THE EFFICACY OF SOME NEONICOTINOID AND OTHER NEW INSECTICIDES IN THE CONTROL OF THE STRAWBERRY ROOT WEEVILS (*CUCURLIONIDAE*) ON STRAWBERRY PLANTATIONS IN POLAND

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A B S T R A C T

The strawberry root weevil (*Otiorhynchus ovatus* L.) is an important pest on strawberry plantations in Poland. Neonicotinoid insecticides: thiametoxam as Actara 25 WG, thiacloprid as Calypso 480 SC, and acetamiprid as Mospilan 20 SP gave good control of the strawberry root weevil on strawberry plantations. The obtained results were better or similar to those obtained with chloropiryfos, diazinon and fenitrothion. Also fipronil (phenopyrazole group) showed very high efficacy in the control of strawberry root weevil.

Key words: strawberry root weevil, *Otiorhynchus ovatus*, strawberry, neonicotinoids, Actara 25 WG, Apacz 50 WG, Apacz 435 GR, Calypso 480 SC, Regent 200 SC, fipronil, malathion, chloropiryfos, chemical control

INTRODUCTION

The strawberry root weevil (*Otiorhynchus ovatus* L.) and the European strawberry weevil (*Otiorhynchus sulcatus* F.) are problem pests on strawberry plantations in Europe and therefore also in Poland. In our country, the strawberry root weevil is more common on strawberry plants than the other mentioned species, but it depends on the plantation. The damage caused by root weevils is mainly done by the larvae. They feed on the roots and damage whole plants (Penman and Scott, 1976; Łabanowska, 1994). The plants are weakened and, especially during dry

springs, whole plants dry out before the fruit harvest. Most of damaged plants are observed on older plantations. The beetles start to feed on leaves at the end of June or at the beginning of July, but they are active until September or even till the beginning of October. Most damage on leaves was noted in July and August. Some organophosphate insecticides such as chloropiryfos, fenitrothion and diazinon were used for a long time in Poland to control strawberry root weevil (Łabanowska, 1994; Łabanowska and Olszak, 2003). At present, the only possibility to control the root weevil is to use a treatment after harvest, usually with the use of the neonicotinoid insecticide acetamiprid as Mospilan 20 SP and chloropiryfos as Dursban 480 EC (Łabanowska et al., 2004; Łabanowska in press). The other possibility is a biological control of the soil pests using entomopathogenic fungi and nemathodes (Kakouli-Duarte et al., 1997; Wilson et al., 1999; Tkaczuk et al., 2005). In recent experiments some neonicotinoid insecticides gave promising results in the control of this pest (Reading and Persad, 2009; Łabanowska in press). The aim of this work was to check the possibility of controlling root weevils with some new insecticides.

MATERIAL AND METHODS

Experiments with new insecticides to control root weevils (*Otiorhynchus* spp.), mainly *O. ovatus*, were conducted in the years 2003-2006 on commercial strawberry plantations localized in Mokra Lewa, Dąbrowice, Skierniewice, Dębowa Góra, Złota, Staropol and Czyżew, Central Poland. The cultivars 'Senga Sengana' or 'Honeoye' were used and set up in a randomized block design with four replications. Plot sizes ranged from 10.5 m^2 to 50 m^2. In some experiments, the treatments were applied before strawberry blossom, at a time when the larvae were feeding on roots. Most experiments were carried out after fruit harvest, when adults were feeding on leaves and females were laying eggs. Some insecticides were used as a foliar and a soil spray-treatment at the rate of 750 l ha^{-1}. The knapsack motor sprayer "Stihl" was used for spraying. The granular insecticide was put into the soil by hand near the plants, in the strawberry rows only. The efficacy of treatments was estimated at the end of June or in early July by counting larvae, pupae and adults (weevils). After spring treatments in May, the individual pests were counted in the same year. However, if the treatments were done after harvest, the larvae were counted in the following year, just at the end of harvest time. Six plants per a plot, i.e. 24 per treatment were removed with soil. The roots and sieved soil were checked for the pest's presence. The results were elaborated with analysis of variance and the data was transformed according to the formula $y = \log (x + 1)$, where x is the number of specimens. Significance of differences between means was tested with Duncan's multiple range "t" test at $p = 0.05$.

