

HARMFULNESS AND EFFECTS OF CHEMICAL CONTROL OF *Ostrinia nubilalis* HBN. ON SWEET CORN (*Zea mays* var. *saccharata*) IN RZESZÓW REGION

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Abstract. The study was conducted in 2006-2009 in Rzeszów (50°01' N; 22°03' E) and Boguchwała (49°58' N; 21°56' E) (south-eastern Poland). Observations of the harmfulness of the European corn borer (ECB) to sweet corn (*Zea mays* var. *saccharata*) were carried out on Candle, Sweet Trophy and Sheba hybrids. In the study years the harmfulness of *Ostrinia nubilalis* was very high. During the analysed period caterpillars in both locations damaged from 58.0 to 97.5% of plants and from 55.0 to 92.7% of cobs. The risk to quantity and quality of cob yield was significant because from 1 to 15 caterpillars of the ECB eating out soft kernels were found on a single cob. Insecticides containing lambda-cyhalothrin and indoxacarb which were used for single and double spraying of plants demonstrated a high suitability for the protection of sweet corn against the ECB. The best results of chemical control of caterpillars were obtained by using two treatments with the studied insecticides during the growing season.

Key words: corn protection, ECB, European corn borer, hybrids, indoxacarb, lambda-cyhalothrin

INTRODUCTION

Sweet corn (*Zea mays* var. *saccharata*) is a relatively new plant in Poland. However, in recent years interest in the cultivation of this plant has increased dynamically. Actually the area of sweet corn cultivation in Poland is about 5-6 thousand ha.

The large cultivation area of fodder corn, the high share of cereals in crop rotation and climate warming are factors contributing to the fact that sweet corn crops are infested by a number of pests, with the European corn borer (ECB) (*Ostrinia nubilalis* Hbn.) being the most significant one [Waligóra 1992].

The European corn borer has been present in south-eastern Poland since 1994 [Lisowicz 1996]. From the time the pest was first detected at that time in Rzeszowski and Przemyskie provinces to the present day, this species has been listed among the

most serious maize pests in this part of Poland [Lisowicz 2001, 2003b, Beres 2006, 2007]. In many crops in the southern part of the country caterpillars of this moth damage from 50 to 80%, and locally up to 100% of plants [Lisowicz and Tekielna 2004].

According to estimates, in Poland the caterpillars of the ECB feeding on maize cause 20-30%, and up to 40% losses in maize grain yields [Lisowicz et al. 2005].

Before the present study, no detailed studies on the distribution and harmfulness of the *O. nubilalis* to sweet corn had been conducted in Podkarpackie province. However, because of frequent reports from sweet corn producers located in Rzeszów area regarding a dramatic situation associated with the harmfulness of this pest and its difficult control, the Regional Experimental Station of the Institute of Plant Protection – NRI in Rzeszów began studies in 2005 on the harmful entomofauna of the sweet corn in this part of the country.

The subject was also taken up owing to the specific cultivation method of this plant, as the commercial crop of sweet corn are cobs harvested when the kernel is at the milky or dough stage. In addition, because the crop is mainly bought by fruit and vegetable processing plants and individual consumers, any damage to these organs is unacceptable. Cobs damaged mechanically or by agrophages (pests and diseases) lose their commercial value and are unsuitable for direct consumption [Waligóra et al. 2008].

Assurance of high quality cobs is additionally more difficult because of the lack of a suitable pest control system for sweet corn, especially against the ECB. Sweet corn is classified as a minor agricultural crop, which is why the majority of chemical companies are not interested in the expensive registration of products for the protection of this plant against pests.

The current protection system of vegetables in the open field and greenhouse system does not cover insecticides for the control of pests on sweet corn [Kupczak 2010]. The lack of detailed recommendations for the chemical protection of this plant against the ECB is the reason why many sweet corn producers, having no guidance, use insecticides recommended for the protection of other crops, and do not always consider their waiting period. The use of non-registered insecticides to control the *O. nubilalis* on sweet corn creates a risk for consumers, because the commercial crop can contain a high residual level of insecticides.

