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Controlling *Ostrinia nubilalis* Hüb. and *Helicoverpa armigera* Hüb. in maize using the chlorantraniliprole insecticide

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Abstract

Ostrinia nubilalis Hüb. and *Helicoverpa armigera* Hüb. represent one of the most important maize pests in Serbia and Europe. Due to the pronounced polyphagy and the increasing number of generations per year, their control has been challenging. In addition to integrated pest management, insecticides application is usually inevitable. During 2023, efficacy experiments of the chlorantraniliprole insecticide (200 g/l a.s., SC) were conducted in order to control *O. nubilalis* and *H. armigera* in the DKC4098 and Pioneer 9911 maize varieties at two localities in Vojvodina according to EPPO methods. The insecticide was applied in a rate of 0.15 l/ha when the maize was in the BBCH 65-67. Foliar treatment was performed during moth flight, egg-laying of the second generation, when larvae are present and active. Three evaluations were performed. The first evaluation was conducted immediately before the treatment when the number of eggs and larvae was determined (25 plants per repetition). In the second evaluation 15 days after the treatment, the number of damaged plants and cobs was determined. The third evaluation, slightly before harvest, determined the number of stem-broken plants above/below the cob and the number of damaged cobs (20 plants per repetition). The results obtained were analyzed using the one-way ANOVA and LSD tests, and the efficacy was calculated according to Abbott. Immediately before the treatment, the average number of *O. nubilalis* egg litters ranged from 4.25 to 8.5 per repetition, while the *H. armigera* eggs were not found in any of the localities. The borer larvae of *O. nubilalis* before the treatment amounted to 1.25-3.25, and 1.0-1.75.0 for *H. armigera*. After 15 days, the efficacy of chlorantraniliprole was 80-85.3%. This

insecticide significantly reduced the number of broken plants and damaged cobs compared to the control, based on the assessment right before the harvest. The efficacy ranged from 82% to 95.4%, indicating significant sensitivity of the pest populations to chlorantraniliprole.

Key words: Maize, *O. nubilalis*, *H. armigera*, Chlorantraniliprole, Efficacy.

Introduction

The European corn borer (*Ostrinia nubilalis* Hüb.), along with the cotton bollworm (*Helicoverpa armigera* Hüb.), represents one of the most significant maize pests, both in Serbia and in Europe (Saladini et al., 2008; Mencarelli et al., 2013), causing a significant yield reduction. The larvae are highly polyphagous, feeding on about 250 cultivated and wild plant species, mainly damaging generative organs. Young larvae can make small holes in the leaves or remain in the leaf for 15-20 days, boring through the leaf vein or stem, where they create long tunnels, cutting through the vascular bundles, reaching the tassel and the cob (Kereši et al., 2018). Infested plants break easily, causing the greatest losses to seed crops. In addition to direct, insects can also cause indirect damage, which contributes to the occurrence of phytopathogenic fungi that produce mycotoxins hazardous to human and animal health. Thus, their control is difficult due to the high polyphagy, the formation of multiple generations per year, and the opening pathways for various disease-causing agents. To reduce the population of these harmful insect species and to enable higher yields, it is necessary to apply different agrotechnical, chemical, biotechnical, and biological measures (Popović et al., 2015). The application of insecticides is inevitable for successful protection. However, intensive use of pesticides leads to negative consequences, such as the development of resistant pest populations, the occurrence of phytotoxicity, and persistence. To avoid and minimize negative consequences, efforts are made to optimize the selection and application of current pesticides, combining appropriate active substances and researching new compounds to achieve high efficacy. Recently, chlorantraniliprole, an insecticide from the anthranilic diamide group, has been used to control various insect pests. Chlorantraniliprole exhibits contact, digestive, ovicidal, and larvicidal activity on all larval stages, as well as adulticidal, being low in toxicity to vertebrates and non-target organisms. It is a neuro-muscular toxin (Enviromental Protection Agency, 2009). Paralysis occurs after a few hours, and death after a few days. It causes the activation of ryanodine receptors in insects, stimulating the release of calcium from the internal depot of smooth and striated muscles, leading to weakened muscle control, paralysis, and eventually death, and it is a limited

systemic insecticide with pronounced translaminar movement (MacBean, 2012). This study evaluated the effects of a plant protection product based on chlorantraniliprole in controlling the European corn borer and the cotton bollworm in maize.

