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Further Investigations of the Sex Pheromone of Female Pear Gall Midge, *Contarinia pyrivora*

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Abstract

The pear gall midge, Contarinia pyrivora *(Riley) (Diptera: Cecidiomyiidae) is an increasingly important pest of pears in Europe and North America. The pest is particularly important in organic orchards where permitted insecticides are limited and timing of application is critical. Two compounds were identified as potential components of the sex pheromone produced by female* C. pyrivora*, 2,7-diacetoxyundecane and 7-acetoxy-2-undecanone. In more recent field trapping tests, the (2R,7R)- and (2S,7R)-isomers of 2,7-diacetoxyundecane both attracted male* C. pyrivora*, while the other isomers and the racemic compound were unattractive. Combining the two attractive isomers did not improve attractiveness, and addition of (7R)-7-acetoxy-2-undecanone as minor component did not improve catches in traps baited with (2R,7R)-2,7-diacetoxyundecane. Traps baited with (2R,7R)-2,7-diacetoxyundecane were demonstrated to provide a sensitive and accurate means of monitoring the short and often intense emergence period of adult* C. pyrivora *midges in trials in The Netherlands, Belgium, Italy and France. Despite promising results of mass trapping reducing damage by* C. pyrivor*a in the UK, replicated experiments on small plots in The Netherlands and Italy showed no evidence of reduction in damage using 100 traps/ha.*

Keywords: 2,7-diacetoxyundecane; trapping; monitoring; mass trapping

Introduction

The pear gall midge, *Contarinia pyrivora* (Riley) (Diptera: Cecidiomyidae) is an increasingly important pest of pears in Europe and North America. Adults emerge from the soil in spring, mate and lay eggs in the unopened blossom. The larvae penetrate into the ovary and destroy the developing fruitlets. Control with insecticides is difficult because of the lack of effective products compatible with IPM programmes and the need for very precise timing of application. The pest is particularly important in organic orchards where removal of infested fruits by hand is often the only effective control method available.

Two compounds were identified as potential components of the sex pheromone produced by female *C. pyrivora,* 2,7-acetoxyundecane and 7-acetoxy-2-undecanone (Amarawardana, 2009). In this previous work, the four stereoisomers of 2,7-acetoxyundecane were separated by HPLC on a chiral column and two of these were shown to be attractive to male *C. pyrivora*, but their configurations were unknown. Addition of racemic 7-acetoxy-2-undecanone did not affect catches (Amarawardana, 2009). The work described here aimed

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to optimise the pheromone blend and carry out initial studies on use of pheromone-baited traps for monitoring and control of *C. pyrivora* in five European countries.

Material and Methods

The four stereoisomers of 2,7-diacetoxyundecane were synthesised from 4-pentenyl bromide and the separate enantiomers of 1,2-epoxyhexane using standard procedures described by Hall *et al*. (2012). Enantiomers of 7-acetoxy-2-undecanone were prepared from levulinic acid and the enantiomers of 1,2-epoxyhexane by similar procedures.

Lures were formulated by impregnating white rubber septa (International Pheromone Systems Ltd, Wirral, UK) with the pheromone in hexane and allowing the solvent to evaporate. Lure loading was 10 µg of the major component.

Traps were white or transparent, sticky delta traps, positioned 0.3 m above ground. Trapping experiments used randomised complete block designs with at least 10 m spacing between traps and at least 10 m between blocks. Data were analysed by transforming to log(x+1) to stabilise variance and analysis of variance followed by a least significant difference test to determine the significance of differences between means. In mass trapping trials, traps were deployed at 100 traps/ha in plots of at least 0.5 ha.