According to the information provided on labels, instructions for individual insecticides registered for maize to control the population and harmfulness of the ECB, including the use for sweet corn (defined as a non-agricultural plant), only Karate Zeon 050 CS, containing lambda-cyhalotrin, can be used with a 7-day waiting period. Following the waiting period principle is very important here for consumer safety, because in a short period after spraying against the caterpillars of *O. nubilalis* cobs are suitable for harvest.

The objective of the conducted study was to specify the current risk of the European corn borer to sweet corn and to evaluate the effects of chemical pest control with selected insecticides with a short waiting period, applied twice.

MATERIAL AND METHODS

Studies on the occurrence and harmfulness of the European corn borer for three hybrids of sweet corn (Candle, Sweet Trophy and Sheba) sown at the same time between 21st and 30th of April or between 1st and 10th of May were conducted in 2006-2009 on cultivation areas from 2.5 to 3.5 ha in Rzeszów (50°01' N; 22°03' E) and Boguchwała (49°58' N; 21°56' E).

To estimate the number of cobs and plants at the dough stage (BBCH 85) [Adamczewski and Matysiak 2002] damaged by caterpillars, 100 consecutive plants in a row were analysed in each of the four cultivation places for each hybrid. In addition, in each of the four cultivation places 25 damaged cobs were sampled (100 for each hybrid) and the minimum, maximum and average number of caterpillars feeding on kernels was defined.

The effects of the chemical control of caterpillars were analysed for 2007-2009 in Rzeszów on Candle hybrid. To do so, 30 m² plots were established on a field in the randomized block design in four replications, where spraying with the following insecticides was applied once and twice: Karate Zeon 050 CS (lambda-cyhalotrin), dose 0.2 dm³·ha⁻¹, and Steward 30 WG (indoxacarb), dose 0.2 kg·ha⁻¹. The above insecticides were also applied in combination, by spraying plants at first with Karate Zeon 050 CS, and secondly with Steward 30 WG.

The date of chemical treatment was established by tracking the fly of the European corn borer moth in a pheromone trap from Medchem with the use of dispensers from AgriSense with the following identification: 2007 – ONC036A, 2008 – ONC048A/107 and 2009 – ONC039A/71. Additionally, starting from the first ten days of June, 50 consecutive plants in each of the four places of cultivation were analysed twice a week, by searching for the first deposited eggs of the pest.

Chemical treatment was carried out with a Kwazar sprayer, using 400 dm³ of working liquid per hectare (medium-droplet spraying) on two dates:

- I – on 4 July 2007, 1 July 2008 and 6 July 2009 – 5 days after 6 or more egg clusters on 100 plants were recorded,
- II – on 18 July 2007, 14 July 2008 and 20 July 2009 – during the mass hatching of caterpillars.

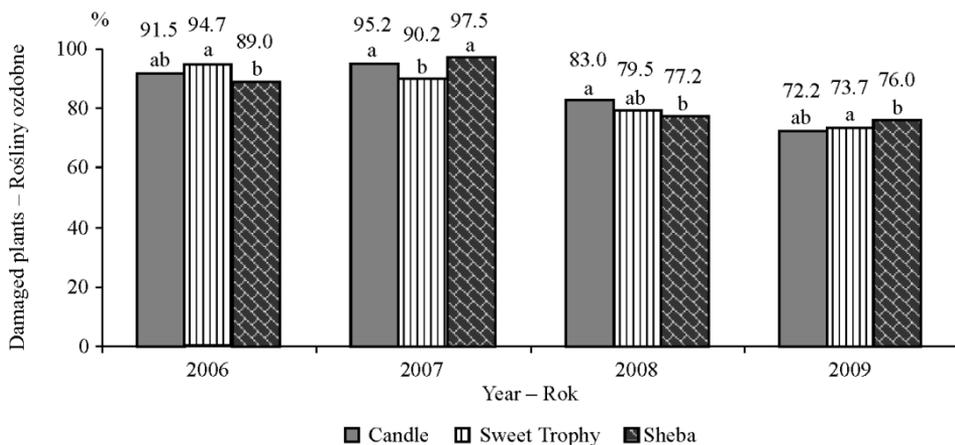
The obtained results were analysed using statistical methods. The statistical significance of differences between mean values was analysed using the Tukey's test at a significance level of $P < 0.05$. The statistical analysis was carried out with Microsoft Office Excel 2003 programme.

