SUSTAINABLE CONTROL OF SOME IMPORTANT FRUIT MOTHS IN BULGARIA

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Abstract: The organic fruit production is one of the most attractive directions for Bulgarian farmers. However, it meets serious difficulties – due to a long list of pests occurring in the orchards as well as to the short list of plant protection products permitted for use in this system. The alternative methods have been extensively tested during the last years. Different kind of dispensers of specific sex pheromones were tested for mating disruption of oriental fruit moth (*Cydia molesta* Busck), peach twig borer (*Anarsia lineatella* Zell.) and plum fruit moth (*Grapholitha funebrana* Tr.) in peach, plum and apricot orchards. Positive results were obtained in all orchards where MD was employed.

Key words: mating disruption, oriental fruit moth, peach twig borer, plum fruit moth

Introduction

Organic farming is a new, but already wide-spread farming system in the world. It forms a limited niche in Bulgarian agriculture, though considerable interest does exist for such farming in the country. The organic fruit production is potential approach for a Bulgarian farmer, but the constraints do exist, i.e. large number of pests and the least permitted products for use. Reduction of pesticide use is an important issue for human health as well as for conservation of biodiversity.

The oriental fruit moth, *Cydia molesta* (syn. *Grapholitha molesta*) Busck (Lepidoptera: Tortricidae) and the peach twig borer, *Anarsia lineatella* Zell. (Lepidoptera: Gelechiidae) are the most important lepidopteran species infesting mainly peaches and apricots in Bulgaria.

The plum fruit moth, *Grapholitha* (*syn.Cydia*) *funebrana* Tr. (Lepidoptera: Tortricidae), is an important pest in Bulgarian plum orchards; at the same time it is the most difficult to control. The larvae of summer generation feed in fruits and cause damage from early summer till the harvest time.

Concerning stone fruit pests, MD has been successfully used for control of oriental fruit moth, *Cydia molesta* Busck - as reported by (Rot and Blazič, 2005), (Molinari, 2007), (Lo and Cole 2007) and many other authors. Successful control by MD of both, oriental fruit moth and peach twig borer, *Anarsia linneatella* Zell. was reported by (Molinari et al., 2008), (Hari and Penzes, 2011), (Kutinkova et al., 2011). Mating disruption was also successful in controlling plum fruit moth, *Grapholitha funebrana* Tr. in plum orchards (Brouwer et al., 2008), **(**Rioli et al., 2010). The objective of our research, carried out in the years 2006-2016, was to evaluate the efficacy of different

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techniques of mating disruption of oriental fruit moth, peach twig borer and plum fruit moth, as an alternative method for control of these pests under Bulgarian conditions.

Material and methods

The trials were carried out during 10 years (2006-2016) in different regions of Bulgaria (South-Central, South-East, North-East and North-Central). Different kind of dispensers of specific sex pheromones were tested for mating disruption of oriental fruit moth, *Cydia molesta* Busck (OFM), peach twig borer (PTwB), *Anarsia linneatella* Zell. and plum fruit moth (PFM), *Grapholitha funebrana* Tr. Peach, apricot and plum orchards, typical for particular regions, were selected for trials. Mainly young orchards with a low population density of the pests were used. They were fragmented into plots of variable size (from 2 to 50 ha), shape, orientation and cultivars grown.

Hand-applied dispensers: Hand-applied dispensers, the most popular and commonly used for mating disruption, were applied in our studies. Some dispensers used in our studies had an action of 60 days, the other ones of 150-180 days. Application rates varied from one to several dispensers per tree and from 250 to 2500 dispensers per ha; hence their installation was rather laborious. In the last two years- 2015 and 2016, the new dispensers of Trécé Inc., USA, CIDETRAK® OFM/PTB MESO, which are designed to deliver a long-lasting performance for the whole season, with remarkably fast application with a reduced rate 80 and 20 dispensers per ha were used. The following, common hand applied MD products were employed.

Dispensers for oriental fruit moth, *Cydia molesta* Busck: Cidetrak® OFM-L dispensers are produced by Trécé Inc., USA. Each dispenser contains Z-8-dodecen – 1 yl-acetate – 4.65%, E- 8-dodecen- 1-yl-acetate – 0.30%, Z-8-dodecen-1-ol – 0.05% and other ingredients – 90%. They are small black dispensers, as a part of puzzle impregnated with pheromone mixture 250 mg a.i. per dispenser. It is designed to deliver a long-lasting performance – (for the whole season), with remarkably fast application. The dosage is 425 dispensers per ha, installed before OFM flight starts.

