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EFFICACY ASSESSMENT OF SYNTHESIS PYRETHROIDS ON *Ostrinia nubilalis* (Hübner) POPULATION REDUCTION FROM CORN AGRO-ECOSYSTEM

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Abstract

Ostrinia nubilalis is the most important corn pest, in las years a aggressivity increasing was observed, causing harvest losses of up to 40%. The aim of this study was to evaluate the efficacy of synthetic pyrethroids (alpha-cypermethrin 50 g/l; alpha-cypermethrin 100 g/l; deltamethrin 25 g/l, acetamiprid 100 g/kg + lambda-cyhalotrin 30 g/kg) in reducing population of Ostrinia nubilalis from the corn agroecosystem (consisting of two semi-early hybrids DKC 4590; DKC 4670). The treatments were applied when the maximum flight curve was reached, assessments were made 10 days after the treatments and prior harvesting. The effectiveness was determined through aggressivity and yield obtained. The aggressivity of Ostrinia nubilalis was higher in the variants drilled with the DKC 4590 hybrid (80%) compared to 71.25% in the variants drilled with DKC 4670; the situation being similar at the second generation. Among synthetic pyrethroids tested alpha-cypermethrin 100 g/l proved superiority by reducing the attack of Ostrinia nubilalis up to 11.25% in the DK 4590 hybrid and 10% respectively in DKC 4670. The yield was correlated with the treatments efficacy (6.67-12.05 t/ha).

***Key words**: Ostrinia nubilalis, synthesis pyrethroids, efficacy, aggressivity, corn.*

INTRODUCTION

In recent years (2016-2018), Romania has occupied the first positions of the European Union ranking on production (27.8% of total production is provided by Romania) and the area cultivated with corn (2.49 million hectares) according to the National Institute of Statistics.

Diseases, pests and weeds are the main biotic factors that reduce corn production. *Ostrinia nubilalis* (Lepidoptera: *Crambidae*) being known as one of the most important pests of corn (*Zea mays*) (Grozea et al., 2019). The species is native to Europe, later reported in North Africa, North America, Canada, and is now found in almost all maize-producing regions (Bereś, 2016).

Ostrinia nubilalis is a special polyphagous (Bengtsson et al., 2006), it attacks a very large number of plants. Research on ECB host plants has been the subject of several studies: Hodgson (1928) stated that this insect feeds on plants of 131 genera from 40 botanical families; Ponsard et al. (2004) estimate that the ECB attacks more than 200 plants; Filip Franeta (2018) points out that the number of ECB host species on the European continent is significantly lower than on the North American continent.

Filip Franeta (2018) states that the plants attacked by the species *Ostrinia nubilalis* are part of the families: *Poaceae, Polygonaceae, Amaranthaceae, Solanaceae, Fabaceae, Malvaceae, Cannabaceae, Iridaceae, Cucurbitaceae and Apiaceae*.

In Romania, the ECB larva attacks corn, hemp, sorghum, millet, sunflower, but also develops on spontaneous plants such as Johnson grass, Sudan grass (Grozea, 2006).

Ostrinia nubilalis attacks all the above-ground organs of maize plants.

The researchers (Papp, 1990; Szőke et al., 2002) divided the damage caused by the ECB into direct (disruption of nutrient transport by destroying vascular tissue) and indirect

