

CONTROL OF CODLING MOTH (*CYDIA POMONELLA* L.) BY APPLICATION OF INSECTICIDE CHLORANTRANILIPROLE*

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Abstract

In the last few decades, intensive apple farming has required increasing technology and knowledge to ensure a high yield and product quality. In pest and disease management in apple orchards, in addition to various control tools including agrotechnical and biological ways of protection, it is necessary to apply different chemical pesticides for plant protection several times during the year. The codling moth is one of the most important orchard pests, particularly in apples. It often causes high damage, resulting in premature fruit drop, larvae-eaten fruit, and difficulties in preserving fruit during storage, primarily due to untimely and unsuitable protection. In 2023 and 2024, the trials were carried out according to the standard EPPO methods. This study aimed to assess the efficacy of plant protection product based upon chlorantraniliprole (200 g a.i./L, SC), against the codling moth in apple protection. In the apple orchard (variety Idared, Golden Delicious and Gala) at Budisava and Mala Remeta localities (Vojvodina, Serbia), the product were foliar applied by backpack sprayer at a concentration of 0.02%. The experiment was set up in four replications in randomized block design. By visual examination the presence of *C. pomonella* eggs was registered, and the hatching of caterpillars of the first (2023) and second (2024) generation of this pest was underway. The efficacy of the tested insecticide was evaluated based on the number of damaged fruits. The efficacy of the insecticide was calculated according to Abbott, and the significance of differences (ANOVA) and LSD test for the confidence interval of 95%. In 2023, fourteen days after application the efficacy chlorantraniliprole was 95.3% at the locality Budisava, while in locality M. Remeta efficacy was 92.4%. After 22 days, the product showed good efficacy which ranged from 88.2-93.0%, depending on the locality. In 2024, 14 days after application, the efficacy was 93.7% at the locality Budisava, while in locality M. Remeta efficacy was 89.8%. After 25 days, the insecticide showed good efficacy which ranged from 89.5-90.6%, depending on the locality. In both years, the number of damaged apples in the variants where applied chlorantraniliprole was significantly lower compared to the control. In the studied localities, in both years, *C. pomonella* displayed notable susceptibility to chlorantraniliprole belonging to the diamides groups. This indicates that this insecticide

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can still be effectively used for managing this economically significant pest in apple orchards, as long as the anti-resistance strategy is strictly adhered to.

Keywords: *apple, Cydia pomonella, chlorantraniliprole, efficacy*

INTRODUCTION

The apple (*Malus domestica*) represents one of the most significant fruit species in the world and is certainly the most significant within its genus (*Malus*). Among all fruit species grown globally, the apple ranks third in production and consumption, right after citrus and bananas (Šoškić, 2011). Among the pests that attack apples, of particular importance are the *Cydia pomonella*, *Aphis pommi*, *Epicometis hirta*, *Melolontha melolontha*, *Hoplocampa testudinea*, *Hyphantria cunea*, and various other pests. The codling moth (*C. pomonella*) is one of the most significant pests of pome and stone fruits worldwide, and it is the most important pest on apples and pears. This species originated from Eurasia but has managed to spread to all areas where apples are grown, thanks to its adaptability. The main contributors to the spread of the codling moth were human migrations along global trade routes (Wearing *et al.*, 2001). The species appears every year and causes the greatest damage to the fruit, reducing their market value and making storage difficult or even impossible (Kereši *et al.*, 2019). Control and the strategy primarily depends on the population density that needs to be determined and monitored. The first measure to implement in orchards is the use of pheromone traps to monitor the presence and population density of the codling moth. Also, collecting and destroying infested fruits from the orchard, especially after June fruit thinning, is significant. Due to the frequent use of insecticides, reduced efficacy of certain insecticides has been recorded in many apple orchards. Therefore, alternating insecticides with different modes of action plays a crucial role in preventing resistance development in this pest to the most commonly used insecticides. In recent years, it often happens that maximum temperatures during spring reach up to 30 °C. Then, the development of the codling moth is much faster, and the satisfactory efficacy of insecticides is shorter due to faster degradation. In the last few decades, intensive apple production requires increasing levels of technology and knowledge to achieve desired yields. The aim of this study was to determine the efficacy of the insecticide chlorantraniliprole, which belongs to the chemical group of diamides and has a different mode of action from most insecticides used in controlling *C. pomonella*, under field conditions.

