Integrated Fruit Protection in Fruit Crops
IOBC/wprs Bulletin Vol. 54, 2010
pp. 657-662

Isomate C plus dispensers as alternative means for control of codling moth, Cydia pomonella (L.), in apple orchards of Bulgaria

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Abstract: In the years 2006-2008, trials on the control of codling moth (CM) by mating disruption (MD) using Isomate C plus dispensers were carried out in an isolated 1-ha apple orchard in South-East Bulgaria. Dispensers were hung in the upper third of tree canopies at a density of 1000 pieces per ha before CM flights started. Dynamics of CM flights was monitored by pheromone traps installed in the trial plot and in a conventionally treated reference orchard. Fruit infestation was periodically assessed till harvest time. Hibernating population of CM was estimated in autumn by counting diapausing CM larvae in corrugated cardboard bands. In each of the years, Isomate C plus dispensers completely inhibited CM captures in pheromone traps in the trial plot. Fruit damage remained at low levels till late July and increased slightly only in August. At harvest the percentage of damaged fruits was below 1%. The hibernating population also stayed at low level. In the reference orchard, in spite of numerous chemical treatments, the final fruit damage was high (5.5-28.4%), apparently due to resistance of CM to insecticides. It has been concluded that mating disruption may serve as an alternative means for control of codling moth in Bulgarian apple orchards. Contrary to reports from other countries, this study has shown that good results from MD can be obtained even on a small-size plot, if isolated from external sources of infestation and if initial CM population is low.

Key words: IPM, apple, codling moth, mating disruption, fruit damage, Isomate C plus dispensers

Introduction

Codling moth (CM), Cydia pomonella L. (Lepidoptera: Tortricidae) is a key pest of Bulgarian pome fruit orchards. Most of recently applied insecticides have a large spectrum of action, so that they eliminate the beneficial entomo- and acarofauna, thus provoking the multiplication of other pests. Moreover, control of CM by conventional methods, in spite of numerous treatments applied, is often ineffective. In Bulgaria, the damage caused by codling moth in apple orchards has steadily increased. In 2008, in most of conventionally treated orchards in South Bulgaria fruit damage due to CM exceeded 25%. This has been apparently due to the development of resistant CM strains. Populations resistant to organophosphates and pyrethroids have been detected by testing diapausing CM larvae collected in some orchards in South Bulgaria (Charmillot et al., 2007). Therefore, the implementation of non-chemical methods for management of this pest is an urgent need. Mating disruption (MD) is one of the alternative means of control. Isomate-C dispensers, emitting synthetic CM pheromones, were released by Shin-Etsu (Japan) as early as in 1989 and then improved and successfully applied in many countries (Veronelli & Iodice 2004). Positive results obtained in trials carried out in Central-South Bulgaria were reported in a previous paper (Kutinkova et al. 2009).

Material and methods

Trial orchard

In the years 2006-2008, trials were carried out in a well-isolated, 1-ha apple orchard in the village Glufishevo, Sliven region, South-East Bulgaria. The orchard was established in 1999. In three consecutive years the dispensers were installed in April, before the expected start of flight of CM. They were hung in the upper third of tree canopies at a density of 1000 pieces per ha. According to the manufacturer, each dispenser is loaded with a minimum of 190 mg of the codling moth pheromone mixture.

Against other pests, only one acaricide treatment was applied in 2006 and two aphicide treatments in 2007 and 2008 as follows: phenpyroximat against mite Panonychus ulmi Koch on August 8, 2006 and thiamethoxam against aphids on May 23, 2007 and on May 25, 2008.

Reference orchard

A 4.8ha orchard located in the same area, near the city of Sliven, established in 1990 served as a conventionally treated reference. Fourteen treatments (21 active ingredients) were applied there during the 2006 and 2007 seasons, to control CM, leaf miners, leaf rollers, aphids and mites. Thirteen of them (19 active ingredients) were timed against codling moth. In 2008 seventeen treatments (24 active ingredients) were applied; fifteen of them (22 active ingredients) were supposed to have an action against CM. The insecticides used included methoxyphenozide, triflumuron, cipermethrin with chlorpyriphos-ethyl and fenitrothion in all three years of the study and additionally alpha-cipermethrin in 2006, esfenvalerate in 2007 and deltamethrin in 2008.

Indices studied

Monitoring of CM flights was carried out by sex trapping. Two CM pheromone traps were installed in the trial orchard – 1 triangular traps baited with a standard capsule (Pheronet OP-72-T1-01) containing 1mg codlemone and 1 triangular trap baited with 20mg codlemone in 2006 and 2 triangular traps baited with a standard capsule (Pheronet OP-72-T1-01) containing 1mg codlemone in 2007 and 2008. In the reference orchard, 2 triangular traps were placed. All traps were installed prior to the beginning of flight of CM and then checked twice a week.

Fruit damage by CM was evaluated on samples of 1000 to 2000 fruits periodically during the season and on 3000 fruits before and at harvest. Sampling was always carried out in the reference orchard and in the trial plot at the same dates.