(damage reflected by grain damage, stem breakage, presence of *Fusarium* pathogens).
Production losses caused by the ECB have values in the range of 15-50% (Papp, 1990; Szőke et al., 2002; Pálfy, 1983; Magg et al., 2002). In Romania, production losses vary between 1.3-17.7% according to studies conducted by Paulian (1976); while Champrag (1994) indicates a decrease in yield between 10% and 30%. More recent data suggest that the average production loss due to the ECB attack was 7.5% (Popov and Roșca, 2007 cited by Georgescu E. et al., 2019).
The economic losses caused by *Ostrinia nubilalis* in the USA counts up to 1 billion dollars (Huang et al. 2014), in Germany according to estimates made by the Federal Biological Research Center for Agriculture and Forestry caused losses of 11-12 million euros/year (Gaspers Claudia, 2009), and worldwide 1.6 billion euros/year (FAOSTAT, 2016, cited by Kárpáti Z. et al., 2016).
The damage and losses caused by this pest have led to numerous studies in order to obtain a more effective method of control.
Direct control (chemical or biological) of *Ostrinia nubilalis* larvae from the maize agroecosystem is difficult to achieve due to the short period of exposure to treatments (from hatching until the larvae enter the stems) (Mason et al., 1996; Degenhardt et al., 2003).
Studies up to date show that the correct determination of the period of application of the insecticide is an essential condition for achieving success in ECB control. Insecticides are most effective when applied immediately after egg larvae hatch (Bartels and Hutchison 1995; Rinkleff et al., 1995) because mature larvae become inaccessible to chemical treatments by penetrating the stem of the host plant (Pélozuelo L. et al., 2006).
This is one of the reasons that led researchers to speed up their research towards an IPM (Integrated Pest Management) program:
- Mechanical control of *Ostrinia nubilalis* to be performed by using the rotary cultivator (to destroy the larvae) (Ackermann et al., 2003); observance of rotation; gathering plant debris; performing deep plowing to increase the mortality of larvae in diapause over the winter (Zellner, 2001).
- Biological control of the species *Ostrinia nubilalis* is frequently used by the application of parasitic wasps *Trichogramma evanescens* and *Trichogramma brassica* (parasitizes eggs and thus avoids the damage caused by larvae). Bioproducts such as *Bacillus thuringiensis* var. *kurstaki* (B.t.k.), are also widely used, Spinosad and insect growth regulators (IGR).
- The ECB's chemical control has been efficient achieved with insecticides from the organophosphorus (OP) and synthetic pyrethroid (P) families (Rinkleff et al., 1995; Musser and Shelton, 2003).

MATERIALS AND METHODS

Research on the control of the species *Ostrinia nubilalis*, with synthetic pyrethroids, was carried out in 2019, in the western part of Romania (Șag locality, Timiș county) (Figure 1).

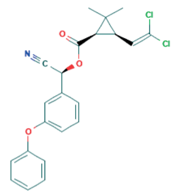
Figure 1. The geographical location of the experimental field

Aiming the aggressivity of the species *Ostrinia nubilalis*, the maize hybrids DKC 4590 and DKC4670 (FAO 350-390) were drilled on 28.04.2019.
The research regarding the evaluation of the efficacy of synthetic pyrethroids, on population of *Ostrinia nubilalis* reduction, was setup using randomized blocks method, including five treatments (for each hybrid) in four replicates. The experimental plots, drilled with maize, had an area of 30 m^2 (length of 10 m and a width of 3 m), according to EPPO standard.
Synthetic pyrethroids tested in experience were alpha-cypermethrin 50 g/l; alpha-cypermethrin 100 g/l; deltamethrin 25 g/l, acetamiprid 100 g/kg + lambda-cyhalothrin 30 g/kg (Table 1).

Table 1. Active substances used in the study on the control of the species *Ostrinia nubilalis* from the maize agroecosystem

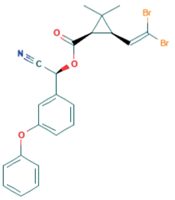
Trt.	Active substance	A.i. content	Commercial name	Dose
1	Alpha-Cypermethrin	50 g/l	Fastac Active ME	0.6 l/ha
2	Alpha-Cypermethrin	100 g/l	Alfadone 10 EC	0.15 l/ha
3	Deltamethrin	25 g/l	Poleci	0.05 l/ha
4	Acetamiprid + lambda-Cyhalothrin	100 g/kg +30 g/kg	Inazuma WG	0.15 l/ha
5	Control	untreated		

The active substances (from the group of synthetic pyrethroids) used in the control of the species *Ostrinia nubilalis* have contact and ingestion action.
Three simple insecticides, as well a compound one (Inazuma), were tested in the study.
It contains acetamiprid 100 g/kg, from the group of neonicotinoids with translaminar penetration and lambda-cyhalothrin 30 g/kg, from the group of synthetic pyrethroids having non-systemic action, blocking the central nervous system.

