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CONTROL OF CODLING MOTH IN BULGARIA WITH A COMBINATION OF ISOMATE C PLUS DISPENSERS AND THE BACULOVIRUS PRODUCT MADEX®

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Abstract: In the years 2007–2009, trials on control of codling moth (CM), *Cydia pomonella* (L.), were carried out in apple orchards of South-East Bulgaria, where the pressure of the pest was very high. Mating disruption with Isomate C plus dispensers was applied in combination with sprays of the virus product Madex®. With a single installation of Isomate C plus dispensers per season + 4 treatments of Madex® at 100 ml per ha against the first and 6 treatments against the second generation, fruit damage at harvest and population density of codling moth were kept at a low level. At the same time fruit damage and population density of the pest, as estimated by the hibernating CM larvae population, was very high in the conventionally treated orchard serving as a reference. Using Isomate C plus dispensers and the baculovirus product Madex® may be a promising alternative to traditional programmes trying to control high initial infestation of codling moth. For Bulgaria, the combined tested strategies of mating disruption and virus control are suggested for control of codling moth in the orchards with CM population density of more than 3 larvae per tree or more than 5% fruit damage in the previous year.

Key words: apple, codling-moth, *Cydia-pomonella*, mating-disruption, Isomate C plus, CpGV, Madex®, flight-dynamics, fruit-damage, hibernating larvae

INTRODUCTION

Codling moth (CM), *Cydia pomonella* (L.), is causing heavy losses in apple production in Bulgaria. In some commercial orchards, in spite of numerous treatments with chemical pesticides, fruit damage rate is still very high. A steady increase of diapausing CM larval population was noted by Kutinkova *et al*. (2008, 2008b, 2009). Conventional methods of controlling codling moth became ineffective, apparently due to appearance of CM strains resistant to commonly used insecticides. The latter was proved in the study of Charmillot *et al*. (2007), who detected resistance to organophosphates and pyrethroids by testing diapausing CM larvae collected in several Bulgarian orchards.

Intensive use of chemicals, and thereby risking pesticide resistances, is also in contradiction with the principles of sustainable horticulture. Chemical pesticides create the risk of contaminating fruits with toxic residues. Recently, the regulation of the European Union banned the use of many insecticides. An alternative to conventional methods of control may be pheromone-based Mating disruption (MD) and the products based on the granulosis virus of CM (CpGV).

Mating disruption (MD) has been tested since the early nineteen-nineties in Switzerland and South Tyrol, Italy (Charmillot 1995; Zingg 2001; Veronelli and Iodice 2004). Later it was also tested in other countries worldwide, as the USA (Gut and Brunner 1998), Canada (Judd *et al*. 1996) or South Africa (Barnes and Bloomefiekd 1997). In Bulgaria, trials with MD for control of codling moth have been recently conducted by Kutinkova *et al*. (2007, 2010, 2009). Results were mostly positive when the CM population was at a low or moderate level. Under high pressure pest conditions, combining both methods was recommended by Miñarro and Dapena (2000) and by Charmillot and Pasquier (2003). This strategy brought also success in the experiments of Dabrowski and Olszak (2007) in Poland, and of Kutinkova et al. (2008, 2008a) in Bulgaria.

In the orchards of South Bulgaria the pressure of codling moth is high and resistance of CM to pesticides is apparently common. The objective of this study was to assess the effectiveness of the mating disruption method, in combination with a granulosis virus product under the above described conditions.

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MATERIALS AND METHODS

The experiment was carried out in the years 2007–2009 in a commercial apple orchard, established in 1990 in the village Samuilovo, Sliven region, South-East Bulgaria, on a 0.8 ha plot. Granny Smith, Macspur and Melrose cultivars were grown in this orchard. According to the manager of the orchard, codling moth pressure was high with above 30% of fruits damaged at harvest in 2006. However, the initial CM hibernating CM larvae population density was unknown. Isomate C plus dispensers of Shin-Etsu (Japan) were installed on this plot at a density of 1 000 pieces per ha, in 2007 on April 24, in 2008 on April 19, and in 2009 on April 23. The dispensers were hung in the upper third of the tree crown. Madex®, the product of Andermatt Biocontrol AG (Switzerland), containing the granulosis virus of codling moth (CpGV) was applied at a dosage of 100 ml per ha (3x10^{12} granules per ha), 10 times in each season, at 10–14-day intervals starting from the 2nd week of May.

