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Effects of Insecticides Used against the European Corn Borer on Thrips Abundance on Maize

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Abstract

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The effect of a single chemical treatment against *Ostrinia nubilalis* (Hbn.) on thrips abundance on maize in south-eastern Poland was evaluated. Two insecticides: Karate Zeon 050 CS, containing lambda-cyhalothrin, and Proteus 110 OD, containing thiacloprid with deltamethrin, were tested. Maize was sprayed in the second ten days of July, during the abundant occurrence of *O. nubilalis* larvae, which coincided with the population peak of thrips on plants. The tested active substances showed high effectiveness against thrips, but a better effect, reflected in a decrease in thrips abundance, was found for the mixture of thiacloprid with deltamethrin. The tested insecticides significantly reduced the population of thrips for up to 14 days after treatment.

Keywords: chemical control; foliar insecticides; effectiveness; Thysanoptera; *Zea mays* L.

In Poland, maize (*Zea mays* L.) has been grown on a commercial scale since the 1950s and this was mainly stimulated by the introduction of hybrids obtained from the same inbred lines (Adamczyk *et al.* 2010). Currently, maize, in addition to winter oilseed rape and winter wheat, is one of the most important crops grown in Poland, and since 2012 its acreage has been slightly more than one million hectares (Central Statistical Office 2013, 2014, 2015; http://stat.gov.pl/en/). Because of differences in soil and climate conditions, there are also regional differences in the cultivation of maize with respect to production purposes. In southern provinces most maize is grown for grain; in northern provinces mainly for silage (Księżak 2008).

Because of the increasing acreage of maize, use of simplified agricultural techniques (e.g. monocultures, systems without ploughing, no shredding of maize residues, etc.), small number of registered insecticides, and climate change, this crop is increasingly exposed to harmful organisms (Bereś & Pruszyński 2008). Currently, the volume and quality of maize yields in Poland may be negatively affected by over 100 weed species, about 400 pathogen species, and about 50 pest species (Mrówczyński 2013). In recent years, the economic importance of pests has been growing rapidly, along with diseases they may cause 20–50% direct losses in grain yield, additionally deteriorating crop quality, and increasing the risk of its contamination with mycotoxins (Lisowicz & Tekiela 2004).

The European corn borer (*Ostrinia nubilalis* Hbn.) is currently the most dangerous maize pest in Poland. In regions, where maize is intensively cultivated, larvae of this moth damage 50–80%, and locally up to 100% of plants (Lisowicz & Tekiela 2004). This insect has to be controlled, including chemical methods, on a growing number of maize fields (Bereś & Pruszyński 2008).

Among the most common pests occurring each year on maize in Poland are thrips (Thysanoptera), including *Frankliniella tenuicornis* (Uzel) and *Haplothrips aculeatus* (Fabricius) (Lisowicz 2001; Lisowicz & Tekiela 2004; Kucharczyk *et al.* 2011). They have been found on maize since the beginning of

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its commercial cultivation in Poland, i.e. the 1950s (Kania 1962a, b), and an increase in their population has been observed over the last several years (Bereś 2013). Thrips, like aphids, colonise maize almost throughout its whole growing season, and their harmfulness is mainly associated with increasing the plants susceptibility to the invasion of pathogens, particularly mycotoxin-producing fungi such as *Fusarium* spp. (Farrar & Davis 1991; Lisowicz & Tekiela 2004; Mailhot *et al.* 2007a; Parsons & Munkvold 2010; Parikka *et al.* 2012).

Previous studies carried out on thrips invading maize in Poland mainly investigated their species composition and population dynamics in individual growing seasons, and only briefly addressed the development of chemical and non-chemical control methods (Lisowicz 1995, 2001; Lisowicz & Jaworowski 2000; Tekiela *et al.* 2005; Kucharczyk *et al.* 2011).