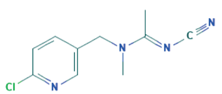


Alpha-Cypermethrin

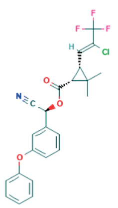
(https://pubchem.ncbi.nlm.nih.gov/compound/alpha-Cypermethrin#section=Structures)



Deltamethrin (https://pubchem.ncbi.nlm.nih.gov/substance/53788229#section=2D-Structure)



Acetamiprid (https://pubchem.ncbi.nlm.nih.gov/compound/6440554#section=2D-Structure)



lambda-Cyhalothrin (https://pubchem.ncbi.nlm.nih.gov/compound/6440554#section=2D-Structure)

The optimal time to apply the treatments, in respect of species *Ostrinia nubilalis* control, was established with the help of pheromone type traps CSALOMON®VARL (Figure 2) (28.06.2019).

Figure 2. Pheromone trap CSALOMON®VARL, used to establish the flight curve

At 36 DAA of the insecticides, the first assessment was performed, regarding the effectiveness of the synthetic pyrethroids and of the insecticide compound Inazuma (acetamiprid + lambda-cyhalothrin) throughout the number of plants attacked (the number of larvae in the stems was determined, the number of holes, as well as the attack of the corn stalker on the cob) (Figure 3).

Figure 3. Assessing the aggressivity of European corn borer in experimental variants

The second assessment of the *Ostrinia nubilalis* agresisvity was performed a day before harvest, At 80 DAA tacking the number of plants attacked (broken above the cobs; broken under the cobs; broken cobs, cobs damaged) in account (Figure 4). In order to determine the frequency of attack on the maize stalk grower, in maize agroecosystem, 80 plants/variant were taken into consideration at first assessment and at the time of second assessment the number of samples was 200.

Figure 4. Assessment of *Ostrinia nubilalis* damage on maize plants, before harvesting

After establishing the aggressiveness of the European corn borer, the yield of the two maize hybrids used in the experiment was determined. The insecticides efficacy was determined using ABBOT formula:

$$\text{Efficacy after Abbott } \% = \left(\frac{C_a - C_t}{C_a}\right) x\ 100$$

where C_a untreated infestation percent, C_t treated infestation percent

The climatic conditions (Figure 5) recorded, in the experimental year 2019, were favorable for the development of the polyphagous pest, *Ostrinia nubilalis*.

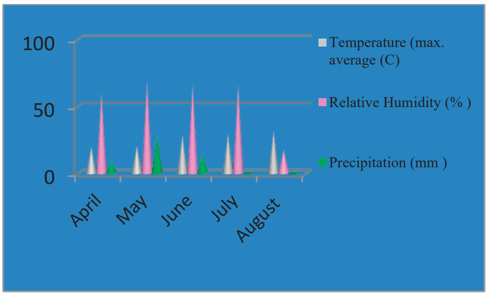


Figure 5. Trial climatic conditions for control of the species *Ostrinia nubilalis* in maize agroecosystem

The average temperature of 20.06°C, recorded in May, shows that the prolificity threshold (14.2°C) (Grozea, 2006) of the species *Ostrinia nubilalis* has been exceeded. The average temperatures recorded in June (28.21°C), July (29.13°C) and August (31.42°C) were still favorable for the development of the species, according to literature data (Grozea, 2006) temperature of 29˚C and the relative high humidity being favorable.

RESULTS AND DISCUSSIONS

Table 2 shows the results on the efficacy of synthetic pyrethroids in the reduction of the *Ostrinia nubilalis* population in the maize agroecosystem (hybrid DKC 4590), 36 days after the application of the treatments.

The frequency of ECB larvae attack on the DKC 4590 maize hybrid treated with synthetic pyrethroids, in the climatic conditions of 2019, had values of 15-77.5%.

Synthetic pyrethroid, alpha-cypermethrin applied at a dose of 0.6 l/ha successfully controlled ECB larvae (80.65%), the aggressivity being 15.0%. Low values regarding the frequency of attack (21.25%) of the species *Ostrinia nubilalis* were also registered in the variants treated with the compound insecticide Inazuma WG, showing an efficacy of 72.58%. At the first evaluation, the highest agresisvity (77.5%) of ECB larvae was recorded in the control variant (untreated).

