Pestic. Phytomed. (Belgrade), 28(4), 2013, 255–263
DOI: 10.2298/PIF1304255M

UDC: 632.951:632.95.024:635.12
Scientific paper

Efficacy of Different Insecticides in Controlling Pollen Beetle (*Meligetes aeneus* F.) in Rapeseed Crop

Predrag Milovanović[1], Petar Kljajić[2], Goran Andrić[2], Marijana Pražić-Golić[2] and Tatjana Popović[3]

[1]Galenika-Fitofarmacija a.d., Batajnički drum bb, 11080 Belgrade, Serbia
[2]Institute of Pesticides and Environmental Protection, Banatska 31b, 11000 Belgrade, Serbia
[3]Institute for Plant Protection and Environment, Teodora Drajzera 9, 11000 Belgrade, Serbia
(milovanovic@fitofarmacija.rs)

Received: September 3, 2013
Accepted: December 9, 2013

SUMMARY

Since pollen beetle, *M. aeneus*, is usually controlled by insecticides, the efficacy of several compounds with different modes of action against adult beetles was studied in a three-year field study. The selected insecticides were: three pyrethroids (lambda-cyhalothrin, alpha-cypermethrin and bifenthrin), an oganophosphate (pirimiphos-methyl), a combination of an organophosphate and a pyrethroid (chlorpyrifos + cypermethrin) and a neonicotinoid (thiacloprid). The insecticides were applied at label rates to winter rapeseed crops at the moment of visible but still closed flower buds (BBCH 55-57). In all experiments, the efficacy of pyrethroids and the organophosphate ranged from 90-100%, while the efficacy of the neonicotinoid was 85-95%. Therefore, they can be recommended for control of pollen beetle in Serbia.

Keywords: Insecticides; Efficacy; Pollen beetle

INTRODUCTION

The pollen beetle *Meligethes aeneus* (F.) is a major pest of rapeseed crops all over the world (Hansen, 1996; Alford et al., 2003) and also in Serbia (Sekulić and Kereši, 2007; Milovanović, 2006, 2007; Milovanović et al., 2008, 2011). *M. aeneus* adults injure rapeseed inflorescences by feeding, reducing considerably the crop's seed yield. Rapeseed is most sensitive at the stage of green and yellow buds, when *M. aeneus* causes the most serious damage. The flowering period is significantly longer in seasons followed by cold springs when damage may go up to 70% unless control of *M. aeneus* is undertaken. Even though *M. aeneus* populations are active every year, damage caused by this species is sometimes below economic threshold and insecticides are not applied at all or the number of treatments is lower. This is especially important as rapeseed is a major pasture for honeybees, and most insecticides used to control *M aeneus* are highly toxic to bees (Frearson et al., 2005; Williams et al., 2007).

Pyrethroid insecticides are the most frequent choice for *M. aeneus* control (Hokkanen et al., 1998) because their activity is better in cold weather (negative temperature coefficient) when *M. aeneus* is normally controlled. Besides pyrethroids, organophosphate insecticides are also used (Węgorek et al., 2009), as well as neonicotinoids (Wegorek, 2005). Years of repetitive application of insecticides, often not fully justified, have lead to reduced susceptibility or resistance of various populations of *M. aeneus* (Hansen, 2003), such as reported from different parts of Europe, e.g. France (Delorme et al., 2002), Germany (Heimbach et al., 2006; Glattkowski et al., 2008; Müller et al., 2008), Denmark (Hansen, 2003, 2008), Switzerland (Derron et al., 2004; Philippou et al., 2010), Austria, Sweden (Kazachkova, 2007) and Poland (Węgorek, 2005; Węgorek et al., 2006, 2007, 2009; Wegorek and Zamojska, 2006, 2008; Philippou et al., 2010). As pyrethroid insecticides are primarily used against this pest species in our country and globally, resistance to that group of insecticides has become most evident (Derron et al., 2004; Heimbach et al., 2006, 2007; Hansen, 2008). On the other hand, susceptibility of *M. aeneus* populations to insecticides in Serbia has not been studed and there is little data on the efficacy of insecticides that are being used against this pest species (Vuković et al., 2007; Milovanović et al., 2008)

The present three-year (2008-2010) study focused on testing the efficacy of several insecticides with different modes of action against *M. aeneus* in winter rapeseed crops at three locations (Kovin, Smederevo and Požarevac) as a basis for thorough examination of the susceptibility of different populations of *M aeneus* to insecticides.

MATERIAL AND METHODS

Efficacy testing was conducted using the label rates of several insecticide products registered in Serbia for control of *M. aeneus* (Janjić and Elezović, 2010) and a thiacloprid-based product registered for *M. aeneus* control in other countries but not yet registered for that purpose in Serbia (Table 1). The efficacy of insecticides was asessed in fields trials at locations listed in Table 2 during three successive vegetation seasons (2008, 2009 and 2010).

