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Sensitivity of pollen beetle (*Meligethes aeneus* F.) to insecticides with different modes of action and their efficacy in the field conditions

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Abstract

Field trials, involving winter and spring oilseed rape, were carried out during the 2009 and 2010 cropping seasons to investigate the sensitivity of pollen beetle (*Meligethes aeneus* F.) to the insecticides, belonging to different classes (pyrethroids, neonicotinoids and organophosphates) as well as the efficacy of different dose rates of Karate Zeon 5 CS (a.i. λ-cyhalothrin) against pollen beetles. All the insecticides used in winter and spring rape significantly reduced the number of pollen beetles 1–3 days after application, compared with the untreated plots; however, the sensitivity of pollen beetles to the tested insecticides in the field conditions was similar, significant differences among the applied insecticides were not observed. It was determined that the recommended field dose rate of the insecticide Karate Zeon and its double and quadruple dose rates did not kill all pollen beetles in the field conditions (efficacy <100%). This implies that the application of Karate Zeon in the field conditions in Dotnuva resulted in the development of partial resistance to λ-cyhalothrin in the population of pollen beetles.

Key words: rape, pyrethroids, neonicotinoids, organophosphates, efficacy.

Introduction

The pollen beetle (*Meligethes aeneus* F.) is a major pest in Lithuanian oilseed rape crops (Petraitienė et al., 2008; Vaitelytė et al., 2011). The adults may damage any of the flowering structures during the green to yellow bud stage (Williams, Free, 1978). The larvae eat pollen within the buds and pollen in flowers (Nilsson, 1988). Feeding by the pollen beetles reduce the number of buds that are able to develop into pods, and the damage to the ovary results in podless stalks (Williams, Free, 1978). Crops are most susceptible to damage at the green and yellow bud stages (Frearson et al., 2005). Successful control of pollen beetle is important since yield reduction by this pest can be as high as 70% in spring oilseed rape (Nilsson, 1987). Insect pests of oilseed rape, including pollen beetles, are usually controlled using insecticides (Walters et al., 2003).

However, where populations are potentially exposed to intensive application of insecticides with the same mode of action, there is a high level of concern regarding the increased potential for selection pressure and resistance development (Thieme et al., 2010). Resistance to insecticides was first reported in 1967 in a Polish population of *M. aeneus* (Lakocy, 1967). However, the first data about pollen beetle resistance to pyrethroids were registered in 2000 in Sweden and Switzerland (Derron et al., 2004; Kazachkova et al., 2007). Over the past few years, resistance of *M. aeneus* to pyrethroids has increased in other European countries (Heimbach et al., 2006; Węgorek, Zamojska, 2006; Hansen, 2008; Slater et al., 2011). Pollen beetle populations highly resistant to pyrethroid λ-cyhalothrin were found in eleven of the twenty one investigated European countries (Austria, Belgium, Czech Republic, Denmark, France, Germany, the Netherlands, Poland, Sweden, Switzerland and the UK) (Slater et al., 2011). Pollen beetle resistance to pyrethroids was not found in Estonia (Veromann, Toome, 2011). The Danish and Polish pollen beetle populations were more sensitive to tau-fluvalinate compared with other pyrethroids (Hansen, 2008; Węgorek et al., 2009).

In Lithuania, the findings of pest abundance assessments indicate that pollen beetle tended to occur in spring rape during the stem elongation-bud formation stages. The population of pollen beetle was found to be on the increase during the experimental period and the efficacy of the tested insecticides tended to decline. A significant yield reduction ranging from 3.3% to 30.1%, resulting from the damage of pollen beetle, was identified (Petraitienė et al., 2008). Some resistance to pyrethroids has been recently identified in the Lithuanian field populations of pollen beetle (*M. aeneus*) using the IRAC method. It was observed that pollen beetle populations were less resistant to tau-fluvalinate compared with λ-cyhalothrin, α-cypermethrin and deltamethrin (Makūnas et al., 2011).