Despite the growing number of thrips infesting maize in Poland, no relevant integrated pest management plan has been developed. Because there are no insecticides approved for the protection of maize against thrips, we carried out a study to evaluate the suitability of lambda-cyhalothrin and a mixture of thiacloprid with deltamethrin for the control of this pest. These active substances are used for the protection of maize against *O. nubilalis*. Because the population peak of thrips on maize is observed in July (Bereś *et al.* 2013), we carried out a study to evaluate whether chemical treatments against *O. nubilalis* may also reduce the number of thrips.

MATERIAL AND METHODS

The study was carried out in 2010–2012 in Krzeczowice (49°59'N, 22°27'E), south-eastern Poland, on a field of San maize variety (FAO 240) grown in a 4–6-year monoculture. The experiment on the chemical control of thrips was designed as a system of completely randomized blocks in four replicates. Maize was sown on 4-row 50 m^2 plots (3.0 m wide × 16.7 m long). A 1.5 m wide buffer zone was left between individual plots to limit the drift of dispensed insecticide to the adjacent plots. The seeding rate was 80 000 seeds per ha. Maize was planted on the optimum dates for this part of Poland, i.e. on April 30, 2010, April 28, 2011, and April 27, 2012.

To determine the optimum date for thrips control, the occurrence of insects on maize was monitored from May, when the plants had developed 1–2 leaves (BBCH 11–12) (Meier 1997), until October, when the plants reached full kernel maturity (BBCH 97). For that purpose, a separate 0.5 ha part of the field was left without insecticidal treatment, and 2 random plants were sampled every 7 days from the field from 5 sites (10 plants in total). Each plant was packed in a separate bag, transported to a laboratory, and inspected for the presence of thrips on all plant parts. The collected insects were counted. The dates of abundant occurrence of thrips on maize were established based on observations.

Two foliar insecticides approved in Poland for the control of *O. nubilalis* on maize were used in the experiment to test their effects on thrips. The first contact product (Karate Zeon 050 CS), containing lambda-cyhalothrin from the class of synthetic pyrethroids, was used in doses of 0.2 and 0.3 l/ha. The second one, a systemic product (Proteus 110 OD) containing a mixture of thiacloprid with deltamethrin from the class of chloronicotinils and synthetic pyrethroids, was used in a dose of 0.5 l/ha. Plants were sprayed with these insecticides once on July 17, 2010, July 16, 2011, and July 14, 2012, when maize plants were at the stage of tassel development and flowering (BBCH 59–67), using 300 l of water/ha. According to earlier research, these dates coincided with the peaks of thrips abundance on maize in south-eastern Poland (Bereś *et al.* 2013). Maize was sprayed using an experimental backpack sprayer, model AP 1/p, with a compressed air tank of constant working pressure. In the experiment we used a 3 m-wide boom with three nozzles spaced every 50 cm, positioned above the plant tops. Medium-droplet spraying was applied using XR TeeJet 110 02 VP nozzles.

Directly before chemical treatment (date 0) the number of thrips was estimated on all experimental plots, and the insecticidal effectiveness was evaluated on days 7, 14, and 21 after treatment. For this purpose, on each observation date 5 plants from the middle two rows on each experimental plot were sampled (10 plants per plot in total). The mean number of insects per plant was calculated at the laboratory.

Results were statistically analysed using STATISTICA Version 10.0 PL (2011) software from StatSoft. One-way analysis of variance in a random block design was used. The significance of differences between means was verified with the Student-Newman-Keuls test at a significance level of P = 0.05. The variability of data in the study years was considered as a random effect. The effectiveness of insecticides in the control of thrips was calculated from mean values according to Abbott's formula, and expressed in per cent (Abbott 1925).

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RESULTS

The monitoring of thrips on maize revealed that insects occurred on the plants almost throughout the whole growing period, i.e. from May to September and October. During the consecutive years of research the highest number of thrips was observed between the first and third ten days of July, with population peaks on July 12, 2010, July 20, 2011, and July 11, 2012 (Figure 1). The most abundant occurrence of thrips on maize was at the stage of tassel development (BBCH 51) in 2010 and 2012, and at the flowering stage (BBCH 67) in 2011.

