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Softpest Multitrap - management of strawberry blossom weevil and European tarnished plant bug in organic strawberry and raspberry using semiochemical traps

ATLE WIBE*[1], JERRY V. CROSS[2], ANNA-KARIN BORG-KARLSON[3], DAVID R. HALL[4], NINA TRANDEM[1], LENE SIGSGAARD[5], CATHERINE BAROFFIO[6], BAIBA RALLE[7], MICHELLE T. FOUNTAIN[2]

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Abstract

Many European organic strawberry and raspberry growers have large losses in yield (sometimes >80%) and reduced quality of their products because of insect damage. To meet these challenges a research project with partners from 6 countries has been established aiming to develop knowledge to manage populations of the major pest insects in the crops; Anthonomus rubi, Lygus rugulipennis *and* Byturus tomentosus*. The main hypothesis is that plant volatiles present in the original host plants in combination with the insect's respective pheromones are the most efficacious for attraction. For* A. rubi *this was confirmed during the first field season. However, variations in catches were found between habitats, generations and countries. For* L. rugulipennis *the temporal catches depended on latitude with an earlier onset in the North. To improve the efficiency of the insect pest traps, the project has also investigated trap design. The initial findings are promising and it is expected that the following two field seasons will allow us to add to the knowledge of insect pest management.*

Introduction

Among the major threats in organic strawberry and raspberry are the strawberry blossom weevil (*Anthonomus rubi* Herbst), the European tarnished plant bug (*Lygus rugulipennis* Popp.) and the raspberry beetle (*Byturus tomentosus* De Geer). In organic soft fruit production there are no effective control measures for many of these pest insects.

For many insect species pheromones and host plant volatiles are of major importance in mate finding and location of host plants for mating, feeding and oviposition. Thus, there is potential for using these insect-insect and/or insect-host plant interactions to develop new strategies and effective control measures for pest insects.

For *A. rubi* three male-specific compounds as components of an aggregation pheromone were identified (Innocenzi et al. 2001) and traps baited with this pheromone can be applied successfully to monitor the pest (Fountain et al. 2014). However, to control the weevil population stronger measures are needed (Cross et al. 2006a,b). Recent studies have shown that the attractiveness of the pheromone can be synergized with specific host plant volatiles (Wibe et al. *sub.*), i.e. the blend attracts more weevils than the pheromone or host plant volatile separately.

Investigations of the pheromone system of *L. rugulipennis* have shown that females produce three different compounds (Innocenzi et al. 2004, 2005). A precise blend of these released from specially-developed dispensers attracts males to traps in the field (Fountain et al., 2014). Frati et al. (2008) found that both male and female *L. rugulipennis* were strongly attracted to host plants when they had conspecific bugs on them in laboratory bioassays, suggesting that host-plant volatiles increased the attractiveness of the pheromone. Some of these host-plant volatiles were identified (Frati et al. 2009), however, preliminary studies failed to show enhancement of the attractiveness of the pheromone by these compounds.

For both *A. rubi* and *L. rugulipennis* it seems there are good possibilities for improving the attractiveness of the pheromone with host-plant volatiles, although further work is required to develop a lure for use in the field.

[1] Bioforsk, Norway, www.bioforsk.no, atle.wibe@bioforsk.no
[2] East Malling Research, UK
[3] KTH Royal Institute of Technology, Sweden
[4] Natural Resources Institute, UK
[5] University of Copenhagen, Denmark
[6] Agroscope, Switzerland
[7] Latvian Plant Protection Research Centre, Latvia

For *B. tomentosus*, a very effective trap based on the key visual and olfactory characteristics of the raspberry flower has been developed to attract the beetle in raspberry plantations (Birch et al. 2008, Baroffio et al. 2012) and it is now commercially available for monitoring.

In this project we want to extend our knowledge of these systems to develop effective control measures to control these pests in organic crops.

The main hypothesis for the study of host plant volatiles of *A. rubi* and *L. rugulipennis* is that the flower volatiles present in the original host plants in combination with the insect's respective pheromones are the most effective for attraction of the Coleoptera and mirids. Conversely, volatiles from unhealthy host plants infested with fungi might deter the pests from feeding and hence provide a source of candidate repellent compounds. We further hypothesised, based on our previous research, that the natural semiochemical mechanisms of these pests and their host plants can be exploited in highly effective semiochemical traps for control by mass trapping. In addition, it is speculated that the attractive mechanisms for these two species are independent and can be combined into a single 'multi-species' trap.

The aim: To develop knowledge about how to manage populations of strawberry blossom weevil (*A. rubi*), European tarnished plant bug (*L. rugulipennis*) and the raspberry beetle (*B. tomentosus*) in organic strawberry and raspberry so that these two soft fruit crops can be grown without significant economic losses by these pests.

Material and methods

Our general strategy was to investigate host plant volatiles from raspberry, strawberry and other pest host plants for identification of important volatile cues for both *A. rubi* and *L. rugulipennis* (WP1); to evaluate host plant volatile synergists for sex pheromone lures to attract pest insects to traps in strawberry (WP2) and raspberry fields (WP3); and to optimise trap design, lures and methods of deployment for pest insect trapping in both crops (WP4). The project period is 2012-2014 and there will be three field seasons.