In June, 40 corrugated cardboard band traps (8 at the border and 32 inside) were attached to the tree trunks in the trial plot and in the reference orchard. They were recovered in autumn, after harvest, in order to count the hibernating population of CM.

Elaboration of data

Data on catches of male moths in the pheromone traps were considered as totals for each date and presented in a graphical form. Rate of fruit damage by CM was expressed as percentage of damaged fruits. Significance of differences in damage rate between the trial reference orchards was estimated by use of Chi-square tests. Significance of differences between mean values of diapausing larvae between the orchards and years was evaluated using the t-test.

Results

CM FLIGHT DYNAMICS

In 2006, the first flight of CM in the reference orchard appeared on May 2, whereas no moths were recorded in the pheromone traps that were installed in the trial plot two weeks before. The flights of the overwintering generation reached their maximum by the fourth week of May (Fig. 1) and remained considerable till the end of June. The flights of the second generation, which overlapped the first one, started in the first week of July, reached its maximum at the end of July, then decreased till mid-August and finished on September 9. In the trial plot the sex pheromone traps have not caught any moth during the season. The traps installed in the reference orchard caught 128 moths in total.

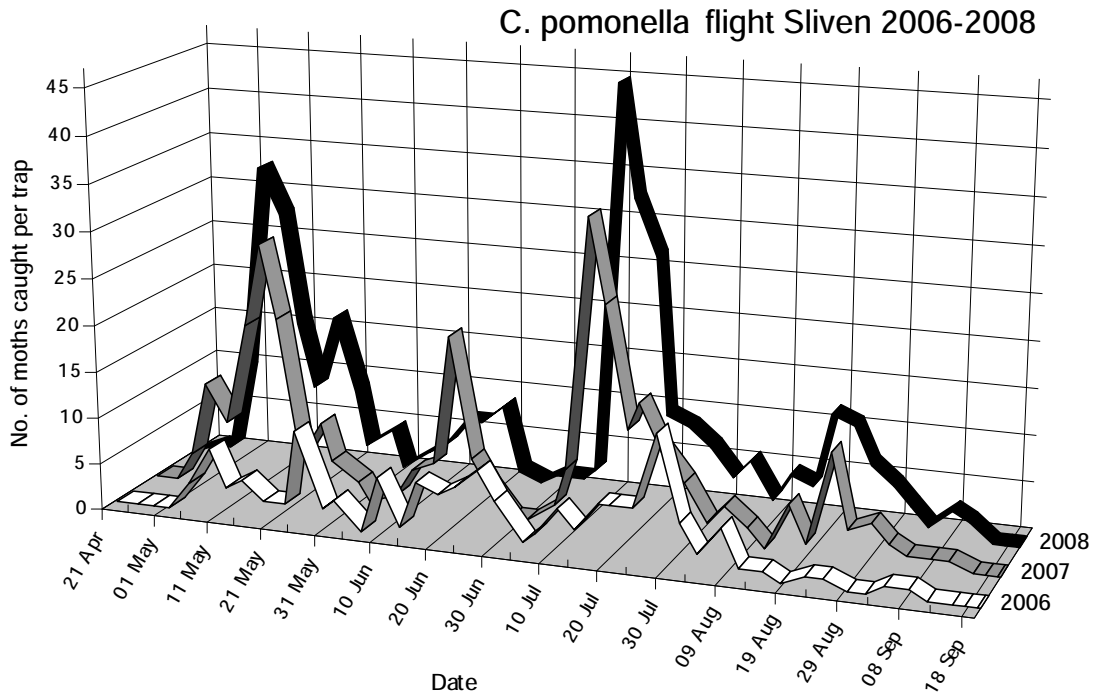

Fig. 1. Captures of male codling moth, Cydia pomonella, per pheromone trap in the reference orchard 2006-2008

In 2007, the first flights of codling moth in the reference orchard appeared on April 30, whereas no moths were recorded in the pheromone traps in the trial plot. The flight of the overwintering generation of CM reached its maximum in the second week of May and after the second week of June (Fig. 1) The flight of the second generation, which did not overlap the first one, started in the first week of July, reached its maximum during the second week of July, decreased in August and finished on September 14. In the trial plot the standard sex traps have not caught any moth during the 2007 season. At the same time the traps installed in the reference orchard caught in total 283 moths.

In 2008, the first flights of codling moth in the reference orchard appeared on April 25, whereas no moths were recorded in the pheromone traps installed before in the trial plot. The flight of the overwintering generation of CM reached its maximum in the first week of May (Fig. 1) and continued through May and June. The flight of the second generation, which overlapped the first one, started by the end of June, reached its maximum during the second

week of July, then decreased in August. A small peak appeared at the end of August. It was probably due to a partial third generation, but this was not well documented yet. The last flights were recorded on September 12. Traps installed in the reference orchard caught in total 359 moths. In the trial plot no moths were caught during the 2008 season.

