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Original scientific paper

Residual efficacy of deltamethrin against *Sitophilus oryzae* (L.), *Rhyzopertha dominica* (F.), *Tribolium castaneum* (Herbst) and *Sitotroga cerealella* (Oliv.) in wheat grain

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SUMMARY

Residual efficacy of the insecticide deltamethrin, an EC formulation containing 25 g/L AI + 225 g/L PBO (piperonyl butoxide synergist), against lab populations of *Sitophilus oryzae*, *Rhyzopertha dominica*, *Tribolium castaneum* and *Sitotroga cerealella* was investigated in the laboratory by applying product water solutions (0.25 mg AI/kg) to wheat grain (at 25±1°C and 60±5% r.h.). Adult mortality on 0, 7, 14 and 30 days old deposits was estimated after 2, 7 and 14 days of exposure to treated wheat grain and additional 7 days of recovery. Progeny reduction (PR, %) was also assessed. After 2 days of exposure to deposits of all ages, deltamethrin caused only 0-10% mortality of coleopterans (up to 37% after the recovery period) and 23-30% of *S. cerealella*, while mortality before and after recovery from 14 days of exposure was 95-50% for *S. oryzae*, 97-100% for *R. dominica*, 99-100% for *T. castaneum* and 100% for *S. cerealella*. Progeny production of *S. oryzae* was highest after parents contacted with 14 days old deposit of deltamethrin (PR, 76%), and lowest after contact with fresh deposit (PR, 95%), while *R. dominica* and *T. castaneum* had no progeny on any deltamethrin deposit age in wheat (PR, 100%), and *S. cerealella* had only a very low progeny (PR, 99%). The results showed that the synergised deltamethrin, applied at 0.25 mg/kg in wheat grain, is a highly effective insecticide for stored-product insect control, while a higher dose is required for successful residual control of *S. oryzae*.

Keywords: Insecticides; Residual efficacy; Progeny; Insect pests; Wheat grain

INTRODUCTION

Several stored-product insect pests: the coleopterans rice weevil *Sitophilus oryzae* (L.), lesser grain borer *Rhyzopertha dominica* (F.) and red flour beetle *Tribolium castaneum* (Herbst) (Coleoptera: Curculionidae), and the lepidopteran Angoumois grain moth *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae), are very important pests of stored plant products, which are able to cause major losses unless

controlled (Hill, 1990; Rees, 2004; Almaši, 2008; Stejskal et al., 2015).

The use of contact (residual) insecticides is still the most important method for controlling pests in storages (Kljajić, 2008; Arthur, 2012; Arthur & Subramanyam, 2012), and several products, mostly organophosphate insecticides and synthetic pyrethroids, have been registered worldwide (Arthur & Subramanyam, 2012; MacBean, 2012) and in Serbia (Team of editors, 2016). The ability of a grain protectant to provide long-term protection against stored-grain insects is one of the most desired characteristics, given that significant quantities of grains are stored for long periods, and are eventually processed right before the next harvest (Rumbos et al., 2018b). The pyrethroid deltamethrin is classified in a group of highly applicable insecticides, and is used to control a great number of arthropod species important for agriculture and public health protection (Baur, 1991; World Health Organization, 1984, 2006; MacBean, 2012). Previous research of different deltamethrin formulations conducted worldwide (Arthur 1997a,b; Kavallieratos et al., 2016) and in Serbia (Kljajić & Perić, 2006; Andrić et al., 2010; Pražić Golić et al., 2015) has verified that it is a highly effective insecticide for controlling different species of stored-product pests with a remarkable residual efficacy (Arthur, 1997a,b, 2018; Kljajić & Perić, 2009; Paudyal et al., 2016).