Another, 4.8 ha orchard, located in the vicinity, served as a reference. At the reference orchard, 14–17 insecticide treatments were applied during the season, from the end of April till the beginning of September, to control CM, leaf miners, leaf rollers, aphids and mites. Of those, 13–15 insecticide treatments were timed against codling moth. Mainly organophospates were used and some pyrethroids, most frequently cipermethrin + chlorpyrifos-ethyl and fenitrothion. In spite of numerous insecticide treatments, fruit damage by CM was quite high there and reached 5.2% at harvest in 2006. Initial hibernating CM larval population, estimated in corrugated cardboard paper bands, was also considerable, amounting to 2.18 larvae per tree in the autumn of 2006.

In both orchards (trial and reference) dynamics of CM flights were monitored by use of pheromone traps. Two triangular, standard traps, baited with a standard capsule (Pheronet OP-72-T1-01) containing 1 mg codlemone, were installed in the reference and in the trial plot prior to the beginning of flights in each season. Traps were inspected twice a week. The caught CM moths were counted and removed. Evaluation of fruit damage was carried out in each plot several times during the season on 1 000 fruits, and before harvest as well as while at harvest on 2 000 fruits. In June, corrugated cardboard paper band traps were placed on the tree trunks in both plots. In each plot the bands were placed on 40 trees – 8 at the borders and 32 inside. They were recovered in autumn, in order to count the diapausing larvae and thus to estimate the hibernating population of codling moth.

RESULTS

Flights of CM in the reference orchard varied depending on the season. In all three years of study they were, however, long lasting – from the end of April (25th to 30th) till the 2nd or even 4th week of September, with numerous peaks through two generations (Fig. 1). Small peaks of flights, appearing at the end of August every year, might indicate the occurrences of a partial third generation which became especially obvious in 2009 (Fig. 1). The total number of moths caught per season in the reference orchard increased from year to year (Fig. 2 A). The trend of increase between the years is statistically significant (Chi-square-test, Chi-square = 74.04, p = < 0.001). At the same time no moths were caught in the trial plot in any season.

Fruit damage by CM larvae in the reference orchard was high, in spite of numerous insecticide treatments. The first damaged fruitlets were noted every year at the beginning of June and the rate of damage increased toward harvest (Table 1). The final fruit damage was considerably higher in 2008 and 2009 than in 2007 (Fig. 2 B). In the trial plot, fruit damage was relatively low; only slightly exceeding the economical threshold at harvest in 2007 and 2008 (Fig. 2 B). Infestation rates in 2007 were signifi-

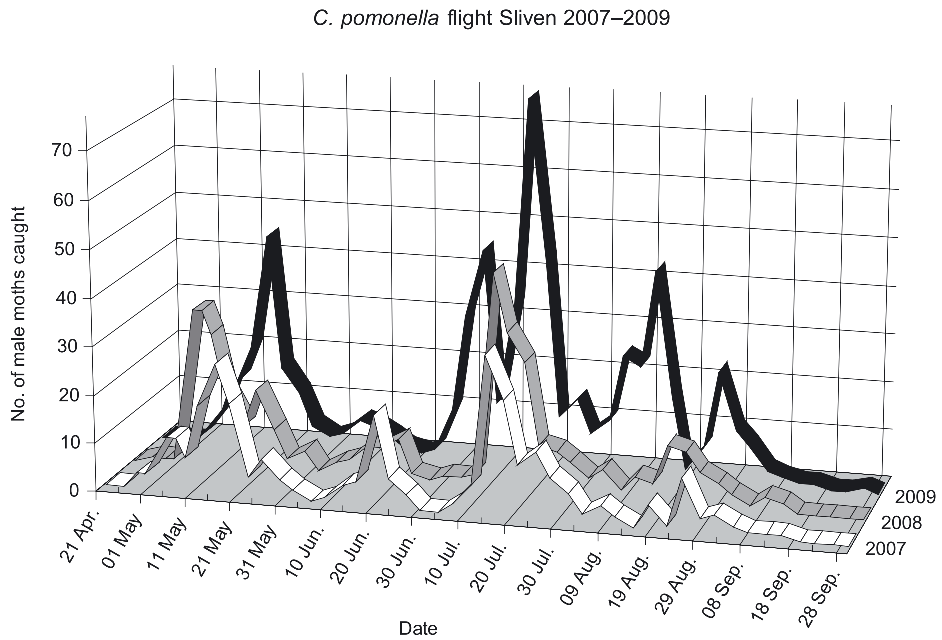

Fig. 1. Dynamics of Codling moth flights in the reference orchard in the successive years of study