A 3-year-long observation on the dynamics of thrips on maize showed that their population peak took place in the second ten days of July, which was the optimal time for the chemical control of pests. The established date of the population peak of thrips on maize coincided with the dates reported from a previous study (Bereś *et al.* 2013). In that period *O. nubilalis* caterpillars also hatch on a mass scale (Bereś 2013).

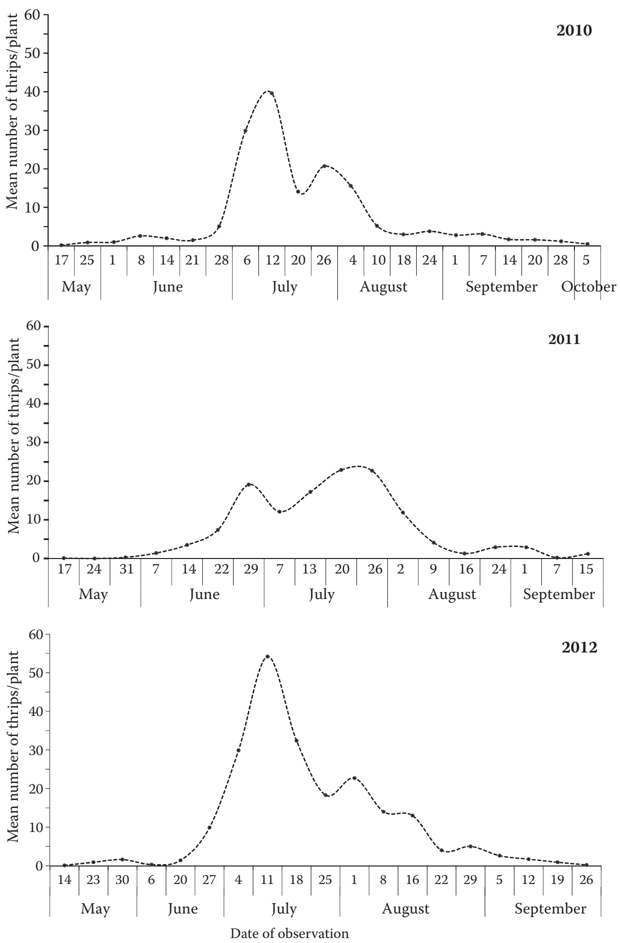

Figure 1. Dynamics of thrips occurrence on maize plants in Krzeczowice in 2010–2012

Table 1. Effectiveness of chemical treatments in the control of thrips in 2010

Experimental plot	Active substance	Dose (l/ha)	Mean number of thrips per plant on subsequent days after treatment (count of insects)											
			2010				2011				2012			
			0*	7	14	21	0**	7	14	21	0***	7	14	21
Untreated plot	–	–	17.0[a]	24.7[a]	24.7[a]	24.7[a]	24.7[a]	15.0[a]	9.5[a]	2.7[a]	29.2[a]	19.2[a]	21.7[a]	15.2[a]
Karate Zeon 050 CS	lambda-cyhalothrin	0.2	19.0[a]	25.7[a]	25.7[a]	25.7[a]	25.7[a]	1.0[b]	1.2[b]	0.5[a]	26.5[a]	2.5[b]	10.5[b]	17.5[a]
Karate Zeon 050 CS	lambda-cyhalothrin	0.3	17.2[a]	21.2[a]	21.2[a]	21.2[a]	21.2[a]	0.5[b]	1.0[b]	0.2[a]	31.2[a]	3.0[b]	9.7[b]	10.7[a]
Proteus 110 OD	thiacloprid + deltamethrin	0.5	15.7[a]	19.5[a]	19.5[a]	19.5[a]	19.5[a]	0.2[b]	0.2[b]	0.2[a]	27.5[a]	2.2[b]	7.5[b]	12.7[a]
			Effectiveness according to Abbott's formula (%)											
Untreated plot	–	–	0.0	77.9	60.5	10.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Karate Zeon 050 CS	lambda-cyhalothrin	0.2	0.0	85.3	67.1	17.4	0.0	93.3	86.8	81.8	0.0	87.0	51.7	–14.8
Karate Zeon 050 CS	lambda-cyhalothrin	0.3	0.0	86.8	75.0	28.3	0.0	96.7	89.5	90.9	0.0	84.4	55.2	29.5
Proteus 110 OD	thiacloprid + deltamethrin	0.5	0.0	0.0	0.0	0.0	0.0	98.3	97.4	90.9	0.0	88.3	65.5	16.4