The objective of this study was to determine the sensitivity of the pollen beetle (*M. aeneus*) to the insecticides with different modes of action as well as the response to different dose rates of Karate Zeon (a.i. λ-cyhalothrin) in the field conditions.

Materials and methods

The field trials were conducted at the Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry during the 2009 and 2010 cropping seasons. The research was carried out with spring (cv. 'Landmark') and winter oilseed rape (cv. 'Libea'). Previous crop for winter oilseed rape (WOSR) was winter wheat and for spring oilseed rape (SOSR) it was spring wheat. WOSR and SOSR crops were cultivated according to the conventional technology.

The sensitivity of pollen beetles to different insecticides was analyzed according to the trial design presented in Table 1. The trial plots were rectangular in form (5 × 5 m, 25 m^2 area), because of the active migration of pollen beetles, especially in temperature above 15ºC. The trials were laid out in a randomized complete block design with four replicates. The insecticide spray application timing was determined by daily observations of pest migration activity, starting from the beginning of oilseed rape stem elongation stage (GS 30). The insecticides were sprayed when 1–2 pollen beetles were identified per plant. If the number of pests was below this level, insecticides were applied at the end of bud formation growth stage (GS 57).

Table 1. Insecticides, used in the field trials for the control of pollen beetle (*Meligethes aeneus* F.), their dose rates, active ingredients and modes of action

Insecticide	Dose l ha^{-1}	Class	Active ingredient g l^{-1}	Mode of action
Karate Zeon 5 CS	0.15	Pyrethroid III	λ-cyhalothrin, 50	Contact and stomach action. Some repellent properties. Sodium channel modulator.
Mavrik 2F	0.3	Pyrethroid II	tau-fluvalinate, 240	Contact and stomach action. Sodium channel modulator.
Biscaya OD 240	0.3	Neonicotinoid	thiacloprid, 240	Contact and stomach action with some systemic properties. Acetylcholine receptor (nAChR) agonist.
Pyrinex 25 CS	0.75	Organophosphate	chlorpyriphos, 250	Contact and stomach action. Acetylcholinesterase (AChE) inhibitor.

Before insecticide application, the number of pollen beetles per plant was determined in the whole trial area, whereas after spraying it was done in each plot. Pollen beetle records were made one, two or three days after insecticide application. In five spots of each plot, pollen beetles were counted on ten selected plants (50 plants per plot), daily at the same time (around midday).

The sensitivity of pollen beetles to different dose rates of pyrethroid insecticide Karate Zeon 5 CS was analyzed using the whole registered dose rate (0.15 l ha^{-1}), also double and quadruple dose rates. In comparison, in addition to the control (not sprayed), ½ and ¼ of registered Karate Zeon dose rates were included in the experimental design.

Plant growth stages were recorded according to the scale (Lancashire et al., 1991).

Biological efficacy (BE) of insecticides was calculated according to Henderson-Tilton's (1955) formula:

$$\text{Efficacy}\,\% = \left(1 - \frac{\text{N in Co before treatment} \times \text{N in T after treatment}}{\text{N in Co after treatment} \times \text{N in T before treatment}}\right) \times 100,$$

where N in Co is number of beetles per plant in control plots, N in T is number of beetles per plant in each treatment.

Significance of data was indicated at $P = 0.05$. Prior to the statistical analysis, the data of pollen beetle counts per plant were Log(X + 1) transformed. Duncan's multiple range test was used to indicate significant differences between insecticides and between different dose rates of insecticide Karate Zeon.

Results and discussion

Despite the fact that at the end of April, 2009 and in the first week of May the daily air temperature was 19–21ºC and it was conducive to pollen beetle migration (Ekbom, Borg, 1996), in the crop of WOSR there was a low number of them and it did not reach the threshold of harmfulness accepted in Lithuania (1–2 pollen beetles per plant at the beginning of the stem elongation stage, GS 30, or 3–4 beetles per plant at the bud formation stage, GS 50–53). When WOSR plants reached the GS 55–57 (individual flower buds visible but still closed), only 6.4 pollen beetles per 10 plants were estimated. The use of chemical control substances in production conditions with such a low number of pollen beetles would be inefficient (Kirch, Basedow, 2008). However, in order to avoid the beginning of oilseed rape blossoming, the trial plots were sprayed with insecticides according to the experimental design.