Material and Methods

To determine the efficacy of chlorantraniliprole in controlling O. nubilalis and H. armigera in maize crops (DKC4098, Pioneer 9898, Pioneer 9911), the trial was set up according to the standard OEPP methods for the efficacy [PP 1/13 (3)] (European and Mediterranean Plant Protection Organization [EPPO], 2004), experimental design and data analysis [PP 1/152 (4)] (EPPO, 2012), and for phytotoxicity [PP 1/135 (4)] (EPPO, 2014). The field trials were set up at two localities (Kovilj and Stejanovci) at the territory of Serbia during 2023. The application was foliar using a "Solo" backpack sprayer with a water consumption of 400 l/ha. The type of experiment was a randomized block design. The insecticide based on chlorantraniliprole (200 g a.i./l, SC) was applied at a rate of 0.15 l/ha. The treatment at the Kovilj locality was conducted on 27 July 2023, and at the Stejanovci site on 01 August 2023. Maize was predominantly in the BBCH 65-67 stage (silk fully developed to silk drying). Three evaluations were performed. Slightly before the treatment, the number of eggs and caterpillars were determined (25 plants per repetition). The second evaluation was conducted 15 days after the treatment, determining the number of damaged plants and cobs, and the third evaluation was realized shortly before the harvest, determining the number of broken plants above/below the cob and the number of damaged cobs (20 plants per repetition). The results obtained were analyzed using the one-way ANOVA and LSD test, while the efficacy was calculated according to Abbott.

Results and Discussion

The results of the efficacy of chlorantraniliprole used in the *O. nubilalis* and *H. armigera* control in maize are presented in the following tables.

Evaluation I

The assessment immediately before the treatment found only the presence of *O. nubilalis*, at the Kovilj locality, while at the Stejanovci locality, both pests were present. Based on the assessment before the trial, the average number of egg litters of *O. nubilalis* ranged from 5.25 to 8.5 and 4.25 to 6.25, respectively (Table 1).

Tab. 1 - The number of *O. nubilalis* egg litters on maize immediately before the treatment (Kovilj and Stejanovci, 2023)

Treatment	*O. nubilalis*	
	Kovilj	Stejanovci
	$\bar{x}$ ±Sd	$\bar{x}$ ±Sd
Chlorantraniliprole (0.15 l/ha)	5.25±0.6 a	4.25±0.8 a
Control	8.50±1.7 a	6.25±1.4 a
LSD, 5%	7.52	5.25
F value	0.57	0.25
p	0.47	0.63

$\bar{x}$ - average number; Sd± - standard deviation.

The number of borer larvae of *O. nubilalis* before the treatment was 1.25-3.25, and 1.0-1.75 for *H. armigera* (Table 2).

Tab. 2 - The number of borer larvae of *O. nubilalis* and *H. armigera* immediately before the treatment (Kovilj and Stejanovci, 2023)

Treatment	*O. nubilalis*		*H. armigera*
	Kovilj	Stejanovci	Stejanovci
	$\bar{x}$ ±Sd	$\bar{x}$ ±Sd	$\bar{x}$ ±Sd
Chlorantraniliprole (0.15 l/ha)	1.75±0.5 a	1.25±1.7 a	1.00±0.25 a
Control	3.25±0.8 a	3.00±2.4 a	1.75±0.9 ab
LSD 5%	2.41	2.24	0.89
F value	0.27	0.84	2.25
p	0.62	0.58	0.23

$\bar{x}$ - average number; Sd± - standard deviation.

Evaluation II

The number of plants damaged by *O. nubilalis*, 15 days after the application of the insecticide, was significantly lower compared to the control with the efficacy of 82.6%. The number of plants damaged by *O. nubilalis* and *H. armigera* at the Stejanovci locality, 15 days after the application of chlorantraniliprole-based product, was significantly lower compared to the control. The efficacy of the chlorantraniliprole, applied in the recommended amount, was 85.3% (Table 3). At the Kovilj locality, the number of maize cobs damaged by *O. nubilalis* larvae 15 days after the treatment was significantly lower compared to the number of damaged cobs in the control, with an efficacy

of 82.9%. The number of maize cobs damaged by *O. nubilalis* and *H. armigera* larvae at the Stejanovci locality after 15 days was significantly lower compared to the control, while the efficacy was 80.0% (Table 4).