Isomate® OFM rosso dispensers: The dispensers, product of Shin-Etsu Japan, are in a form of red plastic tubes. According to the manufacturer, Isomate OFM rosso dispensers are loaded with 240 mg of pheromone mixture. In our studies, considering that the trial orchard was young and the pressure of the pest was relatively low – following the respective recommendations of the company – 500 dispensers were applied per ha, installed once per season, usually before the first onset of the oriental fruit moth. They were supposed to be long lasting – about 150-180 days.

Isomate® OFM TT dispensers – 250 dispensers, product of Shin-Etsu Japan were applied per ha to control oriental fruit moth.

Ecodian® CM dispensers: The dispensers, product of Isagro SpA, Italy, are small grey hooks, impregnated with pheromone. According to the manufacturer each dispenser contains 9.3 mg of Z- 8-dodecenyl-acetate, 0.6 mg of (E)-8-dodecenyl-acetate and 0.1mg of Z-8-dodecen-1-ol. They are composed of a biodegradable material. The dosage was 2000-2500 dispensers per ha, installed twice per season, at about 60-day interval.

Dispensers for plum fruit moth, *Grapholitha funebrana* Tr.: Cidetrak® CM/OFM dispensers. They are small black dispensers impregnated with pheromone mixture. The dosage employed was 500 dispensers per ha, installed before PFM flight started.

Isomate OFM® rosso dispensers. The dispensers, product of Shin-Etsu, Japan, are in a form of red plastic tubes. According to the manufacturer, Isomate OFM rosso dispensers are loaded with 240 mg of pheromone mixture. We used 500 dispensers per ha, installed once per season, usually before the first onset of plum fruit moth. They should be long lasting – 150-180 days.

Ecodian® CF dispensers produced by Isagro SpA Italy, are small lilac hooks, containing – according to the manufacturer – Z8-dodecenyl acetate 10 mg and dodecyl acetate – 10 mg. They are composed of a biodegradable material. The recommended dosage is 2000-2500 dispensers per ha. We used 2000 dispensers per ha, installed two times per season, at about 60-day interval.

Dispensers for peach twig borer, *Anarsia lineatella*: Isonet® A dispensers. The dispensers, product of Shin Etsu Japan, are in a form of red plastic tubes. According to the manufacturer, they are loaded with more than 134 mg of pheromone mixture. The applied dosage, in conformity with the recommendations of the producer, was 1000 dispensers per ha, installed once per season, usually before the first onset of oriental fruit moth. They should be also long lasting – about 140-150 days.

Dispensers for *Cydia molesta* Busck and *Anarsia lineatella* Zell.

Cidetrak® OFM/PTB dispensers They are small black dispensers in a form of puzzle impregnated with pheromone mixture. The dosage employed was 400 dispensers per ha, installed before OFM and PtwB flight started.

Cidetrak® OFM/PTB – Meso dispensers. They are black belts – a new dispensers produced by Trécé Inc., USA, impregnated with pheromone mixture. The dosage employed was 80 and 20 dispensers per ha, installed before OFM and PtwB flight started.

CheckMate® SF, product of Suterra (Oregon, USA) – dispensers, which contain 250 mg of orfamone and 200 mg of anemone in each. The dosage is 375 dispensers per ha, or 93.75 g of orfamone and 75g of anemone per ha installed once per season, usually before the first onset of oriental fruit moth and peach twig borer.

Ecodian combi® CM+AL dispensers, product of Isagro SpA Italy, are small green hooks, impregnated with pheromone. According to the manufacturer each dispenser is loaded with 9.3 mg of Z8 dodecenil acetate, 0.1 mg Z8 dodecenol, 0.6 mg E8 dodecenil acetate, 8.82 mg E-5-Decen-1-ol acetate and 1.68 mg E-5-Decen-1-ol. They were installed at 2,500 units per ha, twice in every season.

Sprayable pheromone formulations: CheckMate® OFM-F microcapsules. The microencapsulated formulation is product of Suterra (Oregon, USA) It contains 231 g of orfamone. The microcapsules have a diameter of approximately 80-100 μm. They were applied at 23.1 g a.i. per ha, at 30-31-day intervals. The total amount of pheromones applied per ha was about 100 ml per ha.