In 2010, also at the beginning of bud formation stage, the invasion of pollen beetles was not intensive and did not reach the threshold of economic harmfulness. After rather warm the first three days of May, the next three days were rather cool. The highest day air temperature in the beginning of the six days (on 4th of May) was 14.6ºC and it dropped to 8.2ºC at the end of the six-day period. Then the highest temperature of the next day already reached 23.5ºC and pollen beetles whooshed into the field of WOSR. In accordance with the trial design, the insecticides in WOSR were applied when there were on average 2.6 pollen beetles per plant, at GS 55–57.

The migration of pollen beetles to the trial field of SOSR in the beginning of June 2009 (from 4th to 7th of June) during the stem elongation period was stopped by a rather low air temperature persisting for several days. However, at the beginning of the bud formation stage (GS 51) pollen beetles reached the threshold of harmfulness and the plots were sprayed with the insecticides. In 2010, the migration of pollen beetles to the SOSR field was similar and the insecticides were applied also at GS 51.

In both experimental seasons, all the insecticides used in WOSR significantly reduced the number of pests 1–3 days after application, compared with the control plots (Table 2). In the 2009 cropping season, the sensitivity of pollen beetles to the insecticides with different modes of action was similar, significant differences were not determined. Due to the low migration of pollen beetles to the field of WOSR, on the third day after spraying the number of pollen beetles did not reach the threshold of harmfulness both in the control and sprayed plots.

Table 2. The sensitivity of pollen beetle (*Meligethes aeneus* F.) to insecticides and their biological efficacy in WOSR in the 2009 and 2010 cropping seasons

Treatment	Pollen beetles/10 plants			BE, %		
	Days after insecticide application					
	1	2	3	1	2	3
2009						
Unsprayed	3.4 (0.6368)	1.6 (0.3805)	6.0 (0.8401)	–	–	–
λ-cyhalothrin	0.2 (0.0752)a	0.1 (0.0198)a	1.7 (0.4018)a	87.8	94.6	52.5
Tau-fluvalinate	0 (0)a	0.1 (0.0198)a	1.4 (0.3816)a	100	94.8	60.5
Thiacloprid	0.3 (0.1074)a	0.2 (0.0708)a	1.2 (0.3510)a	76.0	64.9	42.8
Chlorpyriphos	0.3 (0.1020)a	0.2 (0.0594)a	1.6 (0.4143)a	86.4	85.1	58.5
LSD_{05}	0.155	0.133	0.154	–	–	–
2010						
Unsprayed	26.0 (1.4291)	19.9 (1.3170)	29.7 (1.4834)	–	–	–
λ-cyhalothrin	0.4 (0.1416)bc	4.1 (0.6832)b	2.7 (0.5470)bc	98.2	76.3	89.6
Tau-fluvalinate	0.1 (0.0198)ab	1.3 (0.3510)a	0.5 (0.1681)a	99.8	93.6	98.3
Thiacloprid	0.2 (0.0510)a	2.1 (0.4693)a	1.8 (0.4386)b	99.3	88.4	93.3
Chlorpyriphos	0.6 (0.1857)c	2.8 (0.5775)ab	3.0 (0.5990)c	97.6	83.8	88.4
LSD_{05}	0.097	0.167	0.129	–	–	–

Note. BE – biological efficacy according to Henderson-Tillton; Log(X + 1) transformed data are given in brackets; different letters in the same column in the same year indicate significant differences between insecticides at the $P = 0.05$, according to Duncan's multiple range test.