RESULTS AND DISCUSSION

Weather conditions in Podkarpackie province varied during the study period. Particularly favourable conditions were recorded in 2007, when relatively high temperatures and moderate precipitation facilitated both the development of maize and the European corn borer. Only in 2008-2009 between June and July were there periods with relatively low temperatures and intense precipitation, which disturbed the moth fly and oviposition.

In the first year of the study (2006), a high number of the *O. nubilalis* caterpillars on sweet corn was recorded in both monitored places, and the highest harmfulness of the pest was recorded during the warm and moderately wet year 2007. During the other two years the number and harmfulness of the ECB decreased, mainly owing to intense rain in June and July.

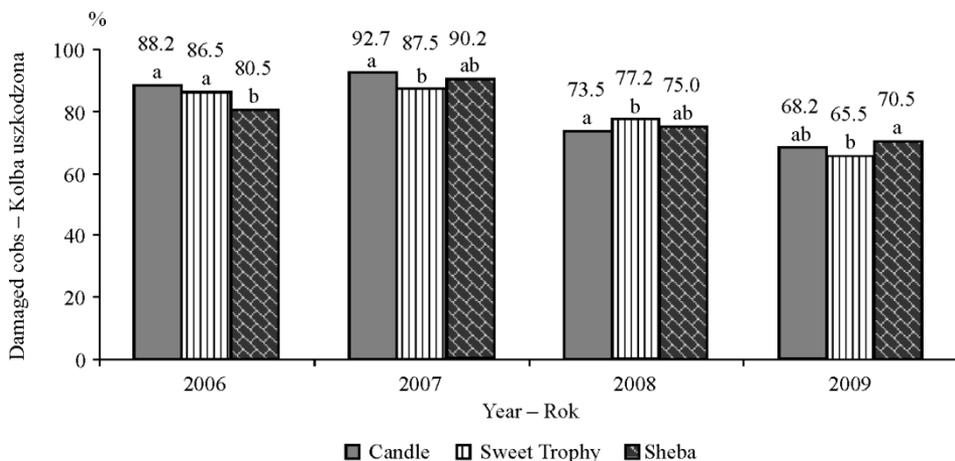
In Rzeszów in 2006-2009 caterpillars of *O. nubilalis* damaged on average for the three studied hybrids: 91.7% of plants in 2006, 94.3% in 2007, 79.9% in 2008 and 74.0% in 2009, respectively (Fig. 1). With the increasing number of plants infested with caterpillars, the percentage of damaged cobs also increased and for the three studied hybrids it was 85.1% in 2006, 90.1% in 2007, 75.2% in 2008 and 68.1% in 2009 (Fig. 2).



means followed by the same letter do not differ at 5% level of significance (Tukey's multiple range test) średnie oznaczone tą samą literą nie różnią się na poziomie istotności 5% (test wielokrotnych porównań Tukeya)

Fig. 1. The percentage of plants damaged by the caterpillars of *Ostrinia nubilalis* in 2006-2009 in Rzeszów

Rys. 1. Udział procentowy roślin uszkodzonych przez gąsienice *Ostrinia nubilalis* w latach 2006-2009 w Rzeszowie



for explanations, see Fig. 1 – objaśnienia pod rys. 1

Fig. 2. The percentage of cobs damaged by the caterpillars of *Ostrinia nubilalis* in 2006-2009 in Rzeszów

Rys. 2. Udział procentowy kolb uszkodzonych przez gąsienice *Ostrinia nubilalis* w latach 2006-2009 w Rzeszowie

The size of the damaged cobs mainly depended on the number of ECB caterpillars feeding on kernels. The analysis conducted when kernels were at the dough stage demonstrated that in the Rzeszów area in the study years from 1 to 15 caterpillars of *O. nubilalis* were feeding on a single cob. The Candle and Sheba hybrids were the most