MATERIALS AND METHODS

During 2023 and 2024, experiments were conducted in apple orchards (varieties Golden Delicious, Idared, and Gala) at the Budisava and Mala Remeta localities for the control of the codling moth (*C. pomonella*). The experiments were set up according to standard EPPO methods for experiment design and data analysis (Anonymous, 2012), insecticide efficacy for codling moth (Anonymous, 2004), and phytotoxicity (Anonymous, 2014). The product based on chlorantraniliprole (200 g a.s. /L, SC) was applied at a concentration of 0.02%. The treatment was carried out foliarly with a backpack atomizer "Solo 423", using 1000 liters of water per hectare. Immediately before the treatment, a visual inspection of the orchard recorded the presence of codling moth eggs (*C. pomonella*). Egg laying and larval hatching of the first (June 5, 2023) and second (July 6 and 8, 2024) generations of this pest were ongoing. The obtained data were statistically processed using ANOVA and LSD tests for a confidence interval of 95%, and efficacy was determined according to Abbott (Wentzel, 1963).

RESULTS AND DISCUSSION

Results of testing the insecticide based on chlorantraniliprole in controlling the codling moth (*C. pomonella*) in apple orchards at the Budisava and Mala Remeta locations during 2023/24, are presented in tables 1-2.

Locality Budisava

At the Budisava locality (2023-24), the number of damaged apples 14 days after the application of the insecticide chlorantraniliprole was significantly lower compared to the control. The insecticide efficacy, at the recommended concentration, was 93.7-95.3%. The number of damaged apples just before harvest was significantly lower in the variant where the insecticide was applied compared to the control. The efficacy was 88.2-90.6% (Table 1).

Table 1. Number of damaged apples and efficacy of the chlorantraniliprole in controlling *C. pomonella* (Budisava, 2023/24)

Insecticide (%)	2023				2024			
	14 days		22 days		14 days		25 days	
	$\bar{x} \pm Sd$	E%	$\bar{x} \pm Sd$	E%	$\bar{x} \pm Sd$	E%	$\bar{x} \pm Sd$	E%
Chlorantraniliprole (0.02)	0.75±0.9b	95.3	3.5±1.3b	88.2	1.0±0.8b	93.7	2.5±1.3b	90.6
Control	16.0±4.5a	/	29.8±7.9a	/	16±2.2a	/	26.5±4.6a	/
LSD 5%	4.85		6.75		2.03		4.01	
F	21.9		42.7		131.2		97.1	
p	<0.01		<0.01		<0.01		<0.01	

Σ – sum; x–average value; Sd+ -standard deviation; E-efficacy.

Locality Mala Remeta

The efficacy of chlorantraniliprole-based products in controlling the codling moth (*C. pomonella*) in apple orchards at the Mala Remeta locality during 2023/24 is presented in Table 2. The number of damaged apples, 14 days after the application of the insecticide, is significantly lower compared to the control. The efficacy of the tested product was 89.8-92.4%. Just before harvest, the efficacy of the insecticide based on chlorantraniliprole, applied at the recommended concentration, was 89.5-93.0%. The number of damaged fruits in the variants where the tested products were applied is significantly lower compared to the control (Table 2). After the application chlorantraniliprole, no phytotoxic changes were observed on the leaves, shoots, or fruits of the apple varieties Golden Delicious, Idared, and Gala at the Budisava and Mala Remeta locations.

Table 2. Number of damaged apples and efficacy of the chlorantraniliprole in controlling *C. pomonella* (Mala Remeta, 2023/24)

Insecticide (%)	2023				2024			
	14 days		22 days		14 days		25 days	
	$\bar{x} \pm Sd$	E%	$\bar{x} \pm Sd$	E%	$\bar{x} \pm Sd$	E%	$\bar{x} \pm Sd$	E%
Chlorantraniliprole (0.02)	1.75±0.5b	92.4	1.5±0.6b	93.0	1.2±0.5b	89.8	1.5±0.6b	89.5
Control	23.0±5.9a	/	21.5±2.6a	/	12±4.1a	/	14.2±2.2a	/
LSD 5%	4.85		2.23		3.52		1.90	
F	22.5		218.2		28.2		123.8	
p	<0.01		<0.01		<0.01		<0.01	

Σ – sum; x – average value; Sd+ -standard deviation; E-efficacy.

Based on the studies by Bassi *et al.* (2009), chlorantraniliprole showed a high level of protection for apples against codling moth (*C. pomonella*), with efficacy exceeding 90%. Thanks to its high efficacy, selectivity, and favorable toxicological and ecotoxicological properties, chlorantraniliprole can be significant in anti-resistance strategies as well as in Integrated Pest Management (IPM) programs (Milanese *et al.*, 2014). In 2013, the efficacy of insecticides from the avermectin and diamide groups in controlling codling moth (*C. pomonella*) was tested. The results of these trials indicated good efficacy (92.0% and 95.6%) of insecticides from the mentioned chemical groups (Tamaš *et al.*, 2018). According to the conducted research by Bosh *et al.* (2018), it was also concluded that chlorantraniliprole showed high efficacy ranging from 85-97% in controlling codling moth, indicating no resistance to chlorantraniliprole, which is consistent with our research. Studies conducted in 2021 in apple orchards at the Budisava location (Vojvodina) showed high efficacy (93.4-94.4%) of chlorantraniliprole-based products in controlling *C. pomonella* (Vuković *et al.*, 2022). Perrin *et al.* (2024) tested the effect of temperature (20, 25, 30, and 35 °C) on the toxicity of three insecticides (chlorantraniliprole, emamectin, and spinosad) for *C. pomonella*, as well as their effect on two natural enemies (*Forficula auricularia* L. and *Mastrus ridens* Horstmann) under laboratory conditions. In these tests, chlorantraniliprole

