to the current application systems, such as the use of adjuvants, their implementation against aerial pests is now possible. Previous laboratory experiments probed the control capability of the EPNs *Steinernema feltiae* and *S. carpocapsae* against *L. botrana* at various larval stages and pupae. We hypothesized that by selecting the best combination of EPN-adjuvant, target area in the grapevine and the timing (season/temperatures), we can enhance EPN efficacy as a biocontrol agent against *L. botrana*. The aim of this study was to screen for the best EPN-adjuvant mix and to determine the best ecological scenarios for their use against *L. botrana*. We investigated (i) survival, viability, and adherence on leaves of EPN-adjuvant mix, (ii) protection capability (mortality of *L. botrana* and reduction of its damage) in leaves, grapes, and trunk bark, and (iii) EPN activity against *L. botrana* at low temperatures as a proxy of the overwintering period. The screening of five adjuvants (Multi-U's, Maximix, Dash HC, Nu-Film-17 and Adrex) and a subsequent combination (Multi-U's+Maximix), showed generally high compatibility with all the adjuvants, resulting Maximix as the best candidate for the EPNs *S. feltiae* and *S. carpocapsae*. Compared with the no-application treatment, Maximix combined with EPN increased their killing against *L. botrana* L3 on grapes and leaves with significant reduction of the damage. The study of the pupae in the trunk bark system at 22°C, 14°C, and 10°C showed that mortality caused by EPNs decreased with temperature, from ~60% at 22°C to values ~20% at 10°C, and the use of Maximix in this scenario did not improve their efficacy. Overall, the results showed that the combination with Maximix can enhance the survival, infectivity, and adherence of the EPN *S. feltiae* and *S. carpocapsae*. In addition, these species combined with Maximix reduced the damage caused by *L. botrana* L3 in leaves, and grapes. However, this combination did not improve their efficacy against pupae. Finally, we suggest their application at sunset and late spring/early autumn (March/September) to target mid-temperatures (22°C-15°C). Further validation in field conditions is necessary for their full implementation.

Keywords: adjuvants, grapevine, *Steinernema*, overwintering.