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THE EFFECTIVENESS OF SELECTED CHEMICAL AND BIOLOGICAL INSECTICIDES IN CONTROL OF EUROPEAN CORN BORER (*OSTRINIA NUBILALIS* HBN.) ON SWEET CORN

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Abstract: The trials conducted with selected chemical and biological insecticides in 1998-2000 showed the highest effectiveness of Karate Zeon 100 CS (lambda-cyhalotrine) in European corn borer (ECB) larvae control in sweet corn. The efficacy of biological insecticides containing *Bacillus thuringiensis* ssp. *kurstaki*: Biobit 3.2 WP and Lepinox WDG was very variable between the years. Reasons for insufficient efficacy of these products are discussed. The most appropriate time for the application of a chemical insecticide against ECB larvae are plant developmental stages since the beginning of pollen shedding to full blooming (63–67 BBCH scale). The efficacy of treatment was the highest at that time.

Key words: European corn borer, ECB, insecticides, bioinsecticides, control, efficacy, sweet corn

INTRODUCTION

Among herbivores found on sweet corn European corn borer (ECB) (*Ostrinia nubilalis* Hbn.) is the key pest, as it is known to feed on cobs and inside them. In Lower Silesia, Poland, cob damage done by the pest varied from 31% to 46%. Leaving the cobs on plants approximately 3 weeks after the optimal harvest time resulted in the increased damage reaching 70% (Mazurek and Hurej 1999; Mazurek et al. 2003).

In Poland, for many years the only products used to control ECB in grain corn were granular insecticides containing diazinon as the active ingredient. Because of the lack of special equipment for granular insecticide application these products are rarely used in practice. In 2000, Karate 025 EC (lambda-cyhalotrine) applied as a spray treatment was registered for ECB control in sweet corn. Till now, there is no other insecticide registered for ECB control in this crop in Poland. In some other

European countries the list of recommended insecticides is quite long (Langerova 1988; Gingera et al. 1998; Tancik and Cagan 1998).

The main objective of our study was to compare the effectiveness of some chemical and biological insecticides against ECB larvae in sweet corn. The appropriate application time of the most effective product was also studied.

MATERIAL AND METHODS

The study was carried out at Kobierzyce near Wrocław (Lower Silesia, Poland), in the fields of the Plant Breeding Station "Nasiona Kobierzyce S.A.". Sweet corn cultivar Trophy F1 was used.

Insecticide efficacy

The experiment to test and compare the efficacy of different commercial products for the control of ECB larvae was set up in the 1998–2000 growing seasons. The experiment was carried out according to randomized block design, in four replications in 1998 and in three replications in 1999 and 2000, on plots of 20.4 m^2 (6.0 × 3.4 m). The following insecticides were tested: Biobit 3,2 WP (*Bacillus thuringiensis* ssp. k*urstaki*), concentr. 0.5% (since 1999 replaced by Lepinox WDG, concentr. 0.35%), Karate Zeon 100 CS (lambda-cyhalotrine), concentr. 0.025%, Nomolt 150 SC (teflubenzuron), concentr. 0.2%, Larvin 375 SC (tiodicarb), concentr. 0.2% and Diazinon 10 GR (diazinon) at the rate of 15 kg per ha. Insecticides were applied on 10.07.1998, 13.07.1999 and 15.07.2000, using knapsack sprayers Solo or Turbine K-45. Only Diazinon 10 GR was applied manually by spreading granules over the corn plots. To determine the efficacy of ECB larvae control, 100 cobs in 1998 or 50 cobs in the next two years were harvested manually from each plot, including untreated plots. The number of damaged cobs was recorded.

Insecticide application time

Another trial was set up in 1999–2001 in order to determine the appropriate time for chemical treatment against the ECB and to describe it in terms of plant developmental stages. That experiment was also designed as randomized blocks, in three replications on plots of 20.4 m^2 (6.0 × 3.4 m). Chemical treatments were applied using only one of the previously tested products: Karate Zeon 100 CS, as this insecticide proved most effective in the first year of the study. The experimental design included two sowing dates of corn and three different dates of chemical treatment against ECB (Table 1). Only one treatment was done in 2001 due to very late plant infestation by ECB larvae as well as for an exceptionally rainy season. To determine the efficacy of control of ECB larvae, 50 cobs were harvested from each plot. The number of damaged cobs was recorded.

The efficacy of insecticides applied in all the experiments was calculated using the following formula: $E = (N - T/N) \times 100$, where: E – treatment efficacy, N – number of damaged cobs on untreated plots, T – number of damaged cobs on treated plots. Obtained data were processed statistically using one way ANOVA and Tukey HSD (Honest Significant Difference) test, at $p \leq 0.05$.