Results

The four stereoisomers of 2,7-diacetoxyundecane were tested in the UK during 2018. The (2*R*,7*R*)- and (2*S*,7*R*)-isomers were highly attractive to *C. pyrivora* males and the other two isomers were unattractive (Fig. 1)

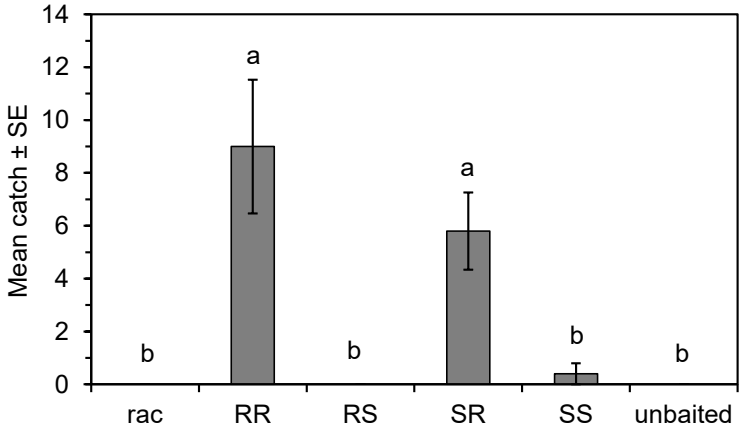

Figure 1: Mean catches of male *Contarinia pyrivora* with stereoisomers of 2,7-diacetoxyundecane in Kent, UK (13-24 April 2018; *N*=5; means with different letters are significantly different *P*<0.05)

Combination of the two attractive isomers of 2,7-diacetoxyundecane did not improve attractiveness to *C. pyrivora* males in trapping tests in The Netherlands and Italy. (e.g. Fig. 2).

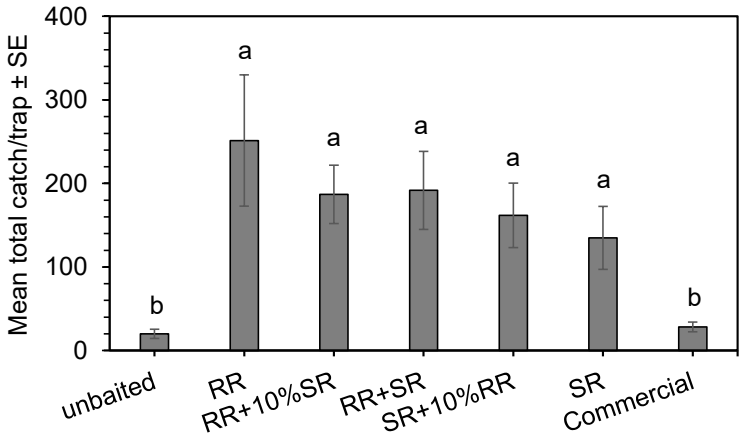

Figure 2: Mean catches of male *Contarinia pyrivora* with blends of (2*R*,7*R*)- and (2*S*,7*R*)-2,7-diacetoxy-undecane in The Netherlands (24 February - 5 April 2022; *N*=5; means with different letters are significantly different *P*<0.05)

Trials in Italy, Belgium, France and The Netherlands during 2023 showed that the potential minor pheromone component, (7*R*)-7-acetoxy-2-undecanone, was weakly attractive to male *C. pyrivora* but did not significantly improve attractiveness when added to (2*R*,7*R*)-2,7-diacetoxyundecane (e.g. Fig. 3)

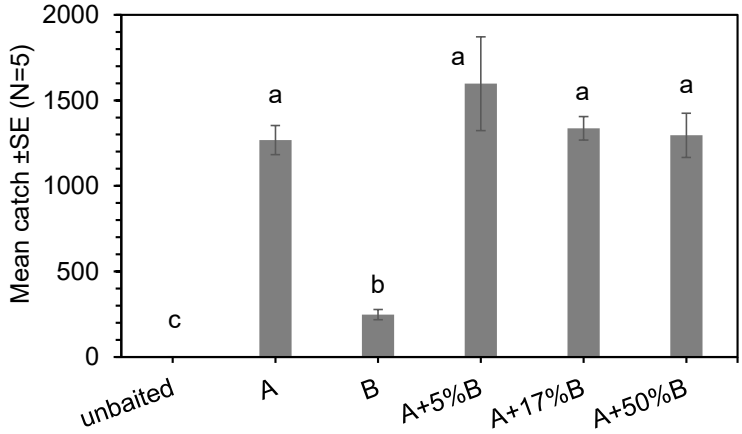

Figure 3: Mean catches of male *Contarinia pyrivora* with blends of (2*R*,7*R*)-2,7-diacetoxy-undecane (A) with (2*R*)-7-acetoxy-2-undecanone in Italy (14 March - 4 April 2023; *N*=6; means with different letters are significantly different *P*<0.05)

Lures containing (2*R*,7*R*)-2,7-diacetoxyundecane have been used to monitor the presence of male *C. pyrivora* adults in the UK, The Netherlands, Italy, Belgium and France. For example, data from different orchards in Italy during 2023 shown in Fig. 4 shows the short, intense emergence period.

