Mating disruption for control of codling moth in apple orchards of Bulgaria

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ABSTRACT

Codling moth (CM), *Cydia pomonella* L., is the key pest of pome fruits in Bulgaria. It causes severe damage on apple, pear and quince. Considerable infestation has been noted on walnut as well. Due to regulatory restrictions in use of conventional insecticides after including Bulgaria into the EU and due to the developing resistance of CM to most commonly used organophosphates and pyrethroids, suitable alternative means of control of this pest have been needed. During the three-year period (2006-2008), trials have been carried out in apple orchards in different regions of Bulgaria using the methodology, originally called as "disorientation of males" and recently as "mating disruption" (MD). For this purpose different kinds of dispensers were used – Isomate C plus, Ecodian CP and CheckMate® CM XL1000. The careful selection of orchards and adoption of a pheromone-based IPM approach can minimise the risks and maximize efficacy of the CMMD (codling moth mating disruption). CMMD works best in orchards where the physical characteristics and environmental conditions ensure a uniform distribution of synthetic pheromone dispersed. The pheromone dispensers should be deployed within 50 cm of the canopy top, prior to the expected first flights of the pest. Borders of pheromone treated orchards are susceptible to high levels of CM infestation; hence the growers should increase the density of dispensers at these sites. Monitoring of CM adult activity in the orchards treated with CMMD is difficult. Capture of moths in pheromone traps baited with 1 mg of codlemone is an unreliable indicator of efficacy. The sensitivity of pheromone traps can be improved by using traps baited with 20 mg lures and locating them in the uppermost parts of the canopy. Positive results were obtained in all orchards, where CMMD was used. The percentage of damaged fruits in trial plots was below economical threshold. Hibernating population of CM was reduced, as indicated by counts of diapausing larvae in corrugated paper band traps. The consequent adoption of CMMD will depend on how well this method meets the grower expectations concerning risk, efficacy and cost.

Keywords: codling moth, mating disruption, apple, IPM, flight monitoring, fruit damage

INTRODUCTION

The codling moth (CM), *Cydia pomonella* (L.), is the major insect pest in apple orchards worldwide (Dorn *et al*., 1999). Moreover, it is a main pest of walnuts in certain regions, Bulgaria included. In spite of a relatively large number of control methods with use of chemical insecticides available for the species, the codling moth continues to pose a serious threat, especially because of development of resistance to various groups of insecticides in many countries around the world (Pasquier and Charmillot, 2003). In Europe, resistance of CM is a relatively recent problem; it appeared for the first time in early nineties of the past century. Insecticides, the effectiveness of which in control of CM has been reduced by resistance, include diflubenzuron and other insect growth inhibitors (IGIs), several insect growth regulators (IGRs), some pyrethroids and several organophosphates (Waldner, 1993; Sauphanor *et al*., 1994, 1998, 2000; Bouvier *et al*., 1995; Charmillot *et al*. 1999, 2002; Ioriatti and Bouvier, 2000; Charmillot and Pasquier, 2002). Issues associated with the widespread use of organophosphates, including insecticide resistance (Varela *et al*., 1993), toxicity to natural enemies (Gut and Brunner, 1998), worker safety and food residues (Brunner, 1994), provoked an intensive research aimed at development of alternative control technologies. Use of pheromone-mediated mating disruption (MD) for control of codling moth has shown considerable promise in pome fruit production areas around the world (Rothschild, 1982; Charmillot, 1990; Thomson *et al*., 1999; Barnes and Blomefield, 1997; Waldner, 1997). According to Thomson *et al*. (2001) other advantages of CMMD include enhanced levels of biological control, reduced costs associated with worker protection and labour management, and decreased potential for the development of insecticide resistance. With respect to the present knowledge about novel control

methods available, the codling moth is a suitable object for introducing the mating disruption technique (Quarles, 2000). By saturating an orchard with the synthetic sex pheromone of the females, the males get thereby disabled to locate the females for mating (Foster and Harris, 1997). The codling moth is suitable for this technique since it has a narrow host range, a relatively low fecundity and the adult females do not disperse far from the emergence sites (Rothschild, 1982).

Selecting suitable orchards

The careful selection of suitable orchards can minimize the risk and control problems associated with CMMD. A careful consideration should be given to the topography (slope), wind exposure, size and structure of tree canopies (Thomson *et al*., 1999; Gut and Brunner, 1994).