Table 1. Applied insecticides

Insecticide	Content of a.i. (g/l)	Manufacturer	Application dose of a.i. (g/ha)
Lambda-cyhalothrin	25	HI „Župa“, Kruševac	7.5
Alpha-cypermethrin	100	BASF Agro, Wadenswil	10
Bifenthrin	100	Galenika-Fitofarmacija, Zemun	15
Pirimiphos-methyl	500	Syngenta-Agro, Dielsdorf	500
Chlorpyrifos + Cypermethrin	500 + 50	Galenika-Fitofarmacija, Zemun	550
Tiacloprid	480	Bayer CropScience, Monheim	48

Table 2. Locations of efficacy evaluation of insecticides

Location	GPS	Coordinates	Date of insecticide treatment
Kovin	N 44º763373`	E0 20º894365`	01.4.2008
	N 44º693552`	E0 20º880718`	04.4.2009
	N 44º733427`	E0 20º962751`	09.4.2010
Smederevo	N 44º684247`	E0 20º957193`	01.4.2008
	N 44º660931`	E0 20º959039`	04.4.2009
	N 44º671766`	E0 20º97878`	09.4.2010
Požarevac	N 44º603974`	E0 21º119564`	01.4.2008
	N 44º624732`	E0 21º146708`	04.4.2009
	N 44º629077`	E0 21º143028`	09.4.2010

Trials were set up according to the methods PP 1/178(3) and PP 1/152(3) (OEPP/EPPO, 1999; OEPP/EPPO, 2004) and a random block design was used with four replicates and experimental plot size of 25 m^2 (Figure 6). The insecticides were applied during the winter rapeseed development stage of visible flower buds but still closed (BBCH 55-59) (Lancashire et al., 1991). A Solo backpack sprayer and 300 l/ha of water were used for treatments (Figure 6). No insecticide was applied on control plots. The trials were set up on April 1st, 2008, April 7th 2009 and April 9th, 2010, after counting the present of *M. aeneus* imagoes.

The efficacy of insecticides was evaluated according to the method PP 1/178(3) (OEPP/EPPO, 2004). Ten top inflorescences of rapeseed were evaluated in each plot representing an insecticide treatment and each replicate. The surviving imagoes of *M. aeneus* were counted three and seven days after treatment on the following dates: April 4th and 8th, 2008, April 10th and 14th, 2009, and April 12th and 16th, 2010, respectively. The data were statistically analyzed by One-way ANOVA and the significance of mean differences was determined by Fisher's LSD test at $P < 0.05$ (Sokal and Rohlf, 1995).

RESULTS

Efficacy testing of insecticides in 2008

Three days after treatments, the efficacy of the tested insecticides ranged from 90-95%, 90-100% and 93-99% at the locations Kovin, Smederevo and Požarevac, respectively (Tables 3-5). In the group of pyrethroids, lambda-cyhalothrin showed the highest efficacy of 99% and 100% at the locations Smederevo and Požarevac, respectively, and bifenthrin had the lowest statistically significant efficacy, while no statistically significant differences were recorded between the pyrethroids at Kovin. Thiacloprid achieved the lowest efficacy at all locations three days after treatment. After seven days, the efficacy of the tested insecticides was significantly lower at all three locations, and the number of *M. aeneus* adults significantly increased, compared to the data after three days. In that interval, the highest efficacy was achieved by pirimiphos-methyl, 87%, 91% and 92% at Kovin, Smederevo and Požarevac, respectively, while the combination of chlorpyrifos and cypermethrin achieved 88%, 91% and 92% efficacy.

Table 3. Efficacy of insecticides at Kovin site, 2008

Insecticide	BT		3DAT			7DAT		
	Ms	Sd	Ms	Sd	E (%)	Ms	Sd	E (%)
Lambda- cyhalothrin	47.75 a*	3.40	5.25 bcd	0.96	92.73	14.50 b	1.91	84.09
Alpha- cypermethrin	41.50 bc	1.29	5.00 bcd	1.41	92.03	14.00 bc	1.63	82.33
Bifenthrin	40.25 c	2.63	5.50 bc	1.29	90.96	13.50 bc	1.29	82.43
Pirimiphos-methyl	40.50 bc	2.64	3.50 cd	1.29	94.28	9.75 c	0.96	87.39
Chlorpyrifos + Cypermethrin	43.50 bc	1.29	3.00 d	0.82	95.44	9.50 c	1.73	88.56
Tiacloprid	44.50 ab	4.04	7.00 b	0.82	89.59	17.25 b	2.22	79.70
Control	44.00 abc	2.83	66.50 a	3.11	-	84.00 a	6.05	-
	$LSD_{0.05}$ = 3.72		$LSD_{0.05}$ = 2.20			$LSD_{0.05}$ = 4.18		

* Means within columns followed by the same letter are not significantly different (p>0.05)
Legend: BT – before treatment; 3DAT – three days after treatment; 7DAT – seven days after treatment; Ms - mean; Sd – standard deviation; E - efficacy