Table 1. Efficacy of synthetic pyrethroids in the control of ECB larvae (hybrid DKC 4590 - 1st assessment)

Active ingridient	Doza	Σ attacked plants/trt	ECB larvae agresisvity/trt	Insecticides efficacy
Alpha-Cypermethrin	0.6 l/ha	12	15.0	80.65
Alpha-Cypermethrin	0.15 l/ha	32	40.0	48.39
Deltamethrin	0.05 l/ha	44	55.0	29.03
Acetamiprid + lambda-Cyhalothrin	0,15 l/ha	17	21.25	72.58
Control	-	62	77.5	-

The efficacy of insecticides used in the experiment was studied by other researchers too. Blandino et al. 2010 emphasizes that the efficacy of insecticides in control of *Ostrinia nubilalis* is greatly influenced by their applications timing. Studies performed by him show a high efficacy of synthetic pyrethroids if applied: 7-10 days before reaching the maximum flight curve or 2-3 days after reaching the maximum flight curve; if applied at the end of flowering the efficacy will be significantly lower. Mason et al. (1996) believe that insecticides should be applied early because the attack of wintering larvae may be more dangerous.

After Rinkleff et al. (1995) the application period of synthetic pyrethroids is flexible due to the good effect in the control of ECB larvae.

Blandino et al. 2010 support the idea of choosing the timing of application of insecticides used in the control of *Ostrinia nubilalis* in respect of the active substance.
After determining the frequency of attack on the variant, the maize plants were analyzed (cutting the stems) and the average number of larvae in the stem was determined for each variant. At 36 days after the application of insecticides, the average number of larvae varied between 0.01-0.3 larvae/plant (Figure 6). By applying deltamethrin treatments, there was a reduction in the average number of larvae (0.2 larvae/plant) compared to the untreated control.
The study showed that corn plants had a higher frequency of attack under cobs (average/exp. 6.25%). The damage through the presence of perforation on the corn leaves recorded the lowest values (3.5%) (Figure 6).

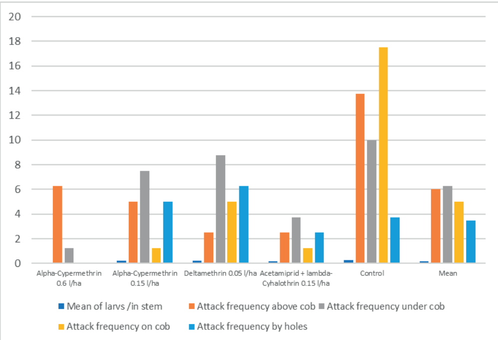


Figure 6. Aggressivity of *Ostrinia nubilalis*, on maize plants, related to plant parts, 36 days after treatment

80 days after the application of the treatments, regarding the reduction of the population of *Ostrinia nubilalis*, the second assessment was performed (Table 3), it showed that the insecticides had lower efficacy in the control of the species *Ostrinia nubilalis*, their effectiveness being of 25.33-54.67% (but with same hierarchy).
The application of synthetic pyrethroids led to a decrease in the percentage of broken plants (1.5-4.5%) compared to the untreated control (7.0%). The analysis of the results by the graph (Figure 7) shows that the ECB larvae showed a higher aggressivity on the cob (11.0%) and above the cob (14.5%).

Table 3. Efficacy of synthetic pyrethroids in the control of ECB larvae (hybrid DKC 4590-2nd assessment)

Active ingidient	Dose	Σ attacked plants/trt	ECB larva aggressivity	Insecticides efficacy
Alpha-Cypermethrin	0.6 l/ha	68	34	54.67
Alpha-Cypermethrin	0.15 l/ha	85	42.5	43.33
Deltamethrin	0.05 l/ha	112	56	25.33
Acetamiprid + lambda-Cyhalothrin	0.15 l/ha	84	42	44.00
Control	-	150	75.0	-

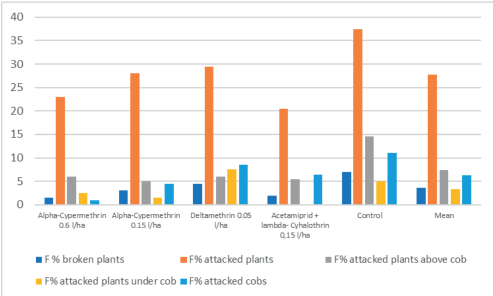


Figure 7. The attack of ECB larvae on maize plants (hybrid DKC 4590-2nd assessment)

The aggressivity of ECB larvae (20-73.75%) on the DKC 4670 hybrid (Table 4) was lower compared to that recorded on the DKC 4590 hybrid. The plants from the untreated control variant showed an attack frequency of (73.75%) (Table 4).