Kind of dispensers used

Hand-applied dispensers are the most popular and commonly used for mating disruption. The large reservoirs utilized in these products allow for long residual activity ranging from 60-140 days. Application rates vary from one to several dispensers per tree (or 500–2500 dispensers per ha) and can be laborious. The following, common hand applied MD products were used in our studies (Kutinkova *et al*., 2007, 2009a, 2009b; Kutinkova and Dzhuvinov, 2008).

Isomate C plus dispensers of Shin Etsu (Japan) are in a form of red plastic tubes. They are distributed in Europe by CBC – Europe, Ltd., Italy. According to the manufacturer, each dispenser is loaded with 190 mg of pheromone mixture. The recommended dosage is 1000 pieces per ha, installed once, before the first onset of CM moths.

Ecodian CP dispensers, the product of ISAGRO Spa Italy, are small blue hooks, impregnated with pheromone. According to the manufacturer each dispenser contains 10 mg of codlemone. They are composed of a biodegradable material. The dosage is 2000-2500 per ha, installed two times per season, at about 60-day interval.

CheckMate® CM XL1000 of Suterra (Oregon, USA) are dispensers that contain 270 mg of E,E,-8,10-dodecadien-1-ol in each dispenser. They are distributed in Europe by AgriSense-BCS Limited, UK. The dosage is 500 dispensers per ha, installed one time per season. All above mentioned products should be placed in an orchard before the occurrence of CM biofix.

Application of different dispensers

According to Gut and Brunner (1994) pheromone dispensers should be installed within one meter from the top of the canopy, just prior to the start of CM flight. In our trials the suitable height of placing dispensers was 50 cm under the top of the tree canopy. It was shown that most CM mating activity occurred in the upper part of tree canopy. Riedl *et al*. (1979) found more CM males caught in lure-baited pheromone traps placed in the upper part of the canopy. So, to optimize the efficacy of CMMD dispensers should be installed as high as possible.

Borders

In our trials some fruit damage was noted in CMMD orchards when the sources of infestation occurred – from an adjoining, neglected orchard or from an orchard with CM resistance. The other authors also emphasized that borders of pheromone treated orchards may be subjected to more intense CM infestation and hence need a reinforced treatment. Gut and Brunner (1998) found that about two-thirds of the CM damage occurred within 30 meters of the border. Knight *et al*. (1995) noted a similar situation. Factors contributing to border infestations include the immigration of mated females from adjacent untreated orchards and/or reduced concentration of pheromone in the border zone (Gut and Brunner, 1998). Recommendations to reduce border infestations include increasing the density of dispensers in border areas and/ or spraying the borders with insecticides (Gut and Brunner, 1996). In our trials the application rates were increased in borders. Additionally, the dispensers were installed at the borders of conventionally treated orchards, located close to the trial orchards.

Supplemental treatments

High CM population is the most important limitation to the successful use of CMMD. In orchards with high CM populations, application of supplemental baculovirus products, as Madex® (Kutinkova *et al*., 2008a, 2009c) or Carpovirusine (Kutinkova *et al*., 2008b) and/or intensive sanitation (Judd *et al*., 1997) is essential to reduce the high population density to levels low enough to achieve a commercially acceptable control.

Monitoring of CM in the trial orchards

Monitoring codling moth adult activity in orchards treated with MD is difficult. Pheromone traps should be uniformly distributed in the orchard at a density of 1 trap per hectare. Additional traps should be placed to monitor the borders Traps should be inspected once or twice a week. Lures should be changed every 4-6 weeks or according to the manufacturer's recommendations. Capture of moths in pheromone traps baited with 1 mg of codlemone often appears unreliable as an indicator of efficacy (Thomson *et al*., 1999). Charmillot (1990) found that the sensitivity of pheromone traps can be improved by using traps baited

with 10 mg lures and locating them in the upper part of the canopy. In our trials lures baited with 20 mg codlemone were used. They were loaded at the Swiss Federal Research Station Agroscope Changins-Wädenswil. Only during the mass flight of CM few moths were caught in these traps in some CMMD plots.

Concluding remarks

Due to increased regulatory restrictions of using conventional insecticides after entering of Bulgaria into the European Union and appearance of codling moth resistance in Central South Bulgaria, an enhancement of the commercial use of CMMD is urgently needed as an alternative to conventional treatments with organophosphates and pyrethroids. The consequent adoption of CMMD will depend on how well this method would meet the grower expectations concerning risk, efficacy and cost.

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