Borders: In our trials the application rates were increased at the borders. Additionally, the dispensers were installed at the borders of conventionally treated orchards, located close to the trial orchards. In our trials we used mainly isolated orchards, located far away from any sources of infestation.

Supplemental treatments: High OFM, PTwB and PFM population is the most important limitation to the successful use of MD. In orchards with high pest populations, application of supplemental insecticides and/or intensive sanitation (Judd et al., 1997) is essential for reducing the high population density to levels low enough to achieve a commercially acceptable control.

Monitoring of OFM, PTwB and PFM in the trial orchards: In our trials the flight of oriental fruit moth, peach twig borer and plum fruit moth was monitored in the experimental plots as well as in the reference, conventionally treated orchards. For that purpose different kind of pheromone traps were used: sticky Delta traps (RAG), product of Csalomon® Hungary, sticky Delta traps Pherocon® IC – Pherocon® VI, Pherocon® IIB of Trécé Inc., USA and standard triangular traps PheroNet, Sweden. The lures were baited with 1 mg of funemone (for PFM), 1 mg orfamone (for OFM) or by 1 mg anemone (for PTwB). The traps were checked daily until biofix and twice a week thereafter. The caught moths were recorded and removed at every check.

Estimation of shoot and fruit damage during the season: The damage to shoots by OFM and PTwB were checked during the activity of larvae of the owerwintering and first summer generation. Damage to fruits by all three pests under study (OFM, PTwB and PFM) was checked during the season as well as before harvest and at harvest time. Fruit damage by OFM, PTwB and PFM was evaluated on samples of 1000 to 2000 fruits periodically during the season and on 3000 fruits before harvest and at harvest. Sampling was always carried out in the reference orchard and in the trial plot at the same dates. Rate of fruit damage was expressed as percentage of damaged fruits.

Results and discussion

OFM, PTwB and PFM flight dynamics: No moths were caught by pheromone traps installed in our trial plots, during the whole season in any year of study. Obviously, the dispensers used completely inhibited the OFM, PTwB and PFM captures in the pheromone traps during the season. This indicated that mating disruption method was very successful.

Evolution of shoot and fruit damage during the season: In the all years of study no shoots were damaged by OFM and PTwB in the trial plots and the rate of fruit damage was rather below the economical threshold. During the period of study only positive results were noted with use of different kind of dispensers as well as with microencapsulated pheromone used. (Kutinkova et al., 2011), (Kutinkova and Dzhuvinov, 2012), (Kutinkova et al., 2012), (Kutinkova et al., 2012a), (Kutinkova et al., 2013), (Kutinkova et al., 2015), (Kutinkova et al., 2016).

Our studies have shown that the damage caused by OFM, PTwB and PFM larvae in the reference orchards were considerable, in spite of numerous insecticide applications. Apparently these pests present in Bulgarian orchards are already resistant to the commonly used insecticides. Resistance of OFM to organophosphate, pyrethroid and carbamate insecticides was detected by (Pree et al., 1998) and by (Kanga et al.,1990) in Canada. The authors considered resistance as the main cause of failure of conventional plant protection. Apparently a similar situation may occur in Bulgarian stone fruit

orchards; however is has not been documented by laboratory tests in respect to the stone fruit pests yet.

In the peach and apricot orchards involved in our trials the contemporary presence of both *Cydia molesta* and *Anarsia lineatella* was observed; thus it was necessary to control both pests at the same time in some years. So, in this case dual dispenser system against both pests should be preferred by the growers.

According to (Weakley et al., 1987) mating disruption method as alternative to conventional insecticide use offers several advantages: (1) it is nontoxic to the applicator, field workers, fish, and other wildlife; (2) the pheromone treatments do not kill beneficial insects or mites and (3) with pheromone use one avoids the difficult management decisions associated with scheduling insecticide sprays against fruit moths around inclement weather or irrigation, thinning or harvest operation.

The usage of CIDETRAK® OFM/PTB MESO in the last two years shows that the number of dispensers used does not affect the effectiveness of mating disruption. The reduced rate of dispensers used will help the growers to decrease labour in the field.

Conclusion

Mating disruption alone is a sufficient means of control, when the population pressure of the pests is low. When the population density is high, additional supplemental treatments are needed. The validation of the novel MD technology for control of main fruit pests on stone fruits and finally their implementation into the farming systems in Bulgaria should favour an improvement of environmental and human health condition.

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