Fruit damage by CM

In the trial plot, where the Isomate-C plus dispensers were installed, no damage of fruits due to CM was noted till July in the years 2007 and 2008 and even till the beginning of August in 2006 (Table 1). Then fruit damage stayed at a low level, reaching finally 0.4-0.7% at harvest. In the reference orchard, located in the same regions and treated with a conventional protection programme the first signs of damage to fruitlets were noted already in June, then the rate of damage successively progressed, reaching very high values at harvest. It is worth noting that the final rate of damage increased in consecutive years – from 5.5% in 2006, through 14.8% in 2007 and as much as 28.4% in 2008.

Table 1. Evolution of fruit damage (% of fruits infested by CM) and number of hibernating CM larvae in corrugated paper bands in autumn, in particular years of study

2006			2007			2008		
Date	Trial	Reference	Date	Trial	Reference	Date	Trial	Reference
June 1	**0.0**	**0.5**	June 9	0	0.8	June 8	0	0.6
June 15	**0.0**	**1.5**	June 25	0	3.5	June 21	0	3.7
July 13	**0.0**	**1.8**	July 5	0	0.0	July 18	0	2.6
Aug 4	**0.0**	**2.4**	July 29	0.2	5.8	Aug 10	0.3	10.5
Aug 23	**0.05**	**4.1**	Aug 12	0.3	9.8	Aug 23	0.4	14.5
Sept 14	**0.35**	**5.2**	Sept 6	0.4	13.2	Sept 7	0.6	23.8
Oct 2	0.40	5.5	Oct 3	**0.5**	14.8	Oct 3	0.7	**28.4**
damage preharvest	0.35	5.2	damage preharvest	**0.4**	13.2	damage preharvest	0.6	**23.8**
damage at harvest	0.40	5.5	damage at harvest	**0.5**	14.8	damage at harvest	0.7	**28.4**
hibernating larvae per tree	0.125	2.175	hibernating larvae per tree	**0.225**	**4.575**	hibernating larvae per tree	**0.425**	**9.025**

Infestation rates in 2006 were significantly different between the treated plot and the reference orchard from the second check on 15 June till harvest (Chi-square tests, $P<0.001$). In 2007, they were significantly different between the treated plot and the reference orchard already at the first control in June (Chi-square test, $P=0.014$) and, except for July 5, thereafter until harvest (Chi-square tests, $P<0.001$). In 2008, fruit damage rates were significantly different between the treated plot and the reference orchard already at the first control in June (Chi-square tests, $P=0.002$) and thereafter until harvest (Chi-square tests, $P<0.001$).

Overwintering population of CM

In autumn 2006, i.e. after the first season of MD treatment, only 0.125 larvae per tree were found in corrugated cardboard bands in the trial orchard. At the same time in the reference orchard the overwintering population of CM reached 2.175 larvae per tree (Table 1). In the

successive years (2007 and 2008) the level of overwintering population of CM in the trial plot increased slightly, stayed below the economical threshold, however. At the same time the population of diapausing larvae of CM in the reference, conventionally treated orchard increased rapidly in successive years, reaching in autumn 2008 the value more than 4 times higher than in autumn 2006.

The populations were significantly different between treated plot and reference orchard (t-test, $P<0.001$) as well as between the years 2006 and 2007 in the reference orchard (t-test, $P<0.001$). In the treated orchard there was no difference in the overwintering population between 2006 and 2007 (t-test, $P=0.24$). In 2008, the hybernating CM populations were significantly different between treated plot and reference orchard (t-test, $P <0.001$) as well as between the years 2007 and 2008 in both treated plot and reference orchard, respectively (t-test, $P<0.001$).

Discussion

The results obtained in this study confirm the findings of Charmillot et al. (2007) that resistance of codling moth to insecticides is a serious problem in Bulgaria. The conventional chemical control of CM is getting ineffective. Increasing intensity of CM flights as well as increased fruit damage and diapausing CM larvae population in the conventionally treated orchard – in spite of numerous chemical treatments – do indicate that the problem of resistance is aggravating.

Results obtained with mating disruption were very positive. Isomate C plus dispensers of Shin Etsu effectively inhibited flights of CM as well as fruit damage and the size of the hibernating CM population. The results obtained are in line with those reported by Gut et al. (1992), Gut and Brunner (1998), Judd et al. (1996), Barnes & Bloomefield (1997), Charmillot et al. (1997), Waldner (1997) and Zingg (2001). They also confirm our previous reports (Kutinkova et al. 2009). It is worth noting that in our study the positive results with the MD method were obtained in a rather small orchard lot (1ha). Apparently, isolation from external sources of infestation and the initial level of CM pressure are more important factors than the orchard size. It has been concluded that mating disruption may be successfully applied as alternative means for controlling codling moth in apple orchards of Bulgaria. Implementation of this method should result in reduction of the use of chemical insecticides, thus minimising environmental pollution and improving fruit quality.

Acknowledgements

This study was supported with a grant of the Swiss National Science Foundation (SNSF) to JS (project no. IB73A0-110978). Isomate C plus dispensers of Shin-Etsu were kindly provided by CBC (Europe), Ltd., Milano, Italy.

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