*Pheromones and other Semiochemicals*
*IOBC/wprs Bulletin Vol. 41, 2009*
*pp. 27-32*

# Mating disruption of codling moth, C*ydia pomonella* (L.), using Isomate C plus dispensers in apple orchards of Bulgaria

**Hristina Kutinkova[1], Jörg Samietz[2], Vasiliy Dzhuvinov[1], Pierre-Joseph Charmillot[2], Vittorio Veronelli [3]**
[1] *Fruit Growing Institute, Ostromila 12, 4004 Plovdiv, Bulgaria, kutinkova@abv.bg*
[2] *Swiss Federal Research Station Agroscope Changins-Wädenswil, Switzerland*
[3] *CBC (Europe) Ltd., Milano, Italy*

**Abstract.** Codling moth, *Cydia pomonella* (L.) (Lepidoptera: Tortricidae), is an important pest of pome fruit and walnut orchards throughout the world and the respective key pest in Bulgaria. Codling moth resistance to many insecticides has been recently detected in Bulgaria. As part of anti-resistance strategy mating disruption with Isomate C plus dispensers (ShinEtsu, Japan) was tested against codling moth (CM) in the two consecutive years 2006 and 2007. In both years Isomate-C plus dispensers inhibited completely the CM captures in the pheromone traps installed in the experimental plot. This indicated that mating disruption was very successful. Before harvest, damage stayed there at in a low level – 0.06% in 2006 and 0.5% in 2007. As comparison in the conventionally treated orchard, eleven to fifteen treatments (17-23 active ingredients) were applied during the season to control CM, leaf miners, leaf rollers and San Jose scale. Eight to fourteen of them (14-21 active ingredients) were timed against codling moth. In spite of that, fruit damage before harvest reached 3.4% in 2006 and 5.2 in 2007. The overwintering population in autumn 2006 reached 1.1 larvae per tree, but increased to 3.3 larvae per tree in 2007. CM population in the conventionally treated orchard was apparently resistant The results of this investigation will open the possibilities for usage of the pheromone dispensers as an alternative measure to control codling moth in Bulgaria. This should promote ecological fruit products and preservation of the natural environment, in accordance with the European standards for integrated fruit production. The studies are being continued.

**Key words:** Integrated fruit production**,** codling moth, mating disruption, Isomate C plus dispensers,

## Introduction

The codling moth, *Cydia pomonella* (L.), is the major pest in apple orchards worldwide (Dorn et al. 1999). In spite of relatively large number of chemical insecticides available for control of the species, the codling moth (CM) continues to pose a serious threat, especially because of development of resistance to various groups of insecticides in many countries (Pasquier & Charmillot 2003). In Europe, resistance is a relatively recent problem and appeared first in the early nineties of the past century. Insecticides, the effectiveness of which has been reduced by development of 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, 2002a, 2000b; Ioriatti & Bouvier, 2000). The laboratory studies carried out by Becid (1997) in France have confirmed the development of resistance and of cross-resistance to all insecticides used for conventional control. Despite of a growing use of insecticides, damage caused by codling moth in Bulgarian apple orchards has steadily increased from 2002 till 2007. Now the crop damage has exceeded the economical threshold; for example, in some regions of South Bulgaria it regularly amounts to more than 15%, even under conventional insecticide treatments.

Charmillot et al. (2007) detected resistance of CM to organophosphates and pyrethroids, by testing diapausing CM larvae collected in some Bulgarian orchards in autumn 2005 and 2006. Therefore, an urgent need appeared for turning to novel, low toxicity means of control of codling moth. Mating disruption (MD) is one of these promising methods. One of the first pheromone product used for MD has been Isomate C (Shin Etsu Chemical Ltd., Japan) appeared on the market in 1989 (Veronelli & Iodice 2004). Since then they have been tested on a large scale in major apple growing regions world-wide. Mostly positive results, consisting in suppressing catches of male CM moths and reducing fruit damage were obtained by Gut et al. (1992) in Washington State (USA), Judd et al. (1996) in British Columbia, Canada, Barnes & Bloomfield (1997) in South Africa, Charmillot et al. (1997) in Switzerland and Waldner (1997) in South Tyrol, Italy. It has been noted, however, that good suppression of CM population and maintaining fruit damage below the economical threshold was possible when the initial CM densities were low (Gut & Brunner 1998). At higher densities of the pest, an increase of number of dispensers (above the standard 1000 per ha) may provide a more effective control (Gut & Brunner 1994).