Tab. 3 - The number of maize plants damaged by *O. nubilalis* and *H. armigera* larvae 15 days after the treatment and insecticide efficacy (Kovilj and Stejanovci, 2023)

Treatment	Kovilj			Stejanovci		
	$\bar{x}$ ±Sd	X%	E%	$\bar{x}$ ±Sd	X%	E%
Chlorantraniliprole (0.15 l/ha)	2.00±0.8 b	10.0	82.6	1.25±0.5 b	6.2	85.3
Control	11.5±1.7a	57.5	/	8.50±1.9a	42.5	/
LSD 5%	1.83			2.02		
F value	46.09			53.68		
p	<0.01			<0.01		

$\bar{x}$ - average value; Sd± - standard deviation; X% - percentage of damaged plants; E- efficacy.

Tab. 4 - The number of maize cobs damaged by *O. nubilalis* and *H. armigera* larvae 15 days after the treatment and insecticide efficacy (Kovilj and Stejanovci)

Treatment	Kovilj			Stejanovci		
	$\bar{x}$ ±Sd	X%	E%	$\bar{x}$ ±Sd	X%	E%
Chlorantraniliprole (0.15 l/ha)	1.75±0.5 b	8.7	82.9	2.25±2.2 b	11.3	80.0
Control	10.25±2.7a	51.2	/	11.25±0.5a	56.2	/
LSD 5%	1.63			1.94		
F value	36.89			277.71		
p	<0.01			<0.01		

$\bar{x}$ - average value; Sd± - standard deviation; X% - percentage of damaged cobs; E- efficacy.

Evaluation III

The number of broken maize plants immediately before the harvest in the variants where the chlorantraniliprole was applied was significantly lower compared to the control. The efficacy of the insecticide ranged from 86 to 95.4%, depending on the locality (Table 5).

Tab. 5 - The number of broken maize plants above/below the cob, shortly before the harvest, and insecticide efficacy (Kovilj and Stejanovci, 2023)

Treatment	Kovilj		Stejanovci	
	$\bar{x}$ ±Sd	E%	$\bar{x}$ ±Sd	E%
Chlorantraniliprole (0.15 l/ha)	1.75±0.5 b	86.0	0.50±1.3 b	95.4
Control	12.5±2.9 a	/	11.0±2.9 a	/
LSD 5%	1.42		1.02	
F value	53.85		49.0	
p	<0.01		<0.01	

$\bar{x}$ - average value; Sd± - standard deviation; E - efficacy.

At the Kovilj locality, immediately before the harvest in the variant where the insecticide was applied, the number of maize cobs damaged by *O. nubilalis* larvae was significantly lower compared to the control. The efficacy of the tested plant protection product was 82.0%. The number of maize cobs damaged by *O. nubilalis* and *H. armigera* larvae before the harvest at the Stejanovci locality, in the variant where chlorantraniliprole was applied, was significantly lower compared to the control, with efficacy of 86.8% (Table 6).

Tab. 6 - The number of maize cobs damaged by *O. nubilalis* and *H. armigera* larvae shortly before the harvest and insecticide efficacy (Kovilj and Stejanovci, 2023)

Treatment	Kovilj		Stejanovci	
	$\bar{x}$ ±Sd	E%	$\bar{x}$ ±Sd	E%
Chlorantraniliprole (0.15 l/ha)	1.75±0.5 b	82.0	1.75±1.2 b	86.8
Control	9.75±1.9 a	/	13.25±2.1 a	/
LSD 5%	2.25		2.56	
F value	115.0		26.83	
p	<0.01		<0.01	

$\bar{x}$ - average value; Sd± - standard deviation; E - efficacy.