Table 1. Evolution of fruit damage in the trial and reference orchard in successive seasons

2007				2008				2009			
Date	trial	reference	chi-squ.	date	trial	reference	chi-squ.	date	trial	reference	chi-squ.
Jun. 9	1.2	0.8	0.44 p = 0.51	Jun. 8	0.2	0.6	1.1 p = 0.29	Jun. 10	0.3	0.5	0.124 p = 0.725
Jun. 21	3.8	3.5	0.051 p = 0.82	Jun. 21	1.3	3.7	10.3 p = 0.001	Jun. 23	1	3.8	14.8 p < 0.001
Jul. 5	0	0	–	Jul. 18	0.9	2.6	7.17 p = 0.007	Jul. 15	0.2	2.3	15.8 p < 0.001
Jul. 29	0.8	5.8	35.2 p < 0.001	Aug. 10	1.6	10.5	60.4 p < 0.001	Aug. 09	1.1	9.6	62.6 p < 0.001
Aug. 12	1	9.8	66.5 p < 0.001	Aug. 23	1.8	14.5	90.2 p < 0.001	Aug. 26	1.4	15.7	109.0 p < 0.001
Sep. 05	2.1	13.2	73.6 p < 0.001	Sep. 07	2	23.8	163.0 p < 0.001	Sep. 04	1.6	21.5	153.2 p < 0.001
Oct. 3	2.5	14.8	82.5 p < 0.001	Oct. 3	2.2	28.4	207.4 p < 0.001	Oct. 05	2	31.7	453.6 p < 0.001
Pre-harvest	2.1	13.2	73.6 p < 0.001	pre-harvest	2	23.8	163.0 p < 0.001	pre-harvest	1.6	21.5	153.2 p < 0.001
At harvest	2.5	14.8	82.5 p < 0.001	at harvest	2.2	28.4	207.4 p < 0.001	at harvest	2	31.7	453.6 p < 0.001

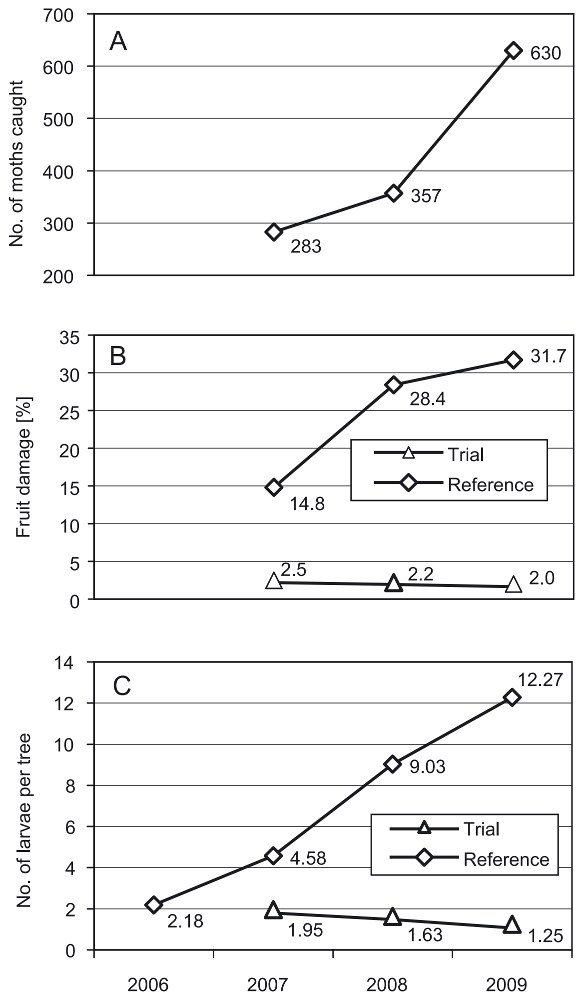

Fig. 2. Trends of development of Codling moth population in the reference orchard and in the trial plot – by different measures: A – total number of moths caught in two traps; not a single moth caught in the trial plot; B – final fruit damage at harvest; C – hibernating larval population

cantly different between the treated plot and the reference orchard from July 29 on until harvest (Chi-square tests, Table 1). In 2008 and 2009, infestation rates differed significantly between the treated plot and the reference orchard already from the second survey (June 21, June 23) and continued until harvest (Chi-square tests, Table 1).