Table 4. Efficacy of insecticides at Smederevo site, 2008

Insecticide	BT		3DAT			7DAT		
	Ms	Sd	Ms	Sd	E (%)	Ms	Sd	E (%)
Lambda- cyhalothrin	29.50 b*	1.29	0 d	0	100.00	8.00 bc	0.82	84.66
Alpha- cypermethrin	31.50 b	4.20	0.75 cd	0.96	98.25	7.75 bc	2.06	86.08
Bifenthrin	28.00 b	2.83	2.50 bc	0.58	93.42	8.25 bc	1.50	83.33
Pirimiphos-methyl	36.50 a	2.64	0.75 cd	0.50	98.49	5.50 bc	1.29	91.48
Chlorpyrifos + Cypermethrin	29.50 b	1.29	0.25 d	0.50	99.38	4.75 c	2.22	90.89
Tiacloprid	31.25 b	2.99	4.25 b	0.50	89.98	9.25 b	0.96	83.26
Control	28.00 b	2.71	38.00 a	3.65	-	49.50 a	5.80	-
	$LSD_{0.05}$ = 4.22		$LSD_{0.05}$ = 1.89			$LSD_{0.05}$ = 3.44		

* Means within columns followed by the same letter are not significantly different (p>0.05)
Legend: BT – before treatment; 3DAT – three days after treatment; 7DAT – seven days after treatment; Ms - mean; Sd – standard deviation; E - efficacy

Table 5. Efficacy of insecticides at Požarevac site, 2008

Insecticide	BT		3DAT			7DAT		
	Ms	Sd	Ms	Sd	E (%)	Ms	Sd	E (%)
Lambda- cyhalothrin	37.00 ab*	3.91	0.50 d	1.00	98.92	8.75 b	1.50	87.34
Alpha- cypermethrin	29.00 d	3.16	1.25 cd	0.96	96.55	8.00 b	1.63	85.23
Bifenthrin	36.50 ab	2.64	2.00 bc	0.82	95.62	9.75 b	0.96	85.70
Pirimiphos-methyl	40.00 a	3.91	0.50 d	0.58	99.00	6.25 b	2.75	91.63
Chlorpyrifos + Cypermethrin	39.50 a	3.11	0.25 d	0.50	99.49	5.75 b	2.22	92.21
Tiacloprid	31.50 cd	2.38	2.75 b	0.50	93.02	10.50 b	1.73	82.15
Control	34.00 bc	2.16	42.50 a	2.08	-	63.50 a	8.89	-
	$LSD_{0.05}$ = 4.14		$LSD_{0.05}$ = 1.25			$LSD_{0.05}$ = 5.85		

* Means within columns followed by the same letter are not significantly different ($p>0.05$)
Legend: BT – before treatment; 3DAT – three days after treatment; 7DAT – seven days after treatment; Ms - mean; Sd – standard deviation; E - efficacy

Table 6. Efficacy of insecticides at Kovin site, 2009

Insecticide	BT		3DAT			7DAT		
	Ms	Sd	Ms	Sd	E (%)	Ms	Sd	E (%)
Lambda- cyhalothrin	57.75 a*	2.75	7.50 bc	1.29	91.38	23.50 b	2.52	81.74
Alpha- cypermethrin	49.25 bc	1.71	6.00 c	1.15	91.91	23.00 b	2.16	79.05
Bifenthrin	45.25 c	4.03	5.75 c	1.89	91.57	20.00 bc	4.24	80.17
Pirimiphos-methyl	53.25 ab	1.71	5.75 c	0.96	92.83	13.00 c	1.82	89.05
Chlorpyrifos+Cypermethrin	54.50 ab	2.38	5.25 c	0.96	93.61	12.50 c	1.29	89.71
Tiacloprid	55.50 a	5.69	9.25 b	1.26	88.94	24.25 b	1.50	80.40
Control	56.75 a	3.30	85.50 a	2.87	-	126.50 a	14.36	-
	$LSD_{0.05}$ = 5.37		$LSD_{0.05}$ = 2.36			$LSD_{0.05}$ = 9.09		

* Means within columns followed by the same letter are not significantly different ($p>0.05$)
Legend: BT – before treatment; 3DAT – three days after treatment; 7DAT – seven days after treatment; Ms - mean; Sd – standard deviation; E - efficacy