Table 4. Efficacy of synthetic pyrethroids in reducing the *Ostrinia nubilalis* population in the maize agroecosystem (hybrid DKC 4670 - 1st evaluation)

Active ingridient	Dose	Σ attacked plants/var	Frequency %	Efficacy %
Alpha-Cypermethrin	0.6 l/ha	16	20	72.88
Alpha-Cypermethrin	0.15 l/ha	24	30	59.32
Deltamethrin	0.05 l/ha	40	50	32.20
Acetamiprid + lambda-cyhalothrin	0.15 l/ha	18	22.5	69.49
Control	-	59	73.75	-

The hierarchy of insecticides in the control of *Ostrinia nubilalis* is maintained in the case of the hybrid DKC 4670, the first position is held by alpha-cypermethrin 0.6 l/ha (72.88%), followed by: acetamiprid + lambda-cyhalothrin 0.15 l/ha (69.49%), alpha-cypermethrin 0.15 l/ha (59.32%) and deltamethrin 0.05 l/ha (32.20%). The results obtained from this study are also supported by research conducted by Bažok R. et al., 2009.
They tested synthetic pyrethroids alone or in combination with ethyl chlorpyrifos to control

Ostrinia nubilalis. Bažok R. claims that the efficacy of deltamethrin was satisfactory, that lambda-cyhalothrin had a very poor efficacy, and the reason for the low efficacy may be the late application. The combination of cypermethrin and ethyl chlorpyrifos has been satisfactory, which is why this combination is very often used in the fight against ECB in many European countries (Bažok, 2009).

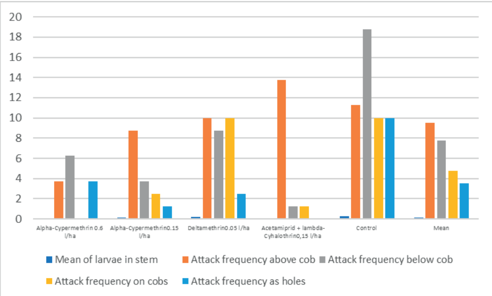


Figure 8. Frequency of attack of ECB larvae on maize plants (hybrid DKC 4670 - 1st assessment)

The study showed that for the DKC 4670 hybrid the highest aggressivity was recorded above the cobs with an average percentage/trial of 9.5% (Figure 8). ECB larvae attacked the cobs with a frequency of 4.75%.
The synthetic pyrethroids used in the experiment since not being systemic insecticides did not offer a very good control of the species *Ostrinia nubilalis* over a long period of time, so that at the second evaluation of their efficacy (Table 5) decreased compared to the first evaluation.

Table 5. Efficacy of synthetic pyrethroids in control of *Ostrinia nubilalis* population in the maize agroecosystem (hybrid DKC 4670 - 2nd assessment)

Active ingridient	Dose	Σ attacked plants/var	Frequency %	Efficacy %
Alpha-Cypermethrin	0.6 l/ha	40	20,0	66,10
Alpha-Cypermethrin	0.15 l/ha	67	33.5	43.22
Deltamethrin	0.05 l/ha	91	45.5	22.88
Acetamiprid + lambda-Cyhalothrin	0.15 l/ha	57	28.5	51.69
Control	-	118	59.0	-

The control of the ECB population, 80 days after the application of the treatments, ranged between 22.88 - 66.10% (Table 6).
In this growth stage (before harvesting) the most dangerous way of damage, caused by the ECB, is the breaking of plants and the attack of cobs, but by applying the four treatments it was possible to decrease the percentage of broken plants (1.5-5.0%). and attacked cobs (0-2.5%) compared to the results obtained in the control variant (untreated) (Figure 9).