showed high efficacy against *C. pomonella* even at high temperatures, while being relatively safe for natural enemies, regardless of temperature or exposure method. This study demonstrated that chlorantraniliprole can be a promising insecticide, especially now that temperatures are rising, as well as for strategies that partially rely on biological control.

CONCLUSIONS

Based on the obtained results, it can be concluded that the codling moth (*Cydia pomonella*) at the tested locations (Budisava, Mala Remeta) showed significant sensitivity to the tested insecticide (chlorantraniliprole). This allows us to continue using the mentioned insecticide in controlling this economically significant apple pest, while adhering to all recommended measures to prevent the development of resistance.

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SUZBIJANJE JABUČNOG SMOTAVCA (*CYDIA POMONELLA* L.) PRIMENOM INSEKTICIDA HLORANTRANILIPROLA

Sažetak

U poslednjih nekoliko decenija, intenzivna proizvodnja jabuke zahteva sve veći nivo tehnologije i znanja kako bi se obezbedio visok prinos i kvalitet proizvoda. U voćnjacima jabuke, pored različitih mera za suzbijanje uključujući agrotehničke i biološke mere zaštite, neophodno je nekoliko puta godišnje primeniti različite pesticidne preparate. Jabučni smotavac je jedna od najvažnijih štetočina u voćnjacima, posebno u jabukama. Često uzrokuje visoke štete, što dovodi do prevremenog opadanja plodova i poteškoća u čuvanju plodova tokom skladištenja, prvenstveno zbog nepravovremene i neadekvatne zaštite. Tokom 2023. i 2024. godine, ogledi su sprovedeni prema standardnim OEPP metodama. Ova studija imala je za cilj procenu efikasnosti sredstva za zaštitu biljaka na bazi hlorantraniliprola (200 g a.s./L, SC), protiv jabučnog smotavca u zaštiti jabuka. U voćnjacima jabuke (sorta Ajdared, Zlatni delišes i Gala) na lokalitetima Budisava i Mala Remeta (Vojvodina, Srbija), preparat na bazi hlorantraniliprola je folijarno primenjen lednim atomizerom u koncentraciji od 0,02%. Eksperiment je postavljen u četiri ponavljanja u slučajnom bloku sistemu. Vizuelnim pregledom registrovano je prisustvo jaja *C. pomonella*, a takođe je ustanovljeno i piljenje gusenica prve (2023) i druge (2024) generacije ove štetočine. Efikasnost testiranog insekticida je procenjena na osnovu broja oštećenih plodova jabuke. Efikasnost je izračunata prema Abbotu, a značaj razlika primenom analize varijanse

(ANOVA) i NZR testa za interval poverenja od 95%. U 2023. godini, četrnaest dana nakon primene, efikasnost hlorantraniliprola iznosila je 95,3% na lokalitetu Budisava, dok je na lokalitetu Mala Remeta efikasnost bila 92,4%. Nakon 22 dana, preparat je pokazao dobru efikasnost koja se kretala od 88,2-93,0%, u zavisnosti od lokaliteta. U 2024. godini, četrnaest dana nakon primene efikasnost je bila 93,7% na lokalitetu Budisava, dok je na lokalitetu Mala Remeta efikasnost bila 89,8%. Nakon 25 dana, insekticid je pokazao dobru efikasnost koja se kretala od 89,5-90,6%, u zavisnosti od lokaliteta. Tokom obe godine, broj oštećenih plodova jabuke u varijantama gde je primenjen hlorantraniliprol bio je značajno niži u odnosu na kontrolu. Na ispitivanim lokalitetima, u obe godine, *C. pomonella* je pokazala značajnu osetljivost na hlorantraniliprol. Ovo ukazuje na to da se ovaj insekticid još uvek može efikasno koristiti za suzbijanje ove ekonomski značajne štetočine u voćnjacima jabuka, pod uslovom da se strogo poštuje antirezistentna strategija.

Ključne riječi: *jabuka, Cydia pomonella, klorantraniliprol, efikasnost*