Table 7. Efficacy of insecticides at Smederevo site, 2009

Insecticide	BT		3DAT			7DAT		
	Ms	Sd	Ms	Sd	E (%)	Ms	Sd	E (%)
Lambda- cyhalothrin	25.50 c*	3.32	0.50 d	0.58	98.39	8.00 bc	1.41	82.95
Alpha- cypermethrin	34.00 a	3.16	3.00 bc	0.82	92.74	9.25 b	1.50	85.21
Bifenthrin	32.00 ab	1.41	3.25 bc	0.96	91.65	9.50 b	1.29	83.87
Pirimiphos-methyl	25.50 c	3.32	0.75 d	0.96	97.58	4.50 d	1.00	90.41
Chlorpyrifos+Cypermethrin	28.25 bc	3.86	1.25 cd	0.96	96.36	5.00 cd	0.82	90.38
Tiacloprid	30.50 abc	1.91	4.00 b	1.41	89.21	10.50 b	1.29	81.29
Control	31.25 ab	3.5	38.00 a	4.08	-	57.50 a	4.65	-
	$LSD_{0.05}$ = 4.75		$LSD_{0.05}$ = 2.07			$LSD_{0.05}$ = 3.02		

* Means within columns followed by the same letter are not significantly different ($p>0.05$)
Legend: BT – before treatment; 3DAT – three days after treatment; 7DAT – seven days after treatment; Ms - mean; Sd – standard deviation; E - efficacy

Table 8. Efficacy of insecticides at Požarevac site, 2009

Insecticide	BT		3DAT			7DAT		
	Ms	Sd	Ms	Sd	E (%)	Ms	Sd	E (%)
Lambda- cyhalothrin	35.00 a*	2.16	2.50 bc	0.58	95.63	8.75 bc	0.96	90.54
Alpha- cypermethrin	33.00 ab	3.46	2.50 bc	0.58	95.36	8.00 bc	1.41	90.83
Bifenthrin	29.00 bc	2.58	3.25 b	0.96	93.14	9.75 bc	0.50	87.28
Pirimiphos-methyl	30.00 bc	3.65	0.50 c	0.58	98.98	6.25 bc	1.26	92.12
Chlorpyrifos+Cypermethrin	31.00 abc	2.83	0.25 c	0.50	99.51	5.75 c	1.71	92.98
Tiacloprid	31.00 abc	2.00	2.75 bc	0.50	94.57	10.50 b	1.29	87.18
Control	28.00 c	3.16	45.75 a	3.86	-	74.00 a	6.98	-
	$LSD_{0.05}$ = 4.17		$LSD_{0.05}$ = 2.27			$LSD_{0.05}$ = 4.13		

* Means within columns followed by the same letter are not significantly different (p>0.05)
Legend: BT – before treatment; 3DAT – three days after treatment; 7DAT – seven days after treatment; Ms - mean; Sd – standard deviation; E - efficacy

Table 9. Efficacy of insecticides at Kovin site, 2010

Insecticide	BT		3DAT			7DAT		
	Ms	Sd	Ms	Sd	E (%)	Ms	Sd	E (%)
Lambda- cyhalothrin	29.50 c*	2.64	5.00 bc	1.41	86.84	11.75 b	3.20	78.93
Alpha- cypermethrin	36.00 ab	3.65	4.75 bc	0.96	89.75	13.25 b	2.63	80.53
Bifenthrin	39.50 a	4.12	5.00 bc	0.82	90.17	12.00 b	4.00	83.93
Pirimiphos-methyl	31.75 bc	4.42	2.50 c	0.58	93.89	10.50 b	2.38	82.51
Chlorpyrifos+Cypermethrin	33.50 bc	2.89	3.00 c	0.82	93.05	9.75 b	1.71	84.60
Tiacloprid	33.25 bc	2.87	6.25 b	1.26	85.40	15.00 b	1.82	76.14
Control	36.50 ab	2.38	47.00 a	3.83	-	69.00 a	8.75	-
	$LSD_{0.05}$ = 4.74		$LSD_{0.05}$ = 2.62			$LSD_{0.05}$ = 6.60		

* Means within columns followed by the same letter are not significantly different (p>0.05)
Legend: BT – before treatment; 3DAT – three days after treatment; 7DAT – seven days after treatment; Ms - mean; Sd – standard deviation; E - efficacy

Efficacy testing of insecticides in 2009

In 2009, all tested insecticides achieved efficacy that exceeded 90% at Kovin and no statistical differences were detected among them, thiacloprid being the only examption (Tables 6-8). At the location Smederevo, the efficacy of all insecticides except thiacloprid exceeded 90% three days after treatment, and the highest was found in rapeseed plots treated with lambda-cyhalothrin (98%), pirimiphos-methyl (98%) and the combination chlorpyrifos+cypermethrin (96%). At Požarevac, all insecticides reached high efficacy of 95-99%. Seven days after treatment, the insecticides showed a significantly lower efficacy at all three locations, compared to the evaluation after three days, i.e. an increased number of *M. aeneus* adults. In that interval, the highest efficacy was demonstrated by pirimiphos-methyl and chlorpyrifos+cypermethrin, 89-92% and 90-93%, respectively, at all three locations. The efficacies of pyrethroids and the neonicotinoid thiacloprid showed no statistically significant difference, ranging from 79-82% at Kovin, 81-85% at Smederevo and 87-91% at Požarevac.