RESULTS AND DISCUSSION

Spring control of the root weevils

Neonicotinoid insecticides: thiametoxam as Actara 25 WG (0.8 kg ha^{-1}), thiacloprid as Calypso 480 SC (0.6 l ha^{-1}), acetamiprid as Mospilan 20 SP (0.6 kg ha^{-1}) applied as a spray-treatment before strawberry blossom, or as a fipronil granular formulation (1.5%) at the rate of 10 kg ha^{-1}, sowed under plants gave satisfactory control of the strawberry root weevil larvae. Pest reduction was at the level 80-92.8%, depending on the insecticide used (Tab. 1 a,b,c). The best efficacy was obtained with thiametoxam and fipronil, but there were no significant differences between the tested insecticides. The results were similar to the standard insecticide diazinon as Diazinon 10 GR (80 kg ha^{-1}). The results with neonicotinoid insecticides confirmed earlier data with the neonicotinoid, chlotianidine (Reding and Persad 2009, Łabanowska in press).

Summer control of the root weevils

An insecticide from the phenylpyrazole group – fipronil granular (1.5%) at the rate 10 kg ha^{-1} put on the soil under plants after fruit harvest once and twice (at one week intervals) showed very good control of root weevils (*O. ovatus* and *O. sulcatus*, mixed population was noted on one experimental plantation) (Tab. 2). The reduction of the pest was over 94-96%. No difference between one and two treatments was noted. The results were significantly better than those obtained with chloropiryfos (Dursban 480 EC – 5 l ha^{-1}). The number of pest on untreated, check plants were higher than on treated ones.

In the next experiments chlotianidine as TI 435 1 GR (10 kg ha^{-1} and 15 kg ha^{-1}) applied under plants after fruit harvest highly reduced the pests, from 86.1% to 91.5% (Tab. 3). The results were better than the results obtained with the standard insecticides chloro-piryfos and diazinon, but similar to the results obtained with the use of granular fipronil. Chlotianidine as Apacz 50 WG gave results which were similar to the standard insecticides, chloro-piryfos and diazinon. The highest number of pest specimens was noted under the untreated, check plants. On a plantation with a low pest population, chlotianidine gave better results than the standard insecticide diazinon (Tab. 4).

In the other experiment two insecticides: thiametoxam as Actara 25 WG (0.8 kg ha^{-1}) and fipronil as Regent 200 SC (0.4 l ha^{-1}) showed very high efficacy in the control of strawberry root weevil, reduction of the pest was at the level of 95.6-97.7% (Tab. 5). The results were similar to those obtained with chloropiryfos (Dursban 480 EC – 2.5 l ha^{-1}) but higher than with the other standard insecticide, fenitrothion (Owadofos 540 EC – 2.25 l ha^{-1}). Malathion as CHA 3110 at the rate of 1.5, 2.5 and 3.5 l ha^{-1} gave 80-85.9% reduction of the pest and results were similar to those obtained with fenitrothion. Also on the plantation which had a very high population of the strawberry root

Table 1. Efficacy of insecticides applied in spring against the strawberry root weevil (Mokra Lewa, Dąbrowice and Skierniewice, 2004)

Insecticide	Rate [l/kg ha^{-1}]	No. of larvae, pupae and adults per plant	Efficacy [%]
a. Mokra Lewa, 2004, date of treatment 5.05; date of counting 16-28. 06. 2004			
Check	-	8.5 c	-
Actara 25 WG	0.8	0.6 a	92.8
Calypso 480 SC	0.6	1.0 ab	88.2
Mospilan 20 SP	0.6	1.6 b	80.7
b. Dąbrowice, 2004, date of treatment 17.05; date of counting 22-24.06. 2004			
Check	-	12.1 b	-
Diazinon 10 GR	80	2.9 a	76.4
Fipronil (granular 1.5%)	10	1.2 a	90.1
c. Skierniewice, 2004, date of treatment 21.05; date of counting 6-7.07. 2004			
Check	-	2.9 b	-
Diazionon 10 GR	80	0.6 a	80.1
Fipronil (granular)	10	0.3 a	89.4