Based on the study by Schmidt-Jeffris et al. (2016), the foliar application of chlorantraniliprole and as a seed treatment significantly reduced the damage to maize crops by *O. nubilalis*. Chlorantraniliprole showed greater efficacy as a seed treatment (protection was effective for 44 days after the application). High efficacy (97.0%) in controlling *O. nubilalis* larvae in 2016 at a locality in Vojvodina was demonstrated by a chlorantraniliprole-based insecticide (Franeta, 2018). It does not exhibit genotoxic, neurotoxic, carcinogenic, or teratogenic effects in mammals and birds and has shown minimal toxicity to these classes of animals, mainly through chronic effects. It exhibits high toxicity to freshwater invertebrates (MacBean, 2012). Chlorantraniliprole is very toxic to aquatic organisms with long-lasting effects and is toxic to bees (contact toxicity),

although risk assessment results indicate no risk from the application of preparations based on this active substance (Aleksić et al., 2024).

Conclusion

Based on the results related to the effect the of chlorantraniliprole insecticide on *O. nubilalis* and *H. armigera* in maize at the Kovilj and Stejanovci localities, it can be concluded that slightly before the treatment, the average number of *O. nubilalis* egg litters ranged from 4.25 to 8.5 per repetition, while the H. armigera egg litters were not recorded at any location. The number of *O. nubilalis* larvae before the trial ranged from 1.25 to 3.25, and *H. armigera* from 1.0 to 1.75 while 15 days after the treatment, the efficacy of chlorantraniliprole ranged from 80 to 85.3%, depending on the observation characteristics and locality. The tested plant protection product significantly reduced the number of broken plants and damaged cobs compared to the control, based on the assessment shortly before the harvest, indicating significant sensitivity of the mentioned pest populations to chlorantraniliprole and allowing for its continued use in protecting maize from these pests.

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Сузбијање *Ostrinia nubilalis* Hüb. и *Helicoverpa armigera* Hüb. у кукурузу применом инсектицида хлорантранилипрол

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Сажетак

Ostrinia nubialis и *Helicoverpa armigera* представљају једне од најзначајнијих штеточина кукуруза, како у нашој земљи, тако и у Европи. Због изражене полифагности и образовања већег броја генерација у току године, начин њиховог сузбијања је комплексан. Поред интегралних мера заштите, примена инсектицида је врло често неизбежна. Током 2023. године, у циљу испитивања ефикасности инсектицида хлорантранилипрола (200 g/l a.s., SC), спроведени су огледи сузбијања *O. nubialis* и *H. armigera* на два локалитета у Војводини (Ковиљ и Стејановци) у складу са стандардним EPPO методама, у усеву кукуруза (хибрид DKC4098 и Pioneer 9911). Испитивани препарат примењен је у количини 0,15 л/ха, када је кукуруз био у фази BBCH 65-67. Третирање је изведено фолијарно у време лета лептира, полагања јаја друге генерације ових штеточина, као и присуства гусеница. Изведене су три оцене, непосредно пре третирања, одређивањем броја јајних легала и убушених гусеница (25 биљака по понављању); друга оцена 15 дана након третирања, одређивањем броја оштећених биљака и клипова; трећа оцена непосредно пред бербу одређивањем броја сломљених биљака изнад/испод клипа и оштећених клипова (20 биљака по понављању). Резултати су анализирани применом ANOVA и NZR теста, а ефикасност према Abbott-у. Непосредно пре третирања просечна бројност јајних легала *O. nubilalis* се кретала од 4,25 до 8,5 по понављању, док присуство јајних легала *H. armigera* није забележено ни на једном локалитету. Број убушених гусеница *O. nubilalis* пре постављања огледа износио је 1,25-3,25, а H. armigera 1,0-1,75. Након 15 дана од третирања ефикасност препарата на бази хлорантранилипрола износила је 80-85,3% у односу на контролу, зависно од обележја посматрања и локалитета. Испитивани препарат обезбедио је значајно смањење броја сломљених биљака као и оштећених клипова од *O. nubialis* и *H. armigera* у односу на контролу, на основу оцене непосредно пред бербу. Ефикасност хлорантранилипрола се кретала од 82% до 95,4%, зависно од обележја посматрања и локалитета, што указује на значајну осетљивост популација поменутих штеточина на хлорантранилипрол.

Кључне ријечи: Кукуруз, *O. nubialis*, *H. armigera*, Хлорантранилипрол, Ефикасност.

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