Efficacy testing of insecticides in 2010

No statistically significant differences were detected between the tested insecticides at the locations Smederevo and Požarevac three days after threatment, while only thiacloprid achieved significantly lower efficacy at Kovin than the other insecticides (Tables 9-11). At all locations, the highest efficacy of 93-95% was achieved three days after rapeseed treatment with the combination of chlorpyrifos and cypermethrin. As in 2008 and 2009, the efficacy of the tested insecticides seven days after treatment was again lower than it was after three days. However, no statistically significant differences were detected between the insecticides at different locations in that interval.

Table 10. Efficacy of insecticides at Smederevo site, 2010

Insecticide	BT		3DAT			7DAT		
	Ms	Sd	Ms	Sd	E (%)	Ms	Sd	E (%)
Lambda- cyhalothrin	24.25 a*	7.18	2.50 b	0.58	92.19	10.00 b	3.56	82.67
Alpha- cypermethrin	28.00 a	2.94	2.50 b	1.00	93.24	12.00 b	3.56	81.99
Bifenthrin	23.00 a	2.94	2.75 b	0.96	90.94	10.00 b	1.82	81.73
Pirimiphos-methyl	25.00 a	1.82	2.00 b	0.82	93.94	9.50 b	0.58	84.03
Chlorpyrifos+Cypermethrin	28.50 a	4.65	2.00 b	0	94.68	8.75 b	2.22	87.10
Tiacloprid	21.50 a	4.43	3.25 b	0.50	88.55	11.00 b	0.82	78.50
Control	25.00 a	6.27	33.00 a	2.94	-	59.50 a	2.64	-
	$LSD_{0.05}$ = 7.04		$LSD_{0.05}$ = 1.92			$LSD_{0.05}$ = 3.49		

* Means within columns followed by the same letter are not significantly different ($p>0.05$)
Legend: BT – before treatment; 3DAT – three days after treatment; 7DAT – seven days after treatment; Ms - mean; Sd – standard deviation; E - efficacy

Table 11. Efficacy of insecticides at Požarevac site, 2010

Insecticide	BT		3DAT			7DAT		
	Ms	Sd	Ms	Sd	E (%)	Ms	Sd	E (%)
Lambda- cyhalothrin	25.00 b*	3.56	2.50 b	1.29	92.00	9.00 b	0.82	80.80
Alpha- cypermethrin	28.00 ab	2.45	2.75 b	0.50	92.14	9.00 b	2.58	82.86
Bifenthrin	30.50 a	2.64	3.50 b	1.29	90.82	10.00 b	4.40	82.51
Pirimiphos-methyl	32.00 a	1.41	2.00 b	0.82	95.00	8.00 b	1.15	86.67
Chlorpyrifos+Cypermethrin	31.00 a	3.46	1.75 b	0.50	95.48	8.00 b	2.71	86.24
Tiacloprid	30.00 a	2.94	3.50 b	1.29	90.67	11.00 b	2.58	80.44
Control	28.00 ab	2.94	35.00 a	4.40	-	52.50 a	5.97	-
	$LSD_{0.05}$ = 4.19		$LSD_{0.05}$ = 2.43			$LSD_{0.05}$ = 5.08		

* Means within columns followed by the same letter are not significantly different ($p>0.05$)
Legend: BT – before treatment; 3DAT – three days after treatment; 7DAT – seven days after treatment; Ms - mean; Sd – standard deviation; E - efficacy

DISCUSSION

Analyzing the results of our field testing of the effectiveness of different insecticides, we found their efficacies to range: from 90-100% in evaluation three days after treatment and 80-92% seven days after treatment in 2008; 89-99% in evaluation three days after treatment and 79-93% seven days after treatment in 2009; 85-95% three days after treatment and 76-87% seven days after treatment in 2010. The combination of chlorpyrifos and cypermethrin (94-99%) and pirimiphos-methyl (93-99%) showed the highest efficacy during the three years of testing at all locations, while the pyrethroids achieved lower efficacy (87-100%), and thiacloprid the lowest (85-95%).

As the weather was favourable during trials, i.e. warm and dry, *M. aeneus* populations recovered relatively fast in winter rapeseed crops, and the efficacy of the tested insecticides consequently declined. Data from other similar studies in our country (Vuković et al., 2007) had also indicated a high level of efficacy (90-100%) of the pyrethroid insecticides alfa-cypermethrin, gamma-cyhalothrin and tau-fluvalinate three days after treatment, while their efficacies were significantly lower 7-8 days after treatment, i.e. 14-61%. Petraitiene et al. (2008) reported that pyrethroids (zeta-cypermethrin 100 g/l, deltamethrin 25, 50 and 100 g/l, alfa-cypermethrin 50 g/l, beta-cyfluthrin 25 g/l, lambda-cyhalothrin 5 g/l) and a neonicotinoid-pyrethroid combination (thiacloprid + deltamethrin 100 + 10 g/l) had an efficacy range of 86-100% one day after application, but it decreased significantly after four and seven days, and the abundance of *M. aeneus* beetles increased. Węgorek and Zamoyska (2006, 2008) reported a drop in the efficacy of pyrethroids of up to 40% four days after treatment in Poland, while efficacy was not satisfactory seven days after treatment.