However, some differences in the sensitivity of pollen beetle to the insecticides applied were revealed in the 2010 cropping season. Pollen beetles were highly sensitive to tau-fluvalinate, the number of insects 1–3 days after spraying was significantly lower in the tau-fluvalinate sprayed plots compared with the plots applied with λ-cyhalothrin and chlorpyriphos. The biological efficacy of the insecticides one day after application was rather high and fluctuated within the limits of 97.6–99.8%. Earlier it was observed that during 1993–1997 in winter oilseed rape the efficacy of deltamethrin, λ-cyhalothrin, α-cypermethrin and β-cyfluthrin against pollen beetle one day after spraying was similar, but not very high 80.2–95.2%; however in spring rape it fluctuated between 95.9–97.8% (Brazauskienė, 1997; 1998). During the 1999–2006 cropping seasons, the efficacy of pyrethroids against pollen beetle in spring oilseed rape one day after the spray application ranged from 86% to 100% (Petraitienė et al., 2008). It was stated that the efficacy of the insecticides depends on the weather conditions of the year and on the conditions for the spread of pollen beetle (Petraitienė et al., 2008). In our study, the biological efficacy of λ-cyhalothrin 2 days after spraying was the lowest, compared with the other insecticides tested, and the number of pollen beetles in the plots applied with this insecticide was significantly higher than in the plots applied with tau-fluvalinate (also pyrethroid) and thiacloprid (neonicotinoid). These results may imply a reduction of the effect of λ-cyhalothrin on pollen beetles (or some level of resistance of this pest to the insecticide). The effect of chlorpyriphos (organophosphate) on pollen beetles was similar to that of the pyrethroid λ-cyhalothrin. Although the biological efficacy of those insecticides 3 days after spraying dropped below 90%, the number of pollen beetles in the spray-applied plots remained lower than the threshold of economic harmfulness.

In SOSR in 2009, all the applied insecticides 1–3 days after spraying significantly reduced the number of pollen beetles in the sprayed plots, compared with the unsprayed ones (Table 3). The number of pollen beetles 1–2 days after spraying in the plots applied with different insecticides did not differ significantly, the sensitivity of pollen beetles to all the tested insecticides was similar. Three days after application, in the plots sprayed with thiacloprid (neonicotinoid class) the number of pollen beetles was significantly higher, compared with the plots sprayed with the other insecticides and its efficacy was the lowest. Neonicotinoids are among the most effective insecticides for the control of sucking insect pests such as aphids, whiteflies, leaf- and planthoppers, thrips, some micro lepidoptera and a number of coleopteran pests. Following foliar application, neonicotinoids penetrate into the leaf lamina and control pests on the lower side of the leaf owing to their good translaminar activity. Furthermore, they are distributed acropetally (xylem movement) and can protect new growing shoots (Elbert et al., 2008). However, it seems that pollen beetles were less sensitive to thiacloprid compared with the other active ingredients; however, significant difference was observed only on the third day after application. The efficacy of both pyrethroids was very similar and there were no significant differences between them.

In 2010, similar data were obtained – all insecticides, irrespective of their mode of action, significantly reduced the number of pollen beetles in the sprayed plots, compared with the untreated. Significant differences were determined – the number of pollen beetles in the plots sprayed with chlorpyriphos was significantly higher compared with that in the plots, sprayed with the other insecticides (Table 3). Comparison of the pyrethroids revealed the same trends, i.e. during all the period tau-fluvalinate reduced the number of pests in the plots of SOSR a little better than λ-cyhalothrin; however, significant differences were not determined. Higher efficacy of tau-fluvalinate compared with β-cyfluthrin against pollen beetle was reported by Vaitelytė et al. (2011). Using the IRAC method it was also determined that pollen beetle (*M. aeneus*) populations were less resistant to tau-fluvalinate compared with λ-cyhalothrin, α-cypermethrin and deltamethrin (Makūnas et al., 2011). Similar trends were revealed in Hansen's (2008) research.

In the field trials, we also investigated the sensitivity of pollen beetles to different dose rates of Karate Zeon (a. i. λ-cyhalothrin). According to the research data, in the 2009 and 2010 cropping seasons in WOSR, one day after spraying, having applied different dose rates of Karate Zeon, in all plots the number of pollen beetles was reduced significantly, compared with the control plots (Table 4). However, in 2009 only with double and quadruple dose rates of the insecticide Karate Zeon 5 CS, it was possible to kill all the pollen beetles in the treated plots (100% efficacy). Three days after spraying, significant differences in the effect after application of different dose rates of insecticides were not determined.