Isomate C plus dispensers have been increasingly applied in organic and integrated fruit production in the EU. For instance, in Italy the area of pome fruit orchards covered with this product exceeded 15,000 ha already in 2002 (Veronelli & Iodice 2004).

## Material and methods

### *Trial orchard*

The well-isolated apple orchard in the village Bogomilovo, Stara Zagora region, Central-South Bulgaria, occupies an area of 4 ha, consisting of two plots (3 ha and 1 ha), separated by a canal. The orchard was established in spring 2003 with the cultivars Gloster 69, Golden Resistance, Mutsu, Melrose and Granny Smith. At one side of the trial apple orchard some old pear trees were growing. The level of previous damage of apples by CM was below 2%. The experiment was carried out in 2006 and 2007.

In both years Isomate C plus dispensers were installed in the trial orchard in April, before an expected start of flight of CM. The dispensers were hung on trees, in the upper third of the crowns, at a density of 1000 pieces per ha. According to the manufacturer, each dispenser was loaded with a minimum of 190 mg of the codling moth pheromone mixture.

Against some other pests, only one insecticide treatment was applied in 2006 and three aphicide treatments in both years as follows: in 2006 – acetamiprid against aphids on July 15 and cipermetrin + clorpyrifos-ethyl against the fall webworm (*Hyphantria cunea* Drury) on August 23 and in 2007 – thiamethoxam on May 21 and acetamiprid on July 16 against aphids.

### *Reference orchard*

A 5-ha orchard located in the same area near the city of Stara Zagora served as a conventionally treated reference. In 2006 eleven treatments (17 active ingredients) were applied there to control CM, leaf miners, leaf rollers and San Jose scale. Eight of them (14 active ingredients) were timed against codling moth. In 2007 fifteen treatments (23 active ingredients) were applied; fourteen of them (21 active ingredients) were supposed to have an action against codling moth. The insecticides used included cipermetrin with clorpyrifos-ethyl, triflumuron, fenitrotion and esenvalerate in both years and additionally lambda chalothrin in 2006.

### *Indices studied*

Monitoring of CM flight throughout the season was carried out by field trapping. Four traps baited with synthetic pheromone were installed in the trial orchard – 3 triangular traps baited

with a standard capsule (Pheronet OP-72-T1-01) containing 1 mg codlemone and 1 triangular trap baited with 20 mg codlemone. 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; the caught male moths were counted and removed.

Fruit damage by CM was evaluated on 1000 or 2000 fruits periodically during the season and on 3000 fruits before harvest in both MD and reference orchards.

In June, 40-60 corrugated cardboard band traps (8-12 at the border and 32-48 inside) were put on 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 of control and presented in a graphical form. The rate of fruit damage by CM was expressed as percentage of damaged fruits. Significance of differences in damage rate between the trial reference orchard was estimated by use of Chi-square tests. Significance of differences between mean values of diapausing larvae between the orchards and the years was evaluated using the t-test.

## Results

***CM flight dynamics***

In 2006 flights of the overwintering generation of CM in the conventionally treated orchard started on April 24, reached the maximum by the 2nd decade of May and remained considerable till the end of June (Figure 1). Flight of the 2nd generation overlapped the first one; it apparently began at the beginning of July, reached maximum in the 3rd decade of July, decreased in mid-August and finished on October 3. Traps in the reference plot caught 521 moths in total.