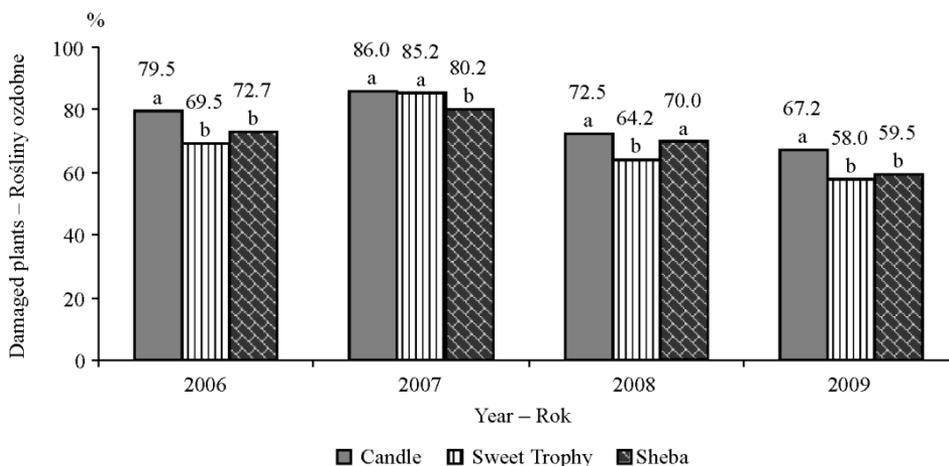
susceptible to infestation by the caterpillars of the ECB. In 2006-2007 on average from 4.4 to 5.5 caterpillars were recorded on the cobs of these hybrids (Table 1).

Table 1. Minimum, maximum and mean number of caterpillars of *Ostrinia nubilalis* on cobs in Rzeszów in 2006-2009

Tabela 1. Minimalna, maksymalna i średnia liczba gąsienic *Ostrinia nubilalis* na kolbach w Rzeszowie w latach 2006-2009

Hybrid Odmiana	Year Rok	Number of caterpillars feeding on cob – Liczba gąsienic żerujących na kolbie		
		minimal – minimalna	maximum – maksymalna	mean – średnia
Candle	2006	1.0	13.0	4.9
	2007	2.0	15.0	5.5
	2008	1.0	7.0	3.0
	2009	1.0	8.0	2.3
Sweet Trophy	2006	1.0	10.0	4.0
	2007	1.0	9.0	3.8
	2008	1.0	6.0	2.5
	2009	1.0	4.0	2.2
Sheba	2006	1.0	11.0	4.4
	2007	1.0	13.0	5.2
	2008	1.0	6.0	2.6
	2009	1.0	7.0	2.6

In Boguchwała the ECB population size and harmfulness were lower than in Rzeszów. In 2006-2009 caterpillars of *O. nubilalis* damaged in this place, on average for the three studied hybrids: 73.9% of plants in 2006, 83.8% in 2007, 68.9% in 2008 and 61.6% in 2009 (Fig. 3).

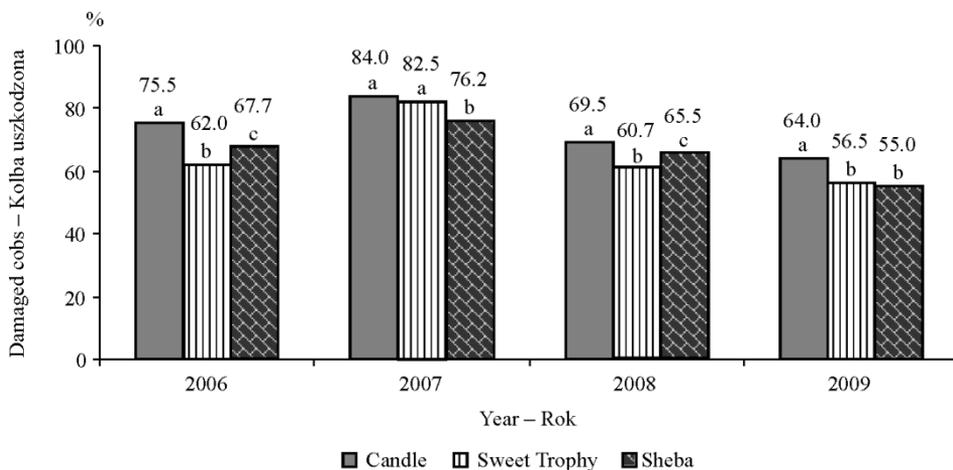


for explanations, see Fig. 1 – objaśnienia pod rys. 1

Fig. 3. The percentage of plants damaged by the caterpillars of *Ostrinia nubilalis* in 2006-2009 in Boguchwała