Table 3. The sensitivity of pollen beetle (*Meligethes aeneus* F.) to insecticides and their biological efficacy in SOSR in the 2009 and 2010 cropping seasons

Treatment	Pollen beetles/10 plants			BE, %		
	Days after insecticide application					
	1	2	3	1	2	3
			2009			
Unsprayed	31.0 (1.5004)	30.2 (1.4915)	21.2 (1.3402)	–	–	–
λ-cyhalothrin	0.2 (0.0510)a	1.1 (0.3042)a	0.7 (0.2152)a	99.5	96.6	97.0
Tau-fluvalinate	0.1 (0.0396)a	0.2 (0.0638)a	0.3 (0.0928)a	99.7	99.3	98.7
Thiacloprid	0.3 (0.0906)a	1.6 (0.3794)a	1.4 (0.3867)b	99.2	93.6	91.8
Chlorpyriphos	0.4 (0.1272)a	1.4 (0.3151)a	0.4 (0.1054)a	98.9	95.3	98.3
LSD_{05}	0.116	0.252	0.129	–	–	–
			2010			
Unsprayed	26.8 (1.4407)	29.5 (1.4798)	26.2 (1.4305)	–	–	–
λ-cyhalothrin	0.5 (0.1514)a	1.6 (0.3741)a	2.3 (0.5134)a	98.3	95.3	92.2
Tau-fluvalinate	0.3 (0.0752)a	0.6 (0.1954)a	0.8 (0.2411)a	99.1	98.1	97.3
Thiacloprid	1.4 (0.3403)a	1.4 (0.3152)a	1.2 (0.3176)a	95.2	95.7	95.7
Chlorpyriphos	2.8 (0.5717)b	5.0 (0.7652)b	6.6 (0.8601)b	88.9	81.7	72.8
LSD_{05}	0.224	0.235	0.196	–	–	–

Note. BE – biological efficacy according to Henderson-Tillton; Log(X + 1) transformed data are given in brackets; different letters in the same column in the same year indicate significant differences between insecticides at the $P = 0.05$, according to Duncan's multiple range test.

Table 4. The sensitivity of pollen beetle (*Meligethes aeneus* F.) to different dose rates of Karate Zeon (a. i. λ-cyhalothrin) and their efficacy in WOSR in the 2009 and 2010 cropping seasons

Treatment	Pollen beetles/10 plants			BE, %		
	Days after insecticide application					
	1	2	3	1	2	3
			2009			
Unsprayed	3.6 (0.6494)	1.5 (0.3919)	5.3 (0.7964)	–	–	–
KZ ¼ (0.0375 l ha^{-1})	0.3 (0.1074)b	0.2 (0.7612)b	1.3 (0.3596)a	92.9	88.8	79.4
KZ ½ (0.075 l ha^{-1})	0.2 (0.0563)ab	0.1 (0.0198)ab	1.6 (0.4101)a	95.9	96.8	70.8
KZ 1 (0.15 l ha^{-1})	0.1 (0.0396)ab	0.2 (0.0563)ab	1.1 (0.3217)a	97.5	91.2	81.8
KZ 2 (0.3 l ha^{-1})	0 (0)a	0 (0)a	1.3 (0.3543)a	100.0	100.0	76.7
KZ 4 (0.6 l ha^{-1})	0 (0)a	0 (0)a	1.5 (0.3949)a	100.0	100.0	76.5
LSD_{05}	0.094	0.080	0.102	–	–	–
			2010			
Unsprayed	20.3 (1.3233)	24.1 (1.3872)	29.8 (1.4849)	–	–	–
KZ ¼ (0.0375 l ha^{-1})	2.3 (0.5144)b	3.8 (0.6730)ab	3.5 (0.6389)a	89.0	84.7	88.6
KZ ½ (0.075 l ha^{-1})	1.7 (0.4251)b	3.3 (0.6229)ab	3.6 (0.6521)a	91.9	87.0	88.4
KZ 1 (0.15 l ha^{-1})	2.0 (0.4652)b	4.1 (0.6950)b	3.9 (0.6678)a	91.7	85.4	88.8
KZ 2 (0.3 l ha^{-1})	0.5 (0.1419)a	2.5 (0.5373)a	2.6 (0.5532)a	97.8	89.9	91.4
KZ 4 (0.6 l ha^{-1})	0.4 (0.1232)a	3.5 (0.6389)ab	3.0 (0.5765)a	98.3	85.7	90.1
LSD_{05}	0.150	0.146	0.172	–	–	–