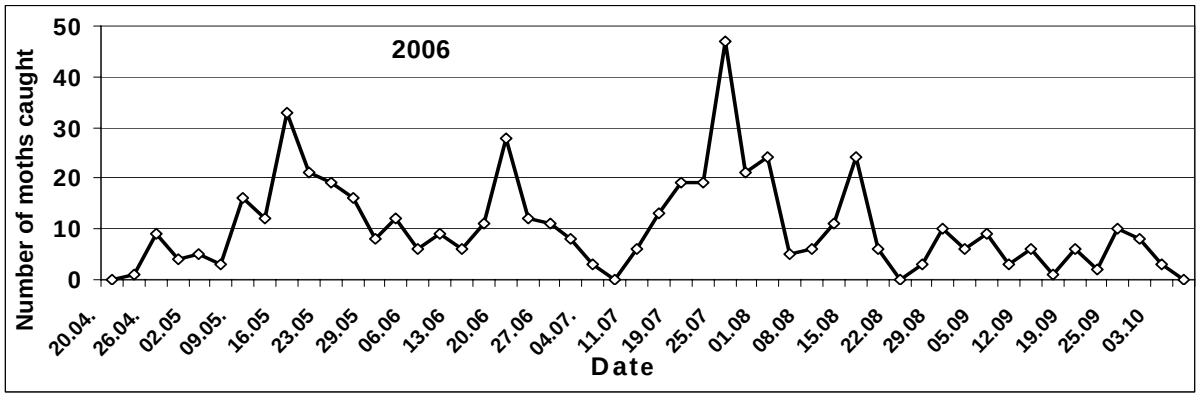


Figure 1. Captures of males codling moth in two standard traps in the reference orchard in 2006

In 2007 the CM flights in the reference orchard started on April 20 (Fig. 2). They reached the maximum in the first decade of May and, albeit with varying intensity, remained considerable till the second decade of June. The flight of the second generation, started in the first decade of July, reached its maximum during the second decade of July, then decreased in August. Some moths were still caught in September, the last one on September 28. In total, the traps of the reference orchard caught 576 moths.

In the trial orchard at Bogomilovo, where the Isomate CM plus dispensers were active, the pheromone traps did not catch any CM male moth neither in 2006 nor in 2007.

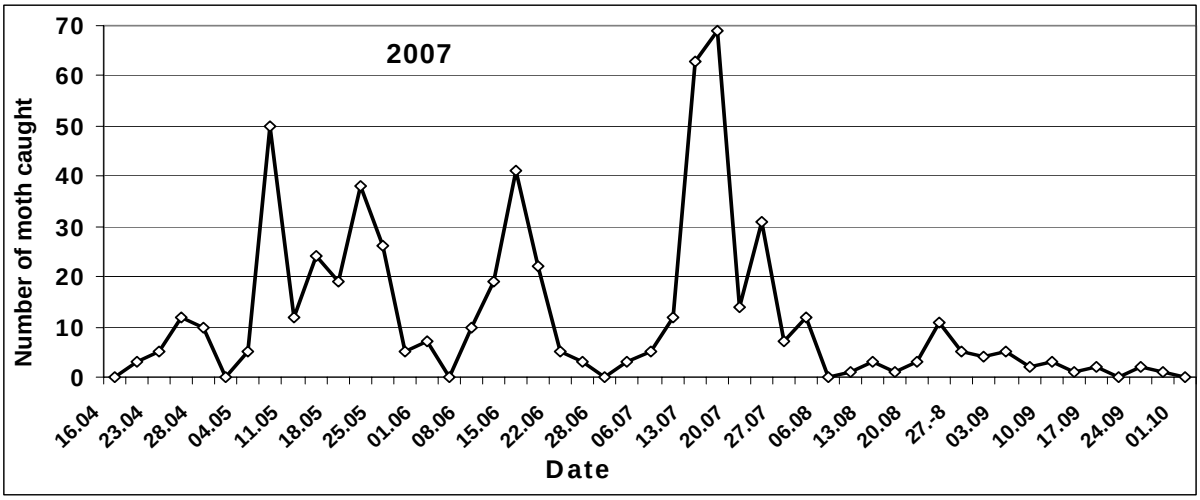


Figure 2. Captures of CM with two standard traps in the reference orchard in 2007

***Fruit damage by CM***

In 2006, in the trial orchard where the Isomate C plus dispensers were installed checks carried out till August 4 did not revealed any fruits damaged by codling moth larvae (Table 1). On August 23 few damaged fruits were found; but the damage rate was only 0.05% and stayed at a similar, very low level (0.06%) till harvest. In the reference orchard, with conventional insecticide treatments, damage progressed from 1.0% on June 15 up to 3.4% before harvest. Differences between the damage rates in the orchard treated with Isomate C plus and in the reference orchard were significant already at the first control in June and thereafter until harvest (Chi-square tests, $p < 0.001$).