Rys. 3. Udział procentowy roślin uszkodzonych przez gąsienice *Ostrinia nubilalis* w latach 2006-2009 w Boguchwałe

The percentage of damaged cobs was also lower, and on average for the three studied hybrids it was 68.4% in 2006, 80.9% in 2007, 65.2% in 2008 and 58.5% in 2009 (Fig. 4).



for explanations, see Fig. 1 – objaśnienia pod rys. 1

Fig. 4. The percentage of cobs damaged by the caterpillars of *Ostrinia nubilalis* in 2006-2009 in Boguchwała

Rys. 4. Udział procentowy kolb uszkodzonych przez gąsienice *Ostrinia nubilalis* w latach 2006-2009 w Boguchwale

In Boguchwała, during the period when kernels were at the dough stage, from 1 to 9 caterpillars of *O. nubilalis* were feeding on a single cob. The highest number of caterpillars (on mean from 2.2 to 3.8) was recorded in 2006-2007 on the Candle and Sheba hybrids (Table 2).

Table 2. Minimum, maximum and average number of caterpillars of *Ostrinia nubilalis* on cobs in Boguchwała in 2006-2009

Tabela 2. Minimalna, maksymalna i średnia liczba gąsienic *Ostrinia nubilalis* na kolbach w Boguchwale w latach 2006-2009

Hybrid Odmiana	Year Rok	Number of caterpillars feeding on cob – Liczba gąsienic żerujących na kolbie		
		minimal – minimalna	maximum – maksymalna	mean – średnia
Candle	2006	1.0	6.0	2.9
	2007	1.0	9.0	3.8
	2008	1.0	5.0	2.0
	2009	1.0	7.0	2.3
Sweet Trophy	2006	1.0	4.0	2.2
	2007	1.0	7.0	3.2
	2008	1.0	5.0	2.0
	2009	1.0	7.0	1.8
Sheba	2006	1.0	7.0	2.8
	2007	1.0	9.0	3.4
	2008	1.0	6.0	2.3
	2009	1.0	5.0	2.0

The effects of the chemical control of ECB caterpillars in Rzeszów in 2007-2009 are presented in Tables 3-5.

Table 3. The effects of the chemical control of *Ostrinia nubilalis* caterpillars in Rzeszów in 2007
Tabela 3. Efekty chemicznego zwalczania gąsienic *Ostrinia nubilalis* w Rzeszowie w 2007 roku

Treatment Doświadczenie	Date of application* Termin stosowania		% damaged plants % roślin uszkodzonych	Effectiveness Skuteczność %	% damaged plants % roślin uszkodzonych	Effectiveness Skuteczność %
	I	II				
Control	–	–	95.2	–	92.7	–
Karate Zeon 050 CS	–	+	16.5	82.6	12.7	86.3
Karate Zeon 050 CS	+	+	10.2	89.2	9.0	90.3
Steward 30 WG	–	+	14.2	85.0	9.7	89.5
Steward 30 WG	+	+	9.2	90.3	6.0	93.5
Karate Zeon 050 CS + Steward 30 WG	+	+	8.5	91.0	6.2	93.3
LSD _{0.05} – NIR _{0.05}			4.28		4.22	

* I – on 4 July 2007, 1 July 2008 and 6 July 2009 – 4 lipca 2007 r., 1 lipca 2008 r. i 6 lipca 2009 r.

II – on 18 July 2007, 14 July 2008 and 20 July 2009 – 18 lipca 2007 r., 14 lipca 2008 r. i 20 lipca 2009 r.