The hibernating CM larvae population in the reference orchard, being conventionally treated, was high and steadily increased during the years of the study (Fig. 2 C). At the same time the hibernating larval population of the pest showed a tendency to decrease from year to year according to the fruit damage values (Fig. 2 B).

DISCUSSION AND CONCLUSIONS

The presented results confirmed our previous findings (Kutinkova *et al.* 2008, 2008b, 2009), pointing to a drastic increase of CM pressure in Bulgarian apple orchards. As proved by the laboratory tests of Charmillot *et al.* (2007) on response of CM larvae to different insecticide, this was due to development of CM strains resistant to the commonly used organophosphates and pyrethroids. In this study a steady increase of intensity of CM flight as well as of the rate of fruit damage and of the hibernating larvae population has been noted in the reference orchard. The reference orchard was treated many times every season with different insecticides. This is demonstrated by the trends of development of different indices of CM density in this orchard – from year to year – in figure 2. Apparently due to the development of resistance, the conventional control programme became totally ineffective.

At the same time, in the trial plot the same direct and indirect measures of CM population density remained on a stable and rather low level, even with a slight tendency to decline (Fig. 2). This confirms that the combined programme, involving pheromone-based mating disruption and applications of the virus (CpGV) product provides a chance not only of immediate CM control, but also of a progressive reduction of the population of the pest in a heavily infested orchard. Based on the results of the recent study as well as on our previous trials and on results obtained in other countries, an alternative strategy has been proposed for control of codling moth in apple orchards with a high CM population density, i.e. more than 3 hibernating larvae per tree or more than 5% fruit damage. This strategy which is the core of the management programme is to make a single installation of Isomate C plus dispensers prior to the beginning of the first CM flights. This approach is then supported by 4 treatments of Madex® at 100 ml per ha against the first and 6th treatments of the same product against the second generation, each starting once the larvae hatch from the egg stage. This strategy should secure the effective control of the pest, avoiding any pollution of the orchard environment or fruits at the same time.

The results of this study do validate the findings of Miñarro and Dapena (2000), of Charmillot and Pasquier (2003) and of Dabrowski and Olszak (2007) in respect to the applied strategy of CM control. They are also in line with our previous experiments (Kutinkova *et al*. 2008, 2008a).

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POLISH SUMMARY

ZWALCZANIE OWOCÓWKI JABŁKÓWECZKI W BUŁGARII KOMBINACJĄ ZWIĄZKÓW ODSTRASZAJACYCH ISOMATE C PLUS I PRODUKTU MADEX Z BACULOWIRUSEM

W latach 2007–2009 wykonano doświadczenia nad zwalczaniem owocówki jabłkóweczki (CM) *Cydia pomonella* L. w sadach, w południowo-wschodniej Bułgarii, gdzie presja szkodnika jest bardzo wysoka. Wykorzystano przerwanie kojarzenia związkami Isomate C Plus w kombinacji z opryskiwaniem preparatem wirusowym Madex®. Przy jednym użyciu odstraszacza Isomate C Plus, w ciągu sezonu + 4 zabiegi preparatem Madex®, w ilości 100 ml/ha, w porównaniu do pierwszego i sześciu zabiegów przeciwko drugiej generacji, uszkodzenie owoców w czasie zbioru i gęstość populacji owocówki jabłkóweczki zostały utrzymane na niskim poziomie. W tym samym czasie uszkodzenie owoców i gęstość populacji szkodnika określona przy wykorzystaniu danych o zimujących larwach owocówki była bardzo wysoka w sadzie traktowanym metodą konwencjonalną. Wykorzystanie odstraszacza Isomate C Plus i produktu z bakulowirusem Madex® może być obiecującą alternatywą dla tradycyjnych programów zwalczania owocówki jabłkóweczki, w przypadku wysokiego poziomu początkowego porażenia. Sugeruje się badanie, kompleksowe przerywanie kojarzenia i strategię zwalczania wirusów w sadach, w celu zwalczania owocówki jabłkóweczki przy wzięciu pod uwagę gęstości populacji wynoszącej ponad 3 larwy na drzewie lub więcej niż 5% uszkodzenia owoców w poprzedzającym roku.