Observations of ECB development

To take proper decision concerning chemical treatments, the supporting biological observations were carried out on the untreated plots on 100 of labeled plants in 1998 and on 75 plants in 1999-2000. These were aimed at determining the dynamics of egg laying and larvae hatching. The results of these observations were presented in our previous paper (Mazurek et al. 2003). During ECB observations the crop developmental stages were also recorded.

Dates of corn sowing and harvesting are shown in Table 1.

Table 1. Sowing time of sweet corn, the time of contact insecticide treatments (Karate Zeon 100 CS) and cob harvesting for the assessment of appropriate application time

Year	1998	1999	2000	2001
Sowing date	27.04.	24.04., 03.05.	23.04., 29.04.	23.04., 02.05.
Treatment date		13.07., 20.07., 26.07.	15.07., 21.07., 28.07.	20.07.
Harvest date	17.08.	19.08.	23.08.	24.08.

RESULTS

The efficacy of different insecticides against ECB larvae

The experiments of 1998–2000 have demonstrated that Karate Zeon 100 CS is highly effective against ECB larvae (Table 2). The insecticide was repeatedly the most effective one among all the products tested in 1998–1999. Its efficacy in 1998 and 1999 was as high as 77% and 80%, respectively. Although in 2000 the efficacy of Karate Zeon 100 CS was higher than in the preceding years (90%), the biological insecticide Lepinox WDG performed that year even better (95%). Nevertheless, the efficacy of *B. thuringiensis* formulations was much more variable in the years than that of Karate. On the one hand, Biobit 3.2 WP in 1998, as well as Lepinox WDG in 1999 proved to be the least effective insecticides against cob-damaging caterpillars, showing 19% and 35% efficacy, respectively. On the other hand, Lepinox WDG applied in 2000 resulted in 95% efficacy of larvae control. Granular insecticide

Table 2. Percentage of cob damage (D) and the efficacy of ECB caterpillars' control (E), using different insecticides. Kobierzyce 1998

Year	Mean	Biobit[1] Lepinox[2]	Larvin	Diazinon	Nomolt	Karate	Untreated
1998	mean D (%)	19.2 a	15.7 a	10 b	10 b	5.5 b	23.7 a
	mean E (%)	19	34	58	58	77	
1999	mean D (%)	8.6 a	8 a	7.3 a	8.5 a	2.6 b	13.3 a
	mean E (%)	35	40	45	36	80	
2000	mean D (%)	1.3 b	5.3 b	8.6 b	6 b	2.6 b	27.3 a
	mean E (%)	95	80	68	78	90	

[1]in 1998
[2]in 1999 and 2000
Mean values of D in lines marked with the same small letter do not differ significantly; one way ANOVA, Tukey HSD test, p = 0.05

Table 3. Percentage of cob damage (D) and the efficacy of ECB caterpillars' control (E), using Karate Zeon 100 CS

Mean	1999			2000			2001		
	Treatment date	Sow. date I	Sow. date II	Treatment date	Sow. date I	Sow. date II	Treatment date	Sow. date I	Sow. date II
mean D (%)	13.07	2.6 b	2.0ba	15.07	1.3 b	2.0 b			
mean E (%)		94	91		95	94			
mean D (%)	20.07	4.0 b	4.6 b	21.07	8.0 b	1.3 b			
mean E (%)		91	80		69	96			
mean D (%)	26.07	16.0 a	6.0 b	28.07	11.3 b	10.0 b	24.07	5.3 b	11.3 b
mean E (%)		62	74		56	70		88	64
mean D (%)	Untreated	42.6 a	23.0 a	Untreated	26.0 a	34.0 a	Untreated	45.3 a	31.3 a

Mean values of D in columns marked with the same small letter do not differ significantly; one way ANOVA, Tukey HSD test, p = 0.05

Diazinon showed rather low effectiveness i.e. between 45% and 68%. All the other tested insecticides varied significantly more over the years in their ability to reduce the number of ECB larvae and the related data remain inconsistent.

The appropriate application time of Karate Zeon 100 CS against ECB caterpillars

Chemical control of ECB larvae using Karate Zeon 100 CS was highly effective when the insecticide was applied at one of the first two of three proposed dates (Table 3). Both in 1999 and in 2000 the application in the first date, i.e. on 13.07. or 15.07. respectively, resulted in the efficacy of cob protection higher than 90%, for both sowing dates of the crop. The crop developmental stages were 63 and 65 respectively, according to BBCH scale (beginning of pollen shedding to full blooming). After the application on the second date, on 20.07. 1999 and on 21.07. 2000, the efficacy was more variable, although still relatively high. On the contrary, the effectiveness of application on the third date, on 26.07. and on 28.07., was apparently lower; the percentage of undamaged cobs was never higher than 75%.

