Sustainable control of codling moth, *Cydia pomonella* L. in some apple orchards of Bulgaria

Kutinkova, H., Dzhuvinov, V., Palagacheva, N., Staneva, I., St. Gandev, G. Kornov and Bill Lingren

ABSTRACT

The codling moth (CM), *Cydia pomonella* L., is the key pest of pome fruits in Bulgaria. Reduction of pesticide use is an important consideration for human health as well as for conservation of biodiversity. Environmentally friendly methods such as semiochemicals are among the most promising. These trials were carried out during the years 2020 and 2021 in southeast Bulgaria to test the effectiveness of microencapsulated sprayable pheromones in apple orchards using CIDETRAK® CM MEC (pheromone) liquid formulations as well as the effectiveness of mating disruption (MD) using CIDETRAK® CMDA COMBO™ MESO™ - A dispensers at rate of 80 dispensers per ha. Monitoring of CM flights was implemented using pheromone or pheromone and kairomone lures with traps during the years of the study. The traps baited with standard PHEROCON® CM L2 lures were changed at 4-week intervals. We also used PHEROCON® CMDA COMBO™ - P + AA lures, which is a new product developed by Trécé Inc., USA for use in orchards with MD. The traps baited with PHEROCON® CM DA COMBO - P + AA lures were changed at 8-week intervals. The damage in the treatment plot increased slowly over time and even in late cultivars, fruit damage by CM was below the economical threshold from 0.1 to 0.2% in both years of the study. Comparatively, ten insecticide treatments were applied to the reference orchard located in the region during the season, targeting CM and other pests. Correspondingly, fruit damage at harvest in the reference orchard by CM was from 2.2 to 2.5%. The significance of differences in the damage rate between the trial and the reference orchard was estimated by Chi-square tests. These new products developed by Trécé Inc., USA can be used in organic farming and fits perfectly into any IPM system. The use of CIDETRAK® CM MEC and CIDETRAK® CMDA COMBO™ MESO™ - A dispensers will help growers to decrease the number of chemical treatments in the field. Introduction of these products for pest management should result in reduction of the use of conventional chemical insecticide treatments, thus resulting in less environmental pollution and improved food quality.

Key words: codling moth, *Cydia pomonella* L., apple, mating disruption, microencapsulated liquid formulations, pheromone dispensers

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INTRODUCTION

Apple trees are infested in Bulgaria by many pests. The codling moth (CM), *Cydia pomonella* L. (*Lepidoptera: Tortricidae*) is the key pest of pome fruits in Bulgaria. Its larvae feed internally within the fruits and cause severe damage to apples, pears, quinces, and walnuts. Until the present time it has been controlled by routine applications of a broad spectrum of insecticides, such as organophosphates, to maintain this pest at an economically acceptable level. Although environmentally compatible integrated control strategies, such as mating disruption, attract and kill strategy, and sterile insect technique have been conducted for management of this notorious pest, effects to

control of codling moth have mainly relied on insecticides. In consequence, different levels of insecticide resistance towards organophosphates, neonicotinoids, hydrazines, benzoylureas, pyrethroids, diamides, spinosyns, avermectins, JH mimics, carbamates, oxadiazines and *C. pomonella* granulovirus (CpGVs) have developed in CM in different countries and regions. (Reyes *et al.,* 2015; Bosch *et al.,* 2018; Balśko *et al.,* 2020; Solèno *et al.,* 2020; Di Ju *et al.,* 2021; Chao Hu *et al.,* 2022). The presence of strong insecticide resistance was reported for CM strains collected from some orchards in Bulgaria (Charmillot *et al.,* 2007). Despite numerous chemical treatments, these orchards show increasing population densities of CM moths, growing populations of overwintering larvae and increasing rates of fruit damage. Reduction of pesticide use is an important issue for human health as well as for conservation of biodiversity. Environmentally friendly methods such as microencapsulated semiochemicals including pheromones and kairomones are among the most promising. The aim of this study was to test the effectiveness of microencapsulated pheromone mating disruption in apple orchards using CIDETRAK® CM MEC (pheromone) liquid formulation for control of codling moth (CM) and CIDETRAK® CMDA COMBO™ MESO™ - A pheromone dispensers. These products were developed and are manufactured by Trécé Inc., USA.

MATERIALS AND METHODS

The trials were carried out during the years 2020 and 2021 in the Southeast region of Bulgaria. Monitoring of CM flights was implemented using pheromone or pheromone and kairomone lures with traps. PHEROCON® VI DELTA traps with replaceable adhesive liners were installed in the trial orchard using a layout provided by the manufacturer. All traps were installed before CM flights started. Traps were baited with standard PHEROCON® CM L2 pheromone lures, which were changed at 4-week intervals. We also used PHEROCON® CM DA COMBO - P + AA lures, which is a new product developed by Trécé Inc., USA for the orchards with MD throughout this study. These lures were changed at 8-week intervals. PHEROCON® VI DELTA traps baited with PHEROCON® CMDA COMBO™ - P + AA lures and standard CM L2 caps were installed for comparison in a reference control orchard located in the region that was treated with insecticides only. All pheromone traps were checked twice per week and adhesive trap liners changed at 4-week intervals in all traps, in all treatments for both years of the study.