Vaitelyte et al. (2011) showed in a study that several pyrethroids (beta-cyfluthrin, lambda-cyhalothrin, tau-fluvalinate), a combination of a neonicotionoid and a pyrethroid (thiacloprid +deltamethrin), a combination of a pyretroid and an organophosphate (chlorpyrifos+ beta-cyfluthrin), an organophosphate (chlorpyrifos) and an oxadiazine (indoxacarb) were able to significantly reduce the number of *M. aeneus* imagoes in winter rapeseed crops and that tau-fluvalinate was the most effective pyrethoid. In our evaluation three and seven days after treatment, the numbers of *M. aeneus* adults were not significantly different between the plots treated with lambda-cyhlothrin, alfa-cypermethrinom and bifenthrin, except at the Smederevo location in 2008 and 2009, and Požarevac in 2008 when rapeseed treated with lambda-cyhalothrin had a significantly lowest number of beetles three days after treatment, while the number was highest in rapeseed treated with bifenthrin.

Pyrethroid and organophosphate insecticides have been used in Serbia (Janjić and Elezović, 2010) for many years to control pests in rapeseed crops, while neonicotinoids have not yet been introduced but their efficacy is the same in some other European countries. In our study, the efficacy of thiacloprid three days after treatment was significantly lower than the efficacy of all other tested insecticides, and the same was observed after seven days, except in 2010 when thiacloprid showed similar efficacy as the other insecticides seven days after treatment.

Research based on the optimization of chemical protection of rapeseed crops against *M. aeneus* has been conducted in recent years in most European countries, such as France, Great Britain, Sweden, Denmark, Germany, Poland, the Check Republic, Austria and Switzerland (Alford et al., 2003; Hansen, 2004). Węgorek et al. (2009) recommended at least 3-5 chemical treatments to control *M. aeneus* in Poland, the first one at the plant development stage BBCH 51-54 using insecticides with chlorpyrifos as an active ingredient; the next one at the stage BBCH 55-59 using pyrethoid or neonicotinoid insecticides (e.g. acetamiprid) or, if two treatments are needed during that period, a compound not belonging to the groups used before. They inferred that chlorpyrifos application at that stage was justified only when infestation was massive or resistance detected to pyrethroids or neonicotinoids. At the beginning of rapeseed flowering (beginning with stage BBCH 60), they recommended insecticides that include tau-fluvalinate or acetamiprid in order to rotate the insecticide chemical groups (Węgorek et al., 2009). The combination of chlorpyrifos and cypermethrin was found in that study to be the most effective at all locations during three years of experiment. Also, the efficacy data indicated that another insecticide treatment was needed after seven days.

Petraitiene et al. (2008) measured rapeseed yields for eight years and found that seed yield in untreated plots was 102-447 kg/ha lower than in plots in which insecticides had been applied. Rapeseed growing has been intensified in Serbia in recent years, and increased usage of insecticides is expected in order to ensure high and stable yields. However, years of insecticide treatments may cause a change in susceptibility/resistance to insecticides in *M. aeneus* populations, especially in regions where rapeseed is grown intensively. In our three-year trials, the efficacy of insecticides was found to range from 85-100% three days after treatment, but it decreased significantly to 75-92% seven days after treatment, which indicates a need to organize monitoring in Serbia.

ACKNOWLEDGEMENT

The study was conducted as part of the project III 46008 „Development of integrated pest management systems aiming to overcome resistance and improve food quality and safety“, funded by the Ministry of Education, Science and the Technological Development of the Republic of Serbia.

REFERENCES

Alford, D.V., Nilsson, C., & Ulber, B. (2003). Insect pests of oilseed rape crops. In D.V. Alford (Ed.), *Biocontrol of Oilseed Rape Pests*. (pp. 9-41). Oxford, UK: Blackwell Science.

Delorme, R., Détourne, D., Touton, P., Pauron, D., & Ballanger, Y. (2002). Résistance Des Méligèthes Du Colza Aux Pyréthrinoides: Quels Mécanismes. In: AFPP - Sixieme Conference Internationale Sur Les Ravageurs En Agriculture, Montpellier, 4-6 Decembre.

Derron, J.O., Clech, E., & Bezencon, G.G. (2004). Resistance of the pollen beetles (Meligethes spp.) to pyrethroids in western Switzerland. *Revue Suisse d'Agriculture,* 36(6), 237-242.