Note. BE – biological efficacy according to Henderson-Tillton, KZ – Karate Zeon; Log(X + 1) transformed data are given in brackets; different letters in the same column in the same year indicate significant differences between different dose rates of KZ at the $P = 0.05$, according to Duncan's multiple range test.

In 2010, even after double and quadruple application of Karate Zeon, we did not succeed in killing all the pollen beetles in the treated plots. It seems that some pests were resistant to λ-cyhalothrin. There were no significant differences between the recommended dose rates (¼ and ½) of Karate Zeon in the reduction of the number of pollen beetles in the treated plots. Two and three days after spraying, the average number of pests increased both in the control plots and the plots applied with different dose rates of insecticide, but their number remained low in the insecticide treated plots.

Similar results were obtained in SOSR in the 2009 and 2010 cropping seasons (Table 5). When compared with the control plots, all the applied dose rates of the insecticide Karate Zeon significantly reduced the number of pollen beetles, but even double and quadruple dose rates of the insecticide did not kill all the pests (efficacy one day after application was lower than 96% in 2009 and lower than 99% in 2010). On the third day after spraying, the effect of the dose rates in reducing the number of pests did not differ significantly in both cropping seasons. This suggests that there are some signs of resistance of pollen beetle to this insecticide. Similar trends were obtained earlier by other researchers (Williams, 2004). It was reported that pollen beetle populations highly resistant to pyrethroid λ-cyhalothrin were found in eleven Europe countries (Slater et al., 2011). Insecticide resistance, which is the result of an increase in the ability of individuals to survive insecticide treatment, is an example of an evolutionary response induced by man (Comins, 1977; Ffrench-Constant et al., 2004).

Table 5. The sensitivity of pollen beetle (*Meligethes aeneus* F.) to different dose rates of Karate Zeon (λ-cyhalothrin) and their efficacy in SOSR in the 2009 and 2010 cropping seasons

Treatment	Pollen beetles/10 plants			BE, %		
	Days after insecticide application					
	1	2	3	1	2	3
	2009					
Unsprayed	27.6 (1.4552)	20.7 (1.3342)	17.4 (1.1531)	–	–	–
KZ ¼ (0.0375 l ha^{-1})	1.1 (0.3122)a	1.0 (0.2707)a	1.3 (0.3448)a	95.7	95.1	91.9
KZ ½ (0.075 l ha^{-1})	2.7 (0.5371)b	1.5 (0.3588)b	0.9 (0.2434)a	90.2	93.0	95.1
KZ 1 (0.15 l ha^{-1})	1.3 (0.3482)a	0.7 (0.2266)ab	0.9 (0.2707)a	95.7	96.8	95.1
KZ 2 (0.3 l ha^{-1})	1.4 (0.3728)a	0.5 (0.1584)ab	1.0 (0.2924)a	94.8	97.8	94.1
KZ 4 (0.6 l ha^{-1})	1.2 (0.3230)a	0.8 (0.2370)ab	0.5 (0.1712)a	95.7	96.4	97.1
LSD_{05}	0.171	0.175	0.317	–	–	–
	2010					
Unsprayed	23.0 (1.3773)	25.4 (1.4186)	22.4 (1.3624)	–	–	–
KZ ¼ (0.0375 l ha^{-1})	1.9 (0.4262)b	2.7 (0.5380)b	2.6 (0.5525)a	90.8	88.0	86.7
KZ ½ (0.075 l ha^{-1})	1.5 (0.3677)ab	1.4 (0.3670)ab	2.5 (0.5327)a	93.3	94.3	88.7
KZ 1 (0.15 l ha^{-1})	0.7 (0.2119)ab	1.4 (0.3677)ab	1.8 (0.4382)a	97.1	94.7	92.2
KZ 2 (0.3 l ha^{-1})	1.0 (0.2914)ab	1.2 (0.3208)a	2.0 (0.4665)a	94.8	94.5	89.3
KZ 4 (0.6 l ha^{-1})	0.3 (0.0836)a	0.6 (0.2024)a	1.9 (0.4348)a	98.8	97.3	90.4
LSD_{05}	0.231	0.172	0.155	–	–	–