Table 2. Efficacy of some insecticides applied after strawberry fruit harvest against the strawberry root weevil (Dębowa Góra, 2003/2004)

Insecticide	Rate [l/kg ha^{-1}]	No. of larvae, pupae and adults per plant	Efficacy [%]
Dębowa Góra, 2003/2004 One treatment on 10.07.2003; date of counting 1-9.07.2004			
Check	-	8.8 c	-
Dursban 480 EC	5.0	2.1 b	75.7
Fipronil (granular 1.5%)	10.0	0.4 a	96.0
Dębowa Góra, 2003/2004 Two treatments on 10 and 17.07.2003; date of counting 1-9.07.2004			
Check	-	8.8 c	-
Dursban 480 EC	5.0	1.8 b	79.5
Fipronil (granular 1.5%)	10.0	0.5 a	94.1

Table 3 Efficacy of some insecticides applied after fruit harvest against the strawberry root weevil (Dębowa Góra, 2004/2005)

Insecticide	Rate [l/kg ha^{-1}]	No. of larvae, pupae and adults per plant	Efficacy [%]
Dębowa Góra, 2004/2005, date of treatment 23.07.2004; date of counting 22.06.2005			
Check	–	6.9 c	–
Apacz 50 WG	0.15	2.5 b	64.6
Apacz 50 WG	0.20	3.0 b	56.2
Apacz 435 GR	10	0.6 a	91.5
Apacz 435 GR	15	1.0 a	86.1
Diazinon 10 GR	80	2.1 b	70.1
Dursban 480 EC	5	2.1 b	69.9
Fipronil (granular 1.5%)	8	1.0 a	86.3
Fipronil (granular 1.5%)	10	0.9 a	87.0

Table 4 . Efficacy of some insecticides applied after fruit harvest against the strawberry root weevil (Złota, 2004/2005)

Insecticide	Rate [l/kg ha^{-1}]	No of larvae, pupae and adults per plant	Efficacy [%[
Złota, 2004/2005, date of treatment 22.07.2004; date of counting 8.07.2005			
Check	–	0.9 b	–
Apacz 50 WG	0.2	0.03 a	96.3
Apacz 435 GR	15	0.2 a	76.3
Diazinon 10 GR	80	1.1 b	–

Table 5 . Efficacy of some insecticides applied after strawberry fruit harvest against the strawberry root weevil (Staropol, 2005/2006)

Insecticide	Rate [l/kg ha^{-1}]	No. of larvae, pupae and adults per plant	Efficacy [%[
Staropol, 2005/2006, date of treatment 22-26.07.2005; date of counting 10.07.2006			
Chkec	-	6.3 d	-
Actara 25 WG	0.8	0.3 ab	95.6
Dursban 480 EC	2.5	0.6 abc	91.9
CHA 3110*	1.5	0.9 bc	85.9
CHA 3110	2.5	1.2 c	80.4
CHA 3110	3.5	1.2 c	81.0
Owadofos 540 EC	2.25	1.5 c	77.0
Regent 200 SC**	0.4	0.1 a	97.7

*malation 440 g l^{-1}**fipronil 200 g l^{-1}

Table 6. Efficacy of some insecticides applied after strawberry fruit harvest against the strawberry root weevil (Czyżew, 2005/2006)

Insecticide	Rate [l/kg ha^{-1}]	No. of larvae, pupae and adults per plant	Efficacy [%[
Czyżew, 2005/2006, date of treatment 23.07.05; date of counting 5.07.2006			
Check	-	35.8 c	-
Dursban 480 EC	2.5	8.9 a	75.1
CHA 3110*	1.5	19.0 b	47.0
CHA 3110	2.5	11.1 ab	69.1
CHA 3110	3.5	7.7 a	78.5
Owadofos 540 EC	2.25	9.3 a	74.1
Pyrinex 480 EC	2.5	10.3 ab	71.2