Only one treatment, using Karate Zeon 100 CS was applied in 2001, on 24.07. Its efficacy was higher in the early sown crop and it reached 88%.

DISCUSSION

Among the insecticides tested in Kobierzyce, Karate Zeon 100 CS was the most effective in controlling ECB larvae. Highly efficient control of ECB by synthetic pyrethroids has been already demonstrated by other authors (Gingera et al. 1998; Langerova 1988; Tancik and Cagan 1998; Bartels et al. 1995; Hutchison 2000). According to Foster (2001) very fast contact action of these chemicals contributes to their very good effectiveness. Lisowicz (1998; 1999) as well as Adamczewski et al. (1997) confirmed high efficacy of pyrethroids in controlling ECB in grain corn in Poland. As reported by Lisowicz (1998), two applications of Karate 025 EC completely protect corn cobs against ECB.

The reduction of number of ECB larvae by *Bacillus thuringiensis* based bioinsecticides was very variable. However, these insecticides are commonly recommended

in other countries for the control of ECB in sweet corn, because they require no pre-harvesting period and therefore the cobs can be harvested early and consumed as fresh or cooked food (Sulewska 1996). Bartels et al. (1995) have never found the efficacy of ECB control by *B.t.* as sufficient. On the other hand, according to Hazzard et al. (1998), using *B.t.* allows reduction of the number of caterpillars to the same extent as does the application of contact insecticides. Although the problem seems to be unresolved, there are some well known factors that undoubtedly affect performance of *B.t.* formulations. They are rainfall and UV radiation. The deposit of *B.t.* spores on plant leaves is vulnerable to wash-off and the intensive UV exposure reduces the biological activity of protein endotoxin within the spores (Malinowski 1985; Tappeser 1997). It seems therefore possible, that in our experiments in 1998 and 1999 unfavourable weather conditions prevented proper insecticidal action of Biobit and Lepinox before they were ingested by the emerging caterpillars.

Critical factor that determines the effective control of ECB larvae is treatment time. An effective chemical treatment against ECB larvae should be applied late enough to allow majority of eggs to hatch, and, at the same time, early enough not to allow first of hatched larvae to bore into stems and cobs (Andaloro et al. 1983; Witkowski and Wright 1997; Gianessi and Carpenter 1999). In our experiments, the insecticide proved most effective if application took place in the second decade of July, at the plant developmental stages between beginning of pollen shedding to full blooming. It was the time of most intensive larvae hatching. Only in 2000, the most effective control of the pest was achieved after insecticide application in the third decade of July, but such result was only obtained for corn sown later. The plants were at that time at the end of flowering stage (BBCH – 69). However, it must be emphasized that early application of insecticide always enabled pest control efficacy above 90%, whereas the effect of later treatments was apparently lower. Most likely the lower efficacy of later treatments comes from the fact that some larvae were already able to bore into plant tissues, where they evade toxic action of the applied insecticides.

As maize developmental stages are not always a good indication of the current phase of the ECB population, still more precise method to determine application time can be based on direct observation of the pest in the field.

CONCLUSIONS

1. Of all the tested insecticides, the most effective control of European corn borer larvae on sweet corn was obtained after the application of Karate Zeon 100 CS.
2. The efficacy of biological treatments using formulations of *Bacillus thuringiensis* ssp. *kurstaki*: Biobit 3,2 WP and Lepinox WDG, was very variable between the years. Presumably, it was related to the products' susceptibility to unfavourable weather conditions.
3. The most appropriate time for the application of a chemical insecticide against ECB larvae are plant developmental stages since the beginning of pollen shedding to full blooming (63–67 BBCH scale). The efficacy of the treatment was the highest at that time.

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POLISH SUMMARY

SKUTECZNOŚĆ WYBRANYCH CHEMICZNYCH I BIOLOGICZNYCH INSEKTYCYDÓW W ZWALCZANIU OMACNICY PROSOWIANKI (*OSTRINIA NUBILALIS* HBN.)

Spośród testowanych w latach 1998–2000 chemicznych i biologicznych insektycydów najwyższą skuteczność w zwalczaniu larw omacnicy prosowianki na kukurydzy cukrowej wykazał preparat Karate Zeon 100 CS (lambda-cyhalotryna). Skuteczność preparatów biologicznych opartych na *Bacillus thuringiensis* ssp. *kurstaki* tj. Biobit 3,2 WP i Lepinox WDG była bardzo zmienna w poszczególnych latach. Wynikało to prawdopodobnie z wrażliwości tych preparatów na niekorzystne warunki pogody. Najwłaściwszym terminem dla wykonania zabiegu chemicznego przeciwko larwom omacnicy prosowianki okazał się przedział czasowy pomiędzy początkiem pylenia kukurydzy a pełnią kwitnienia (stadia rozwojowe kukurydzy 63–67 w skali BBCH).