Table 4. The effects of the chemical control of *Ostrinia nubilalis* caterpillars in Rzeszów in 2008
Tabela 4. Efekty chemicznego zwalczania gąsienic *Ostrinia nubilalis* w Rzeszowie w 2008 roku

Treatment Doświadczenie	Date of application Termin stosowania		% damaged plants % roślin uszkodzonych	Effectiveness Skuteczność %	% damaged plants % roślin uszkodzonych	Effectiveness Skuteczność %
	I	II				
Control	–	–	83.0	–	73.5	–
Karate Zeon 050 CS	–	+	15.0	81.9	10.7	85.4
Karate Zeon 050 CS	+	+	9.7	88.3	6.2	91.5
Steward 30 WG	–	+	13.7	83.5	9.5	87.0
Steward 30 WG	+	+	7.5	90.9	5.7	92.2
Karate Zeon 050 CS + Steward 30 WG	+	+	6.5	92.1	5.5	92.5
LSD _{0.05} – NIR _{0.05}			4.83		4.15	

Table 5. The effects of the chemical control of *Ostrinia nubilalis* caterpillars in Rzeszów in 2009
Tabela 5. Efekty chemicznego zwalczania gąsienic *Ostrinia nubilalis* w Rzeszowie w 2009 roku

Treatment Doświadczenie	Date of application Termin stosowania		% damaged plants % roślin uszkodzonych	Effectiveness Skuteczność %	% damaged plants % roślin uszkodzonych	Effectiveness Skuteczność %
	I	II				
Control	–	–	72.2	–	68.2	–
Karate Zeon 050 CS	–	+	16.5	77.1	14.2	79.1
Karate Zeon 050 CS	+	+	8.7	87.9	7.5	89.0
Steward 30 WG	–	+	17.2	76.1	12.0	82.4
Steward 30 WG	+	+	6.2	91.4	4.7	93.1
Karate Zeon 050 CS + Steward 30 WG	+	+	6.5	91.0	4.0	94.1
LSD _{0.05} – NIR _{0.05}			5.03		5.13	

All the used insecticides demonstrated high effectiveness in reducing the number of plants and cobs damaged by the caterpillars of *O. nubilalis*.

Plant protection products used only once per season during the mass hatching of caterpillars reduce the number of damaged cobs by 79.1-89.5%. A higher effectiveness of 89.0 to 94.1% was obtained by spraying twice, both when one insecticide was applied twice per growing season and when the two studied insecticides were used in an alternating system.

Studies on the harmfulness of the ECB confirmed that in the Rzeszów area this pest poses a significant risk to the commercial cob yield of sweet corn. In the studied years the harmfulness of *O. nubilalis* to sweet corn was very high. The highest harmfulness was recorded in 2006-2007, when weather conditions were favourable for the development of this species. At that time the percentage of damaged plants and cobs for the three studied sweet corn hybrids ranged from 62.0 to 97.5%. A similarly high harmfulness of *O. nubilalis* in this part of Poland was recorded on fodder corn by Lisowicz [2003a, b] and Beres [2007].

In the Rzeszów area it is practically impossible to obtain a high yield of sweet corn cobs with good quality parameters when the population size and harmfulness of the European corn borer are high without the use of pest control methods.

In the United States, where the ECB is one of the most significant pests of sweet corn, its harmfulness is controlled by the cultivation of transgenic hybrids, currently the most effective method. Such hybrids have a close to 100% resistance to damage caused by the caterpillars of the ECB [Burkness et al. 2001] and bring measurable economic benefits to sweet corn producers [Speese et al. 2005].

In Poland transgenic hybrids of sweet corn are not currently cultivated, and therefore other methods are used to control the pest population.

An important part of integrated corn protection against the ECB is to follow correct agricultural techniques, as well as to select conventional hybrids for cultivation which are less susceptible to caterpillars feeding [Beres et al. 2007, Beres and Pruszyński 2008]. In regions where the harmfulness of the ECB is high, biological and chemical methods are used for pest control [Lisowicz 2003b, Beres and Lisowicz 2005, Beres 2006, 2008].

The control of *O. nubilalis* on sweet corn is very difficult due to limited choice of registered insecticides. In addition, very few maize producers use biological pest control with *Trichogramma* spp., because the effectiveness of this method is not always satisfactory, and it does not provide full protection to cobs against damage caused by caterpillars.

In Poland sweet corn is classified as a minor agricultural crop, which is why few chemical companies are interested in the expensive registration of insecticides for the protection of this plant against the ECB. Because of this situation sweet corn producers have no effective methods to protect this plant against caterpillars feeding and, in addition, in many cases the small range of available insecticides forces them to use other, non-registered products for the protection of sweet corn.