CIDETRAK® CM MEC is a flowable microencapsulated CM pheromone, which we applied for mating disruption in addition to an insecticide treatment program. Accordingly, CM MEC was tank mixed with the insecticide designated for application at the recommended time interval within a series of insecticide treatments.

CIDETRAK® CMDA COMBO™ MESO™-A mating disruption dispensers contain a unique combination of CM pheromone and a patented male and female behavior modifying kairomone called DA. They are formulated to deliver long-lasting performance with remarkably fast application for apples, pears and walnuts. CIDETRAK® CMDA COMBO™ MESO™ - A provides a dramatic reduction of dispenser rate per hectare and increased performance. We used these dispensers at the dosage 80 dispensers per ha. The damage to apples was inspected during the season and at harvest on 2000 fruits.

RESULTS AND DISCUSSION

The figures below present the flight dynamics of codling moth in the trial and in the reference orchards in the region in 2020 and 2021 (Figures 1, 2, 3, 4 and 5). The pest developed two full generations each year of the study. Table 1 shows the percentage damaged fruits during the study.

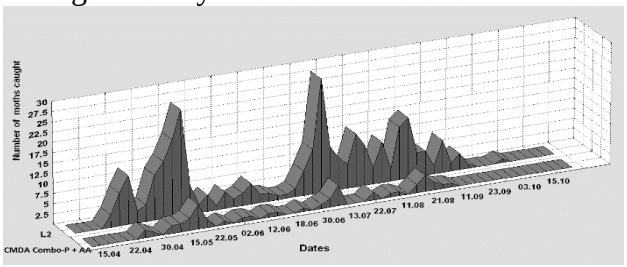

Figure 1. Flight dynamics of CM with CMDA COMBO - P + AA and CM L2 lures in the reference orchard treated with conventional insecticides only in 2020 in Sliven region.

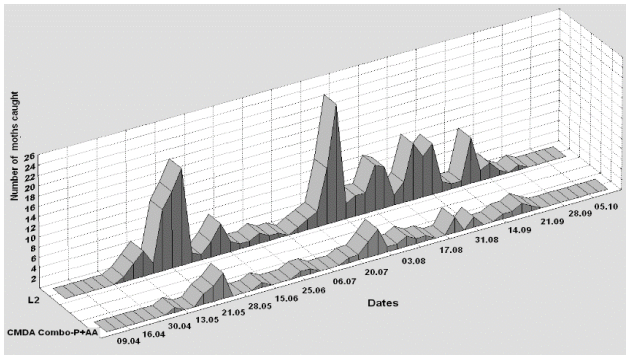

Figure 2. Flight dynamics of CM with CMDA COMBO - P + AA and CM L2 lures in the reference orchard treated with insecticides only in 2021 in Sliven region.

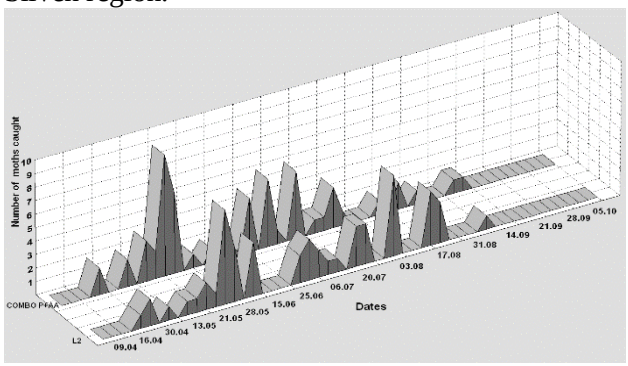

Figure 3. Flight dynamics of CM with CMDA COMBO - P + AA and CM L2 lures in the experimental orchard treated with insecticides and CM MEC in 2020 in Sliven region.

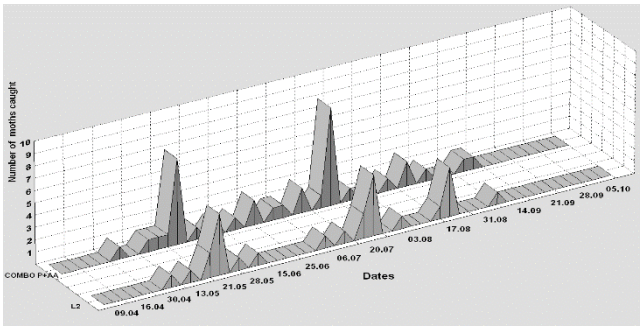

Figure 4. Flight dynamics of CM with CMDA COMBO - P + AA and CM L2 lures in the experimental orchard treated with insecticides and CM MEC in 2021 in Sliven region.