Mean number of thrips per plant [*n* insects] on the day of treatment: *July 17, **July 20, ***July 19; means in columns followed by the same letter do not differ at 5% level of significance in the Student-Newman-Keuls test

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In the study years, the mean numbers of thrips on plants immediately before chemical treatment on all experimental plots did not differ significantly, and ranged from 15.7 to 31.2 individuals per plant. The largest number of thrips on maize was noted in 2012.

In the 3-year-long study the highest efficacy of the chemical control of thrips was observed on day 7 after treatment. At that time the efficacy of treatment calculated using Abbott's formula was in the range of 77.9–98.3%. A comparable high efficacy of the tested insecticides was noted on day 14 after treatment. At that time the insecticides reduced the number of thrips on plants by 51.7–97.4%. On day 21 after chemical treatment the insecticidal effect of products on thrips was no longer observed (Table 1). However, in 2011 the efficacy of chemical treatments at the level of 80% was also noted on day 21 after spraying, despite the lack of statistically significant differences between the control and experimental plots treated with chemical methods. This high efficacy of the used insecticides was due to the fact that the number of thrips was reduced on the untreated plot (Table 1).

DISCUSSION

The monitoring of thrips on maize to determine the optimum dates for their chemical control demonstrated that depending on the study year the abundant occurrence of the pest in south-eastern Poland took place between the end of June and mid-August, with a single population peak in the second ten days of July. The period of abundant occurrence of thrips on maize partly concurs with findings by Kucharczyk *et al.* (2011), who carried out research in the same region of Poland and reported numerous feeding insects, usually from the second ten days of July to the first days of August. Studies on sweet maize grown in the same region of Poland also showed the highest abundance of thrips between the end of June and the first ten days of August, with a population peak in the second ten days of July (Bereś *et al.* 2013). The results of our observations on the peaks of thrips populations on plants differ from previous studies by Lisowicz (1995) conducted in Krzeczowice in 1982–1993. Lisowicz reported that the population peak for thrips on maize was usually at the end of July or in mid-August, and it took place on July 15 only in 1993, which is similar to our study.

The date of the population peak for thrips on maize (July 12, 20, and 11 in 2010, 2011, and 2012, respectively) coincided with the time of the mass hatching of *O. nubilalis* larvae, which is usually observed from the end of the first ten days of July, and lasts until the beginning of the last ten days of July (Bereś 2013). This study carried out in 2009–2011 in south-eastern Poland revealed that the mass hatching of *O. nubilalis* caterpillars occurred between July 9 and 20. Studies carried out recently in south-eastern Poland indicated that the mass hatching of ECB caterpillars tends to occur on earlier dates compared to previous years, which implies the need to change the dates of pest control. For example, a study by Bereś (2012) conducted in 2004–2008 in the same region of Poland revealed the peak of hatching of *O. nubilalis* caterpillars between July 18 and August 2. At that time the hatching peak for caterpillars usually occurred in the third ten days of July, but more recently these dates shifted to the second ten days of July or early in the third ten days of July.