Frearson, D.J.T., Ferguson, A.W., Campbell, J.M., & Williams, I.H. (2005). The spatial dynamics of pollen beetles in relation to inflorescence growth stage of oilseed rape: implications for trap crop strategies. *Entomologia Experimentalis et Applicata,* 116(1), 21-29. doi:10.1111/j.1570-7458.2005.00299.x

Glattkowski, H., Saggau, B., & Goebel, G. (2008). Experiences in controlling resistant pollen beetle by type I ether pyrethroid Trebon 30 EC in Germany. *EPPO Bulletin,* 38(1), 79-84. doi:10.1111/j.1365-2338.2008.01186.x

Hansen, L.M. (1996). Blossom beetles in oilseed rape - monitoring and threshold. In: A. Corell (Ed.), 13th Danish Plant Protection Conference: Pests and Diseases. Foulum (Denmark): SP., Mar.,.139-143.

Hansen, L.M. (2003). Insecticide-resistant pollen beetles (Meligethes aeneus F) found in Danish oilseed rape (*Brassica napus* L) fields. *Pest Management Science,* 59(9), 1057-9. pmid:12974359. doi:10.1002/ps.737

Hansen, L.M. (2004). Economic damage threshold model for pollen beetles (*Meligethes aeneus* F.) in spring oilseed rape (*Brassica napus* L.) crops. *Crop Protection,* 23(1), 43-46.

Hansen, L.M. (2008). Occurrence of insecticide resistant pollen beetles (*Meligethes aeneus* F.) in Danish oilseed rape (*Brassica napus* L.) crops. *EPPO Bulletin,* 38(1), 95-98. doi:10.1111/j.1365-2338.2008.01189.x

Heimbach, U., Muller, A., & Thieme, T. (2006). First steps to analyze pyrethroid resistance of different oil seed rape pests in Germany. *Nachrichtenblatt des Deutschen Pflanzenschutzdienstes,* 58(1), 1-5.

Heimbach, U., Müller, A., & Thieme, T. (2007). Pyrethroid resistance status of pollen beetle populations in Germany in 2006 and 2007. In: Poster presented at EPPO Workshop on insecticide resistance of Meligethes spp. (pollen beetle) on oilseed rape, Berlin, 3-5 September..

Hokkanen, H., Husberg, G.B., & Söderblom, M. (1998). Natural enemy conservation for the integrated control of the rape blossom beetle *Meligethes aeneus* F. *Annales Agriculturae Fenniae,* 27, 281-293.

Janjić, V., & Elezović, I. (2010). *Pesticidi u prometu u poljoprivredi i šumarstvu u Srbiji*. Beograd: Društvo za zaštitu bilja Srbije.

Kazachkova, N.I. (2007). *Genotype analysis and studies of pirethroid resistance of the oilseed rape (Brassica napus) Insect pest pollen beetle* (*Meligethes aeneus).* Swedich University of Agriculture Sciences.

Lancashire, P.D., Bleiholder, H., van den Boom, T., Langeluddeke, P., Stauss, R., Weber, E., & Witzenberger, A. (1991). A uniform decimal code for growth stages of crops and weeds. *Annals of Applied Biology,* 19, 561-601.

Milovanović, P. (2006). *Štetočine uljane repice u Srbiji*. Beograd.

Milovanović, P. (2007). Štetni insekti na uljanoj repici u Srbiji. *Zaštita bilja,* 58(1-4), 25-53.

Milovanović, P., Petrović-Obradović, O., & Kljajić, P. (2008). Efikasnost insekticida u suzbijanju repičinog sjajnika (Meligethes aeneus Fabr.). In: IX Savetovanje o zaštiti bilja, Zlatibor, Zbornik rezimea. 70.

Milovanović, P., Kljajić, P., Andrić, G., Pražić-Golić, M., & Popović, T. (2011). Osetljivost repičinog sjajnika na insekticide iz grupe piretroida i organofosfata. In: XI Savetovanje o zaštiti bilja, Zlatibor, 28.novembar-3.decembar, Zbornik rezimea. 114-115.

Muller, A., Heimbach, U., & Thieme, T. (2008). Pyrethroid sensitivity monitoring in Germany of oilseed rape pest insects other than pollen beetle. *EPPO/OEPP Bulletin,* 38(1), 85-90.

OEPP/EPPO. (1999). Design and analysis of efficacy evaluation trials: PP1/152 (2). In: EPPO Standards, Guidelines for the Efficacy Evaluation of Plant Protection Products: Vol. 1. Introduction: General and Miscellaneous Guidelines, New and Revised Guidelines. Paris.

OEPP/ERRO. (2004). *Guideline for the efficacy evaluation of insecticides, (3) Meligethes aeneus on rape. EPPO Standards, Guidelines for the Efficacy Evaluation of Plant Protection Products*. 1/178.

Petraitiene, E., Brazauskiene, I., Šmatas, R., & Makunas, V. (2008). The spread of pollen beetle (*Meligethes aeneus* F.) in spring oilseed rape (*Brassica napus* L.) and the efficacy of pyrethroids. *Zemdirbyste- Agriculture,* 95(3), 344-352.