In studies on the control of the *O. nubilalis* on sweet corn we used Karate Zeon 050 CS (lambda-cyhalotrin), the only one which can be used to protect this plant against the feeding caterpillars. In addition, we used Steward 30 WG, containing indoxacarb, an active substance used for the control of the ECB, for example on maize in North America [Musser and Shelton 2003] and in Slovenia [Koršič and Ramšak 2007].

The obtained results confirmed the high suitability of the used insecticides for the protection of sweet corn against the ECB. Similar results with lambda-cyhalotrin for sweet or fodder corn were also obtained by Lisowicz [2003b], Mazurek et al. [2005] and Beres [2008], and the highest effectiveness was obtained when plants were sprayed twice with this active substance.

A very good effectiveness in reducing the number of plants and cobs damaged by caterpillars was also obtained for indoxacarb and it was insignificantly higher than the effects of control with lambda-cyhalotrin. A similarly high effectiveness of indoxacarb in the control of the ECB was observed by Reinhard et al. [2008].

Owing to the great harmfulness of the ECB to sweet corn, it is necessary to develop a complex plant protection system for this plant against the pest, with particular consideration of a chemical method based on the use of a wider number of insecticides with a short waiting period, containing active substances classified to different chemical groups.

In addition, it is recommended to begin studies on the eradication of residual insecticides in the cobs, with consideration of those currently used and those insecticides with the potential to control the ECB, in order to establish their safety for consumers.

CONCLUSIONS

1. The European corn borer is currently the most dangerous sweet corn pest in the Rzeszów area. During the study years the caterpillars of this species in Rzeszów and Boguchwała damaged from 58.0 to 97.5% of plants and from 55.0 to 92.7% of cobs.

2. Risk to the commercial crop of cobs was very significant, because in 2006-2009 from 1 to 15 caterpillars of the ECB were feeding on a single cob.

3. The insecticides containing lambda-cyhalotrin and indoxacarb used in the study demonstrated a high suitability for the protection of sweet corn against the *O. nubilalis*. The best results were obtained by spraying plants twice with the studied insecticides.

4. The high effectiveness of indoxacarb in the control of the ECB allows for recommending this active substance for registration in the protection of sweet corn against the caterpillars of this moth, especially for integrated programs of corn protection.

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SZKODLIWOŚĆ ORAZ EFEKTY CHEMICZNEGO ZWALCZANIA *Ostrinia nubilalis* HBN. NA KUKURYDZY CUKROWEJ (*Zea mays* var. *saccharata*) W OKOLICACH RZESZOWA

Streszczenie. Badania wykonano w latach 2006-2009 w Rzeszowie (50°01' N; 22°03' E) oraz Boguchwale (49°58' N; 21°56' E). Obserwacje nad szkodliwością omacnicy prosowianki dla kukurydzy cukrowej (*Zea mays* var. *saccharata*) prowadzono na odmianach: Candle, Sweet Trophy i Sheba. W latach badań szkodliwość *Ostrinia nubilalis* była bardzo wysoka. Gąsienice w analizowanym okresie w obu miejscowościach uszkadzały od 58,0 do 97,5% roślin oraz od 55,0 do 92,7% kolb. Zagrożenie dla wysokości oraz jakości plonu kolb było duże, gdyż na jednej tylko kolbie występowało od 1 do nawet 15 gąsienic omacnicy prosowianki, które wyjadały miękkie ziarniaki. Insektycydy zawierające lambda-cyhalotrynę oraz indoksakarb, użyte do jedno- oraz dwukrotnego opryskiwania roślin, charakteryzowały się dużą przydatnością w ochronie kukurydzy cukrowej przed omacnicą prosowianką. Najlepsze rezultaty chemicznego zwalczania gąsienic uzyskano po wykonaniu dwóch zabiegów w sezonie wegetacyjnym z wykorzystaniem badanych preparatów.

Słowa kluczowe: indoksakarb, lambda-cyhalotryna, ochrona kukurydzy, odmiany, omacnica prosowianka

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