Our study demonstrated the high efficacy of lambda-cyhalothrin and a mixture of thiacloprid with deltamethrin used against thrips on maize. Similar studies on the use of lambda-cyhalothrin (Karate EC 025 at a dose of 0.2 l/ha and Karate 10 CS at a dose of 0.05 l/ha) for the integrated control of aphids, thrips, and *O. nubilalis* were carried out by Lisowicz and Jaworowski (2000). The researchers investigated the effects of a single and double spraying of plants with insecticides on two dates, with the first treatment on June 18 and the second treatment on July 12. They demonstrated the low effectiveness of treatment done in June. This was associated with the fact that thrips had only begun invading plants and were thus found in low numbers. Between June 18 and 28, on average 0.8–2.0 thrips/plant were feeding on the control plot, and 0.5 thrips/plant on plots sprayed with lambda-cyhalothrin. But after July 5 the differences between the populations of thrips on the control plot and plots treated with insecticides were not statistically significant. On that day 10 1 thrips/plant were recorded on the control plot, and 9.2–9.6 thrips/plant on plots sprayed with insecticides. Low insecticidal effectiveness was also observed after spraying plants on July 12. At that time the population of thrips was large (on average 33.8 thrips/plant on the untreated plot, on the day of treatment). On day 7 after treatment 12.6 thrips/plant were feeding on the control plot and 10.0–10.8 thrips/plant on plots treated with insecticides. Also, on day 14 after treatment the population of thrips on chemically treated plots was comparable to the populations on control plots. The researchers attributed the low effectiveness of treatment to the cryptic feeding of

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insects (e.g. under sheaths and cob husks), where they were less exposed to direct contact with the used insecticides. Our study showed no low effectiveness of lambda-cyhalothrin in controlling thrips, also feeding cryptically at the treatment time, even though this insecticide has a contact activity on plants. The reduction in the number of thrips achieved with lambda-cyhalothrin was only slightly lower compared to the mixture of thiacloprid with deltamethrin, producing a systemic effect. Presumably, the poor performance of lambda-cyhalothrin in the study by Lisowicz and Jaworowski (2000) can be attributed to other factors, e.g. high temperature, or the dose of active substance per ha. This is even more likely, as studies by Tekiela *et al.* (2005) also revealed the good effectiveness of a single treatment in the control of thrips, where Karate Zeon 050 CS was used at a dose of 0.2 l/ha on maize at the stage of tassel development (second half of July). Our study demonstrated that a single treatment of maize with insecticides effectively reduced the population of thrips up to 14 days after treatment, although a general decline in the population of thrips after that time usually occurred, and the need for the second chemical treatment was not justified. Studies by Lisowicz (1995) also indicate a temporary reduction in the number of thrips on plants after a single insecticidal treatment, followed by re-establishment of the population size.

Synthetic pyrethroids such as lambda-cyhalothrin and deltamethrin were successfully used for the control of thrips on maize, and also other crops, e.g. cotton, white cabbage, and onions (MacIntyre-Allen *et al.* 2005; Mailhot *et al.* 2007b; Trdan *et al.* 2007). The widespread use of synthetic pyrethroids by farmers may result, however, in the resistance of thrips to these insecticides, which has already been observed on various crops (Reitz & Funderburk 2012).

With respect to thiacloprid, our study demonstrated its high suitability in combination with deltamethrin for the control of thrips, but the individual insecticidal effects of thiacloprid and deltamethrin cannot be specified. A study by Nderitu *et al.* (2010) demonstrated the variable effectiveness of thiacloprid used in snap beans depending on the target species of thrips. The researchers reported, for example, weaker insecticidal effects on *Frankliniella occidentalis* (Pergande) and good insecticidal effects on *Megalurothrips sjostedti* (Trybom). On the other hand, Ahmed *et al.* (2014) reported the high effectiveness of thiacloprid alone used for the control of thrips on cotton. However, as the authors have pointed out, the use of neonicotinoids in integrated pest management is still being discussed. When considering the possibility of using the study results in practice, it should be noted that the integrated pest management enforced in the European Union in 2014 recommends limiting the use of chemical plant protection products (Meissle *et al.* 2010; Matyjaszczyk 2015). Since no insecticide is currently approved in Poland for the control of thrips, and the date of their abundant occurrence coincides with the optimum time for the control of *O. nubilalis*, the control of these pests can be integrated. This is possible due to the non-selective effects of lambda-cyhalothrin, deltamethrin, and thiacloprid, which in addition to the control of the European corn borer larvae also indirectly affect the population of thrips. As long as these active substances are approved for use in Poland to control *O. nubilalis* on maize, there is no need for the separate control of thrips, and in this way the number of chemical treatments in maize fields can be reduced.

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