Following some promising early results in the UK showing mass trapping with pheromone traps seemed to reduce subsequent damage by *C. pyrivora,* replicated trials were carried out on 0.7 ha plots in Italy, and no significant effect on damage was observed with 100 traps/ha (Fig. 5).

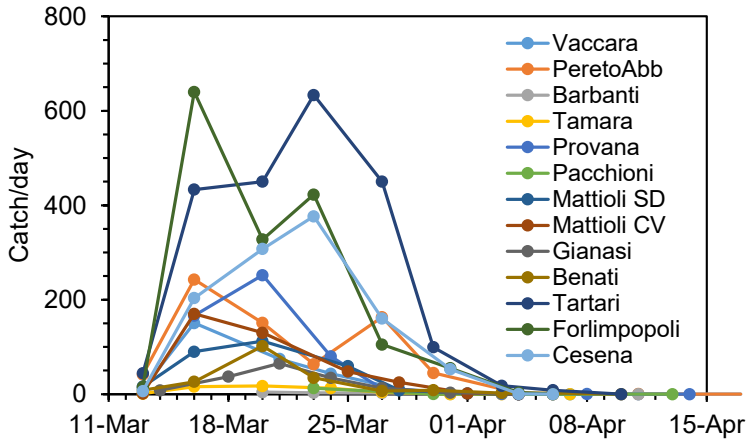

Figure 4: Monitoring of male *Contarinia pyrivora* with pheromone traps in 13 orchards in Italy during March-April 2023 (1 trap per orchard; graph shows catches at 2-3 day intervals corrected for number of days between intervals)

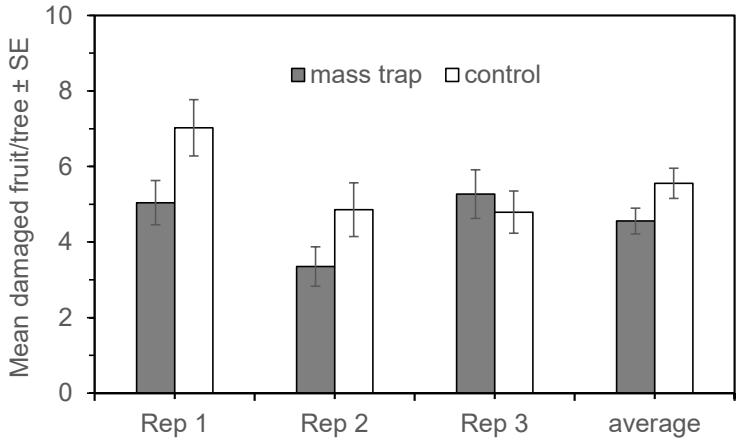

Figure 5: Comparison of damage due to *Contarinia pyrivora* in plots with mass trapping at 100 traps/ha and untreated plots in three orchards in Italy (3 March – 28 April 2022).

Discussion

Traps baited with lures containing (2*R*,7*R*)-2,7-diacetoxyundecane are highly attractive to adult male pear midge, *C. pyrivora.* They can be used to monitor emergence of the pest which typically occurs over a very short period, and hence to schedule application of control measures against the adults or the young larvae when they are likely to be most effective. Mass trapping with pheromone traps at 100 traps/ha on replicated 0.5 ha plots was not effective in reducing damage. However, this could be further explored in larger, more isolated orchards to reduce the immigration of gravid female midges. Increasing the loading of pheromone in the lures from the current 10 µg could also be tested. As the pheromone is highly attractive at very low levels, control by mating disruption should also be evaluated.

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