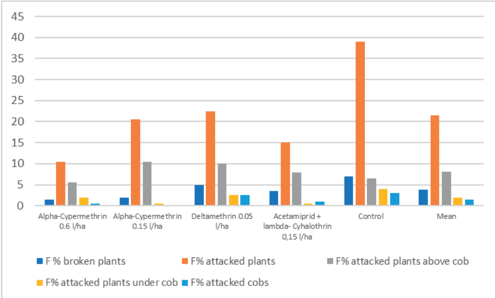


Figure 9. Graphical representation of the frequency of attack of ECB larvae on maize plants (hybrid DKC 4670 - 2nd assessment)

The successful control of ECB by the application of synthetic pyrethroids has been demonstrated by other authors (Gingera et al., 1998; Zhekova et al., 2015; Bartels et al., 1995; Hutchison, 2000). According to Foster (2001) the efficacy of pyrethroids is due to the very fast contact action. Lisowicz (1998; 1999), and Adamczewski et al. (2002) confirmed the high efficacy of pyrethroids in controlling ECB in maize. According to studies by Lisowicz (1998), two applications of synthetic pyrethroids would completely protect maize plants against ECB. Research by Lisowicz (2003), Mazurek et al. (2005) and Bereś (2008) confirm the efficacy of lambda-cyhalotrin in controlling ECB, and the highest efficacy was obtained when plants were treated twice with this active substance.
The maize yields, for the DKC 4590 hybrid, registered in the experimental variants varied between 8.71 t/ha (untreated control) and 11.72 t/ha (in the variants treated with alpha-cypermethrin 0.6 l/ha). By applying the treatments, production increases of 1.96-3.01 t/ha were obtained, the results being very significantly positive compared to the results recorded in the untreated variant.
The yield results (Table 6) for the DKC 4670 maize hybrid were lower compared to those obtained for the DKC 4590 hybrid, which is explained by the lower germination density/ha (69000). Yields higher than those recorded in

the untreated control variant (7.57 t/ha) were obtained in the variants treated with 0.6 l/ha alpha-cypermethrin (10.82 t/ha) acetamiprid + lambda-cyhalothrin 0.15 l/ha (10.18 t/ha), alpha-cypermethrin 0.15 l/ha (9.33 t/ha), these differences being very significant and distinctly significantly positive.

Table 6. Insecticides efficacy of in the control of the *Ostrinia nubilalis* population in maize cultivation expressed in terms of production

Hybrid	Treatment	Mean t/ha	Relative. diff.	significance
DKC 4590	Alpha-Cypermethrin 0.6 l/ha	11.72	3.01	***
	Alpha-Cypermethrin	10.89	2.18	***
	Deltamethrin	10.673	1.96	***
	Acetamiprid + lambda-Cyhalothrin	11.20	2.49	***
	Control	8.71	0	-
	LSD (p5%) = 0.58 LSD (p5%) = 0.84 LSD (p5%) = 1.27			
DKC 4670	Alpha-Cypermethrin	10.82	3.25	***
	Alpha-Cypermethrin	9.33	1.76	**
	Deltamethrin	8.44	0.87	-
	Acetamiprid + lambda-Cyhalothrin	10.18	2.61	***
	Control	7.57	0.00	-
	LSD (p5%) = 0.91 LSD (p5%) = 1.32 LSD (p5%) = 1.98			

Grain maize production, recorded in the variant treated with delthamethrin 0.05 l/ha (8.44 t/ha), did not show significant differences compared to the untreated control.

CONCLUSIONS

The efficacy of synthetic pyrethroids in the control of ECB larvae was satisfying at the first evaluation (36 days after treatment).

The control rate of *Ostrinia nubilalis* in the maize agroecosystem (consisting of the two hybrids DKC 4590 and DKC 4670) has decreased 80 days after treatment, this result is explained by the fact that non-systemic insecticides did not protect the maize plants over a longer period.

Pyrethroid alpha-cypermethrin (0.6 l/ha) showed the best efficacy in reducing the population of *Ostrinia nubilalis*.

The aggressivity of the attack of ECB larvae on maize plants was ascending, from the first assessment to the second.

Maize production has been correlated with the efficacy of treatments against *Ostrinia nubilalis*.

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