Philippou, D., Field, L., Węgorek, P., Zamojska, J., Andrews, M., Slater, R., & Moores, G. (2010). *Characterising metabolic resistance in pyrethroid-insensitive pollen beetle (Meligethes aeneus F.) from Poland and Switzerland*. Pest: Management Science. Society of Chemical Industry.

Sekulić, R., & Kereši, T. (2007). Repičin sjajnik (Meligethes aeneus), najvažnija štetočina ozime uljane repice. *Biljni lekar,* 35(4), 410-419. Retrieved from http://scindeks.ceon.rs/article.aspx?artid=0354-61

Sokal, R.R., & Rohlf, F.J. (1995). *Biometry: The principle and practice of statistics in biological research, 3rd ed*. New York: W.H. Freeman and Company.

Vaitelyte, B., Petraitiene, E., Šmatas, R., & Brazauskiene, I. (2011). Control of *Meligethes aeneus*, *Ceutorhynchus assimilis* and *Dasineura brassicae* in winter oilseed rape. *Žemdirbystė=Agriculture,* 98(2), 175-182.

Vuković, S., Inđić, D., & Turinski, I. (2007). Efikasnost insekticida u suzbijanju repičinog sjajnika (Meligethes aeneus F.). *Biljni lekar,* 35(5), 516-523. Retrieved from http://scindeks.ceon.rs/article.aspx?artid=0354-61

Williams, I.H., Frearson, D., Barari, H., & Mccartney, A. (2007). Migration to and dispersal from oilseed rape by the pollen beetle, *Meligethes aeneus*, in relation to wind direction. *Agricultural and Forest Entomology,* 9(4), 279-286. doi:10.1111/j.1461-9563.2007.00343.x

Węgorek, P. (2005). Preliminary data on resistance appearance of Pollen beetle PB (*Meligethes aeneus* F.) to selected pyrethroids, organophosphorous and chloronicotynyls insecticide, in 2004 year in Poland. *Resistant Pest Management Newsletter,* 14(2), 19-21.

Węgorek, P., Mrowcznski, M., & Zamoyska, J. (2009). Resistance of Pollen Beetle (*Meligethes aeneus* F.) to Selected Active Substances of Insecticides in Polland. *Journal of Plant Protection Research,* 49(1), 119-128.

Węgorek, P., Obrepalska-Steplowska, A., Nowaczyk, K., Zamoyska, J., & Nowaczyk, K. (2007). The Level of Resistance of Polish Populations of Pollen Beetle (*Meligethes aeneus* F.) Against Pyrethroids; Mechanism of Resistance in Light of Molecular Research. *Progress in Plant Protection,* 47(1), 383-388.

Węgorek, P., Obrepalska-Steplowska, A., Zamoyska, J., & Nowaczyk, K. (2006). Resistance of Pollen Beetle (*Meligethes aeneus* F.) in Poland. *Resistant Pest Management Newsletter,* 16(1), 28-29.

Węgorek, P., & Zamojska, J. (2006). Resistance of pollen beetle (*Meligethes aeneus* F.) to pyrethroids, chloronicotynyls and organophosphorous insecticides in Poland. *IOBC/wprs Bulletin,* 29(7), 135-140.

Węgorek, P., & Zamoyska, J. (2008). Current status of resistance in pollen beetle (*Meligethes aeneus* F.) to selected active substances of insecticides in Poland. *EPPO Bulletin,* 38(1), 91-94. doi:10.1111/j.1365-2338.2008.01188.x

Efikasnost različitih insekticida u poljskim uslovima u suzbijanju repičinog sjajnika (*Meligethes aeneus* F.) u usevima ozime uljane repice

REZIME

S obzirom da gajenje uljane repice za sobom povlači i primenu insekticida za suzbijanje repičinog sjajnika kao najštetnije insekatske vrste, u radu je tokom trogodišnjih poljskih ogleda (2008-2010. godina) na tri lokaliteta (Kovin, Smederevo i Požarevac) ispitana efikasnost insekticida različitih mehanizama delovanja: piretroida (lambda-cihalotrin, alfa-cipermetrin, bifentrin), organofosfata (pirimifos-metil), kombinacije organofosfata i piretroida (hlorpirifos + cipermetrin) i neonikotinoida (tiakloprid) za imaga *M. aeneus*. Komercijalne formulacije insekticida su primenjivane u preporučenim dozama u usevima ozime uljane repice u vreme vidljivih cvetnih pupoljaka, ali još zatvorenih (BBCH 55-57). Efikasnost piretroida i organofosfata je tokom svih ogleda bila 90-100%, a neonikotinoida 85-95%, pa se zbog ispoljene visoke efikasnosti može preporučiti njihova primena u Srbiji.

Ključne reči: Insekticidi; efikasnost; repičin sjajnik