Table 1. Percentage of fruits damaged by CM at different dates and overwintering CM population in two seasons

| 2006 | | | 2007 | | |
|---|---|---|---|---|---|
| Date | Isomate C plus | Reference | Date | Isomate C plus | Reference |
| June 1 | 0 | 0.08 | June 3 | 0 | 1.20 |
| June 15 | 0 | 1.00 | June 14 | 0 | 1.60 |
| July 14 | 0 | 1.50 | July 28 | 0.40 | 2.30 |
| Aug 4 | 0 | 1.80 | Aug 11 | 0.40 | 2.95 |
| Aug 23 | 0.05 | 2.20 | Aug 26 | 0.45 | 3.75 |
| Sept 14 | 0.06 | 3.40 | Sept 5 | 0.50 | 5.20 |
| preharvest | 0.06 | 3.40 | preharvest | 0.50 | 5.20 |
| Larvae/tree | 0.075 | 1.075 | Larvae/tree | 1.271 | 3.263 |

In 2007 the damage rate in the trial orchard was nil in June and only 0.4% at the end of July. Then it amounted to 0.45% in the third decade of August, 0.5% before harvest (on

September 5) and finally 2.1% at harvest (on October 4). In the reference orchard, with conventional treatments, damage progressed from 1.2% on June 3 up to 5.2% before harvest and finally to 6 % at harvest (on October 4). Also in 2007, differences between the damage rates in the orchard treated with Isomate C plus and in the reference orchard were significant already at the first control in June (Chi-square test, $p = 0.002$) and thereafter until harvest (Chi-square tests, $p < 0.001$).

***Overwintering population of CM***

In autumn 2006 only 0.075 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 1.075 larvae per tree (Table 1).

In autumn 2007 the overwintering population in the trial orchard, treated with Isomate C plus, amounted to 1.271 larvae per tree, whereas in the reference, conventionally treated orchard it reached 3.263 larvae per tree. The populations were significantly different between trial and reference orchard within a particular year (t-test, $P < 0.001$) as well as between the years 2006 and 2007 in both treated 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 fruit damage and diapausing CM larvae population in the conventionally treated orchard – in spite of numerous chemical treatments indicates that the problem is aggravating.

Results of mating disruption with use of Isomate C plus dispensers of ShinEtsu were, in general, very positive. Some increase of fruit damage just before harvest and especially at harvest in the second year of study could be due to a migration of female CM moth from the adjacent neglected pear trees and by the more favourable conditions for CM development that is also found in the control. In future this problem may be partly avoided by installment of dispensers on the pear trees too. It should be emphasised that even in the second year the damage in the trial plot was above the economical threshold. The results obtained are in line with those reported by Gut et al. (1992), Gut and Brunner (1994, 1998), Judd G.J. et al. (1996), Barnes & Bloomefield (1997), Charmillot et al. (1997), Waldner (1997) and Zingg (2001). Apparently mating disruption may be successfully applied in apple orchards of Bulgaria. Application of this biological method of control should help to avoid contamination of fruit products with residues of pesticides and should favour preservation of natural environment.

## 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 ShinEtsu were kindly provided by CBC (Europe), Ltd., Milano, Italy.

## References

Barnes, B.N. & Blomefield, T.L. 1997: Risultati preliminari con la confusione sessuale del tortricide ricamatore, *Tortrix capensana*, nei meleti del Sud-Africa. – Difesa delle Piante 20 (1/2): 49-53.

Bouvier, J.C., Brosse, V. & Sauphanor, B. 1995: Insecticides. La résistance du carpocapse. – L'Arboriculture Fruitière 479: 21-23.

Becid, P. 1997: Mating disruption of the codling moth, *Cydia pomonella*: experiences from the U.N.C.A.A. Arbotech Pool. – IOBC/wprs Bull. 20 (1): 79-82.

Charmillot, P.-J., Pasquier, D., Dorsaz, L., Keimer, C., Herminjard, P., Olivier, R. & Zuber, M. 1997: Lutte par confusion contre le carpocapse *Cydia pomonella* L. en Suisse en 1996 au moyen des diffuseurs Isomate-C Plus. – Revue Suisse Vitic. Arboric. Hortic. 29 (2): 91-96.