WP1. Host plant volatiles were collected and quantified by using several headspace sampling methods to enrich certain fractions of the volatiles. The volatile samples are analyzed using gas chromatography linked to mass spectrometry (GC-MS). The tasks were to:

- Investigate and compare flower and host leaf volatiles from raspberry and strawberry as potential synergists of *A. rubi* aggregation pheromone and *L. rugulipennis* female sex pheromone.
- Identify host volatiles from unhealthy/dying (e.g. fungi infested) strawberry plants that might act as repellents in order to add repellents in control strategy.
- Develop and produce lures based on plant volatiles for field testing.

WP2** and **WP3. Successful management of pest populations by mass trapping requires good knowledge of the target pest biology. The biology of *L. rugulipennis* is fairly well known, but there is lack of knowledge about overwintering strategies and how it is affected by mulching and weed cover. *A. rubi* has a univoltine life cycle, but variation in overwintering habitat in different countries has been observed (Trandem & Haslestad 2011). For both species we are using traps with species-specific lures to elucidate phenology and migration between different habitats and the effect of cropping methods. The tasks were to:

- Investigate overwintering sites and seasonal distribution of *A. rubi* and *L. rugulipennis* in strawberry- and raspberry crops. In raspberry crops studies of *B. tomentosus* are also included.
- Field evaluation of host plant volatile synergist(s) for the *A. rubi* and *L. rugulipennis* pheromones.
- Determine whether the characteristic host volatiles from unhealthy/dying plants identified are active in repelling *A. rubi.*
- Conduct large-scale field experiments to explore the density and pattern of trap deployment.

WP4. The current monitoring traps are a green funnel (bucket) trap with white or green cross vanes and the lure fixed at the top. This is satisfactory for monitoring but would be costly for mass trapping. An optimised design for mass trapping, where quite large numbers of traps are required, is needed. The tasks were to:

- Optimise trap designs and methods of deployment for *A. rubi* and *L. rugulipennis* mass trapping in strawberry and raspberry.

- Conduct field experiments to determine whether the same trap design could be used with acceptable control of *A. rubi*, *L. rugulipennis* and *B. tomentosus*, and whether the lures can be used in the same trap without interference.

Results

Here we present results from the first field season (2012):

Chemical analysis of plant volatiles (WP1)

- Wild strawberry plants and cultivars of strawberry have revealed differences in volatiles between the leaf and the bud.
- New volatiles in the host plants have been identified and candidates will be tested as attractants in the field.
- Analyses of fungi infected wild strawberry plants have identified possible candidates to repel pest insects in the fields.

In strawberry crops (WP2)

- In Norway *A. rubi* catches of the new generation (August) were conspicuously larger than those of the overwintered generation. The same was recorded in Denmark although the density of weevils was lower.
- *A. rubi* catches increased with crop age, while the catches of *L. rugulipennis* don't show the same tendency
- The temporal pattern of *L. rugulipennis* catches depended on latitude, probably reflecting differences in voltinism: in Norway, catches ceased after mid-June, while in UK and Denmark they peaked during July-August.

In raspberry crops (WP3)

- Large variation in trap catches of *A. rubi* between Switzerland and Norway were recorded. In Switzerland there was no effect of the trap position in the habitat (crop, boundary, forest), whereas in Norway the trap position had a significant effect by catching more in the crop.
- In spring, *A. rubi* becomes active when the temperature reaches 18°C. Mating occurs in May which corresponds to the development of leaves in the crop (April/May). A 2nd population peak appears during fruit development in Switzerland. This 2nd generation appears about one month later, depending on the temperature.
- In both Norway and Switzerland *B. tomentosus* was present before raspberry flowering, and in Norway there was a large trap catch peak at that time. In Switzerland a weak population peak is observed at the flowers development stage (BBCH 60-69, Schmid et al. 2001**)**.

Trap design (WP4)

- In strawberry crops the most effective traps for capturing *A. rubi* and *L. rugulipennis* were green cross vane bucket traps with no bee excluder grid over the funnel. These traps caught both species without attracting bees.
- In raspberry crops the most effective traps for catching *A. rubi* and *B. tomentosus* were white cross vane bucket traps with a grid to prevent bees being captured. This design caught both species and the efficacy was not affected by the incorporation of the grid.
- The height of the trap in the raspberry crops had an effect on the *A. rubi* catch. Significantly more *A. rubi* were found in traps on the ground than those placed at 0.75 or 1.5 m.

Discussion

To date, we have accumulated further information for developing strategies for managing insect pests in organic strawberry and raspberry. The chemical analysis has revealed specific volatile characteristics of different parts of the host plants, important information to understand the insect host plant attraction and selection. In addition potential attractive and repellent volatiles have been identified; new candidates for manipulating the insect populations in organic crops. These compounds will be further tested in the plantations in the next field seasons.

A. rubi second generation populations are larger than the new emerging generation*, in both* organic strawberry and raspberry crops. It is important to uncover what effects this overwintering second generation has the crops in the following year. Surprisingly, differences in trap catches depending on habitat were found in the different countries involved in this project.

Consequently, local conditions will need to be considered when devising strategies for insect pest management. Strawberry crops need different strategies to raspberry crops even though in some countries the insect pests may be the same. Latitude the crops are grown in is also important. However, there are no indications that the efficiency of the traps differs significantly from one location to another. Therefore, we hope to be able to develop one effective combined 'SOFTPEST' trap for two or three species in either strawberry or raspberry plantations.

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