*malation 440 g l^{-1}

Weevil – about 36 specimens on the roots of 1 plant, malathion in lower rates (1.5; 2.5 l ha^{-1}) gave poorer efficacy, but in a higher rate – 3.5 l ha^{-1} gave similar results to the standard products: fenitrothion or chloropiryfos (Dursban 480 EC – 2.5 l ha^{-1} and Pyrinex 480 EC – 2.5 l ha^{-1}) (Tab. 6).

Thiametoxam, thiacloprid, acetamiprid and fipronil granular applied before strawberry blossom, showed high efficacy in reduction of the strawberry root weevil on strawberry. These results were similar to the results of treatments with the standard insecticides chloropiryfos and diazinon. Results obtained with chlotianidine used after the strawberry harvest confirmed the data obtained earlier in the control of strawberry root weevil (Łabanowska in press) and the Colorado potato beetle on potato (Wachowiak and Mrówczyński, 2005). Usually chlotianidine gave better or similar efficacy when compared to standard insecticides chloropiryfos or diazinon. Another insecticide called fipronil, used after harvest, showed very good results in pest control. In some experiments fipronil in a sublethal dose applied with *Metarhizium anisopliae* (Metschn.) gave good control of *O. sulcatus* (Shah et al., 2007).

Chlotianidine applied as a spray--treatment on plants and soil, as well as the granular form applied in the soil near strawberry plants after fruit harvest, reduced the number of the strawberry root weevil. The efficacy was similar to that obtained with the standard insecticide chloropyrifos and other new products from the neonicotinoid group such as imidacloprid, thiacloprid and thiametoxam used earlier (Łabanowska and Olszak, 2003; Łabanowska 2007).

CONCLUSIONS

1. Neonicotinoid insecticides: thiametoxam as Actara 25 WG, thiacloprid as Calypso 480 SC, and acetamiprid as Mospilan 20 SP gave good control of the strawberry root weevil on strawberry plantations. The obtained results were better or similar to those

obtained with chloropiryfos, diazinon and fenithrothion.
2. Fipronil (phenopyrazole group) showed very high efficacy in the control of the strawberry root weevil.
3. The most convenient time to control strawberry root weevil is after fruit harvest because at this time weevils are feeding on leaves and are much easier to control than larvae which are feeding on the roots, under the soil surface.
4. The time after fruit harvest is also a safer time to control weevils from the consumers` point of view than pest control in spring. This is because consumers want fewer residues in sold fruit.

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EFEKTYWNOŚĆ WYBRANYCH NEONIKOTYNOIDÓW I INNYCH NOWYCH INSEKTYCYDÓW W ZWALCZANIU OPUCHLAKÓW (*Cucurlionidae*) NA PLANTACJACH TRUSKAWEK W POLSCE

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S T R E S Z C Z E N I E

Opuchlak rudonóg (*Otiorhynchus ovatus* L.) jest poważnym szkodnikiem truskawki w Polsce. Insektycydy z grupy neonikotynoidów: Actara 25 WG (tiametoksam), Calypso 480 SC (tiachlopryd) i Mospilan 20 SP (acetamipryd) skutecznie zwalczały opuchlaki na plantacjach truskawek. Skuteczność środków z grupy neonikotynoidów była wyższa lub podobna do skuteczności preparatów standardowych (porównawczych) – chloropiryfos, diazinon i fenitrotion. Także fipronil z grupy fenylopirazoli wykazał bardzo wysoką efektywność w zwalczaniu opuchlaków na truskawce.

Słowa kluczowe: opuchlak rudonóg, *Otiorhynchus ovatus*, neonikotynoidy, Actara 25WG, Apacz 50 WG, Apacz 435 GR, Calypso 480 SC, Regent 200 SC, fipronil, malation, chloropiryfos, zwalczanie chemiczne