Charmillot, P.-J., Pasquier, D., Sauphanor, B., Bouvier, J.C. & Olivier, R. 1999: Carpocapse des pommes: premier cas de resistance au diflubenzuron en Suisse. – Revue Suisse Vitic. Arboric. Hortic. 31: 129-132.

Charmillot, P.-J. & Pasquier, D. 2002a: Progression de la résistance du carpocapse *Cydia pomonella* aux insecticides. – Revue Suisse Vitic. Arboric. Hortic. 34: 95-100.

Charmillot, P.-J., Pasquier, D., Dessimoz, S., Genini, M. & Olivier, R. 2002b: Résistance du carpocapse *Cydia pomonella* aux insecticides: tests par application topique sur des larves diapausantes collectées en automne 2001. – Revue Suisse Vitic. Arboric. Hortic. 34: 247-251.

Charmillot, P.-J., Pasquier, D., Salamin, C., Briand, F., Azizian, A., Kutinkova, H., Peeva, P. & Velcheva, N. 2007: Détection de la résistance du carpocapse *Cydia pomonella* par application topique d'insecticides sur des chenilles diapausantes de Suisse, d'Arménie et de Bulgarie. – Revue Suisse Vitic. Arboric. Hortic. 39 (6): 385-389.

Dorn, S., Schumacher, P., Abivardi, C. & Meyhöfer, R. 1999: Global and regional pest insects and their antagonists in orchards: spatial dynamics. – Agric. Ecosyst. Environ. 73: 111-118.

Gut, L.J. & Brunner, J.F. 1994: Implementation of pheromone-based pest management programs in pear in Washington, USA. – Bull. OILB/SROP 17 (2): 67-75.

Gut, L.J. & Brunner, J.F. 1998: Pheromone-based management of codling moth (Lepidoptera: Tortricidae) in Washington apple orchards. – J. Agric. Entom. 15 (4): 387-405.

Gut, L.J., Brunner, J.F. & Knight, A. 1992: Mating disruption as a control for codling moth and leafrollers. – Good Fruit Grower 43 (5): 56-60.

Ioriatti, C. & Bouvier, J.C. 2000: La resistenza agli insetticidi il caso della carpocapsa (*Cydia pomonella* L). – Informatore Fitopatologico 9: 5-10.

Judd, G.J., Gardiner, M.G, & Thomson, D. 1996: Commercial trials of pheromone-mediated mating disruption with Isomate-CReg. to control codling moth in British Columbia apple and pear orchards. – J. Entom. Soc. British Columbia 93: 23-34.

Pasquier, D. & Charmillot, P.J. 2003: Effectiveness of twelve insecticides applied topically to diapausing larvae of the codling moth, *Cydia pomonella* L. – Pest Manag. Sci. 60: 305-308.

Sauphanor, B., Benoît, M., Bouvier, J.M., Perron,G., Malezieux, S. & Fremond, J.C. 1994: Un cas de résistance du carpocapse des pommes au diflubenzuron dans le Sud-Est de la France. – Phytoma 458: 46-49.

Sauphanor, B., Brosse, V., Bouvier, J.C., Speich, P., Micoud, A. & Martinet, C. 2000: Monitoring resistance to diflubenzuron and deltamethrin in French codling moth populations (*Cydia pomonella*). – Pest Manag. Sci. 56: 74-82.

Sauphanor, B., Brosse, V., Monier, C. & Bouvier, J.C. 1998: Differential ovicidal and larvicidal resistance to benzoylureas in the codling moth, *Cydia pomonella*. – Entomol. Exp. Appl. 88: 247-253.

Veronelli, V. & Iodice, A. 2004: The use of Shin Etsu mating disruption system in Italy. – IOBC/wprs Bull 27 (5): 63-65.

Waldner, W. 1993: Rückblick und Vorschau auf die Bekämpfung des Apfelwicklers. – Obstbau Weinbau 12: 355-357.

Waldner, W. 1997: Three years of large-scale control of codling moth by mating disruption in the South Tyrol, Italy. – Bull. OILB/SROP 20 (1): 35-44.

Zingg, D. 2001: Mating disruption in Switzerland. – Bull. OILB/SROP 24 (2): 65-69.