Note. BE – biological efficacy according to Henderson-Tillton, KZ – Karate Zeon, Log(X + 1) transformed data are given in brackets; different letters in the same column in the same year indicate significant differences between different dose rates of KZ at the $P = 0.05$, according to Duncan's multiple range test.

Although the effect of ¼ of dose rate in reducing the number of pollen beetle significantly differed after the first day after spraying from the applied quadruple dose rate of the insecticide, biological efficacy of the insecticide in the plots applied with this insecticide was the lowest – 90.8%. This suggests that reduced dose rates increase the possibility for the pests affected by the insecticide, but not killed, to survive. This, in turn, increases pollen beetle resistance to this insecticide. Pests affected, but not killed, by the insecticide might be a presumption to increasing resistance to this insecticide, especially if the number of pests is high. The data obtained confirm that the monitoring of the resistance of pollen beetles to pyrethroids and insecticides with different modes of action is very important and needs to be continued.

Conclusions

1. All the insecticides used in winter and spring rape significantly reduced the number of pollen beetles 1–3 days after application, compared with the untreated plots; however, the sensitivity of pollen beetles to the insecticides with different modes of action in the field conditions was similar, significant differences were not determined.

2. The recommended field dose rate of the insecticide Karate Zeon (a.i. λ-cyhalothrin) and its double and quadruple dose rates did not give a 100% protection of oilseed rape against pollen beetle in the field conditions. Biological efficacy of the recommended dose rate of Karate Zeon one day after application fluctuated within the limits of 91.7–97.5% in WOSR and within 95.7–97.1% in SOSR. This implies that the application of Karate Zeon in the field conditions in Dotnuva resulted in the development of partial resistance of pollen beetle population to λ-cyhalothrin.

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Rapsinio žiedinuko (*Meligethes aeneus* F.) jautrumas skirtingo poveikio insekticidams ir jų efektyvumas lauko sąlygomis

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Santrauka

Rapsinio žiedinuko (*Meligethes aeneus* F.) jautrumas skirtingų klasių (piretroidų, neonikotinoidų bei organofosfatų) insekticidams ir insekticido Karate Zeon 5 CS (v. m. λ-cihalotrinas) įvairių normų efektyvumo palyginimo tyrimai lauko sąlygomis 2009–2010 m. atlikti žieminių bei vasarinių rapsų pasėliuose. Visi tirti insekticidai esmingai mažino rapsinių žiedinukų kiekį žieminiuose ir vasariniuose rapsuose 1–3 dienas po purškimo, lyginant su nepurkštais laukeliais, tačiau rapsinių žiedinukų jautrumas skirtingo poveikio insekticidams lauko sąlygomis buvo panašus, esminių skirtumų tarp tirtų insekticidų nebuvo nustatyta. Nustatyta, kad insekticido Karate Zeon rekomenduojama lauko norma ir du bei keturis kartus didesnės normos insekticido rapsinio žiedinuko visiškai nesunaikino (efektyvumas <100 %). Tai sudaro prielaidas teigti, kad rapsinio žiedinuko Dotnuvos populiacijoje, insekticidą Karate Zeon naudojant lauko sąlygomis, yra išsivystęs dalinis atsparumas λ-cihalotrinui.

Reikšminiai žodžiai: rapsai, piretroidas, neonikotinoidas, organofosfatas, efektyvumas.