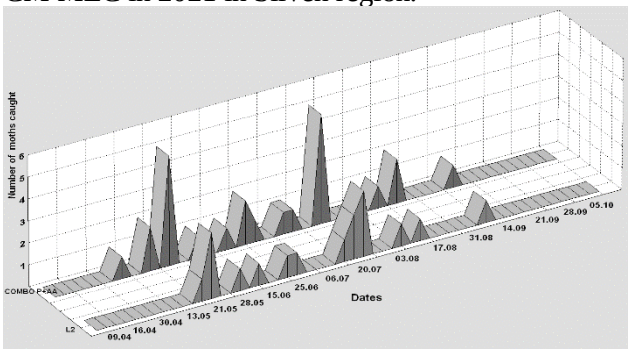

Figure 5. Flight dynamics of CM with CMDA COMBO - P + AA and CM L2 lures in the experimental orchard treated with insecticides and CIDETRAK® CMDA COMBO™ MESO™ - A MD dispensers in 2021 in Sliven region.

Table 1. Evaluation of fruit damage (%) by CM in the treatment and reference orchards in 2020 and 2021.

2020			2021		
Date	**Treatment (%)**	**Reference (%)**	**Date**	**Treatment (%)**	**Reference (%)**
June 8	0.0	0.3	June 10	0.0	0.2
June 24	0.0	0.8	June 23	0.0	0.6
July 10	0.0	0.0	July 9	0.0	0.0
July 22	0.0	1.2	July 22	0.0	1.0
August 7	0.0	1.5	August 6	0.0	1.3
August 21	0.1	1.7	August 20	0.1	1.5
Before harvest	0.1	2.3	Before harvest	0.1	1.8
At harvest	0.1	2.5	At harvest	0.1 – 0.2	2.2

Chi-square tests, $p < 0.001$

The results with CIDETRAK® CM MEC liquid formulation and CIDETRAK CMDA COMBO™ MESO™-A MD dispensers in the trial apple orchard were encouraging. Correspondingly, fruit damage in the treatment orchard was compared with a reference orchard in the region, which was located in the vicinity and treated with conventional insecticides only. First signs of fruit damage were noted in the reference orchard at the first decade of June in

both years. Beginning in the middle of July, through August and September, the fruit damage rate increased, reaching 2.5% in 2020 and 2.2% in 2021 at harvest. Comparatively, ten insecticide treatments were applied in the reference orchard during the season, targeting CM and other pests. In the experimental orchard very few damaged fruits were noted at the end of the season. The damage in this orchard increased slowly throughout the season, and even in late cultivars fruit damage by CM was below the economical threshold, ranging from 0.1 to 0.2% in both years of the study. The significance of differences in the damage rate between the trial and the reference orchard was determined using Chi-square tests. Damage levels were significantly different between the treatment and reference orchard beginning on July 22 and August 7, and thereafter on each sample date until harvest in both years of the study (Chi-square tests, $p < 0.001$). Considering the risks of pollution of the environment and the potential for residue on fruits, a reduction in the frequent use of chemicals in fruit production is urgently needed. Monitoring pests using pheromone and/or kairomone baited traps is an important part of an integrated pest management program to better target insecticide spray timing so it coincides with insect activity, thereby reducing the number of inseciticide treatments. Resistance of insects to insecticides is always a concern in pest management, and the implementation of non-chemical pest control methods in one way to prevent or prolong this. For example, the combination of CIDETRAK® CM MEC liquid formulations of pheromones and CIDETRAK® CMDA COMBO™ MESO™ - A dispensers in combination with suitable insecticides with precise spray timing for the orchards registered for a biological production may be one perspective strategy.

The present results confirm that CIDETRAK® CM MEC microencapsulated pheromones and CIDETRAK® CMDA COMBO™ MESO™ - A dispensers for codling moth added to the grower insecticide program with precise targeted sprays increases the effectiveness of the insecticide program for adult CM control. Correspondingly, these semiochemicals can provide more effective control compared with insecticide treatments alone. These new products developed by Trécé Inc. can be used in organic farming and fits perfectly into any IPM program. The use of CIDETRAK® CM MEC and CIDETRAK® CMDA COMBO™ MESO™ - A will assist growers with decreasing the number of chemical treatments used in the field over a growing season. Introduction of these products for pest management should result in reduction of the use of chemical insecticide treatments, thereby resulting in reduction of environmental pollution and overall improved food quality.

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