The residual efficacy of contact insecticides applied to stored plant products is known to depend on the type of insecticide, its formulation, species of stored product insect pests, and/or duration of exposure (Arthur, 1996, 2012, 2018; Kljajić & Perić, 2009; Andrić et al., 2011, 2013; Arthur & Subramanyam, 2012; Wakil et al., 2013; Rumbos et al., 2018 a,b). The present study therefore focused on laboratory tests of the residual efficacy of an EC formulation of deltamethrin with piperonyl butoxide synergist, applied at the recommended rate (0.25 mg AI/kg of wheat grain) against several stored-product insect pests, i.e. the coleopterans *S. oryzae*, *R. dominica*, and *T. castaneum,* and the lepidopteran *S. cerealella*, after different periods of contact with treated wheat grain.

MATERIALS AND METHODS

Test insects and insecticides

Laboratory populations of *S. oryzae*, *R. dominica*, *T. castaneum* and *S. cerealella*, were reared in an insectary at 25±1°C temperature and 60±5% relative humidity (r.h.), as described by Harein and Soderstrom (1966) and Davis and Bry (1985) for coleopterans, and Boles and Marzke (1966) for lepidopterans. Two-to-four weeks old *S. oryzae*, *R. dominica*, *T. castaneum* unsexed adults, and 1-day old imagoes of *S. cerealella*, were used in the bioassay.

An EC formulation of deltamethrin insecticide combining 25 g/l AI with the synergist piperonyl butoxide 225 g/l (K-Obiol EC 25, Bayer Environmental Science SAS, France) was tested.

Bioassay

Residual efficacy tests were performed on several stored-product insects using a methodology described in PP 1/203 (1) and PP 1/204 (1) (OEPP/EPPO, 2004). The tests were conducted in the laboratory at 25±1°C and 60±5% r.h. by applying the insecticide directly to wheat grain cv. NS 40 of 11.0±0.5% grain moisture measured by a Dickeye-John Mini GAC (Dickeye-John Co., USA) device before the experiment. An amount of 50 ml of deltemethrin water solution was applied to 50 kg wheat grain at the recommended rate of 10 mL product/t grain, which corresponds to 0.25 mg AI/kg wheat. Wheat was mixed in a cement mixer for 15 minutes after insecticide application, and the same procedure was performed with control wheat treated with water alone instead of insecticide solution. Treated wheat was then kept in sacks under laboratory conditions of 20-24°C and 40-50% r.h.

Insecticide effects on *S. oryzae*, *R. dominica*, *T. castaneum* and *S. cerealella* adults were then tested on 0, 7, 14 and 30 days old deposits. An amount of 50 g of treated wheat was poured into each 200 ml plastic cup to represent each deposit age, and then 25 imagoes of *S. oryzae*, *R. dominica* and *T. castaneum,* and 10 imagoes of *S. cerealella* were released into each cup, providing three replicates. Insect mortality was determined 2, 7 and 14 days later. After each mortality assessment for each exposure period, the surviving insects recovered in clean plastic cups containing 0.25 g broken wheat, and total mortality was again assessed after seven days of recovery (except for *S. cerealella*). The experiment was repeated twice.

Data analysis

Mortality data were analyzed using one-way ANOVA. Means were separated by Fisher's LSD test at P=0.05 (Sokal & Rohlf, 1995). Progeny production/reduction in wheat grain was determined using the formula PR (%) = (K-T) 100/K (Tapondjou et al., 2002), where K is the number of progeny in untreated control, and T is the number of progeny in treatments.

RESULTS

The efficacy of deltamethrin after 2 days of *S. oryzae* exposure to treated wheat grain was 0-1%, regarding deposits of all ages (0-30 days) (Table 1). The highest weevil mortality after 7 and 14 days of exposure was found on fresh deposit (91-95%), than on 14 days old deposit (65-66%), and the lowest on 7 and 30 days old deposits (around 50%). After seven days of recovery on untreated wheat in the laboratory, the mortality of adults resulting from two days of exposure to 0 day old deposit was 37%, while it was only 7% on 30 days old deposit. Also, the mortality of weevils exposed for 7 and 14 days remained unchanged at the end of the recovery period.

The efficacy against *R. dominica* after 2 days of exposure to treated wheat grain was similar to the data for *S. oryzae* on all age deposits, i.e. 0-1% (Table 2). After 7 days of exposure, the highest mortality was recorded on fresh and 30 days old deposits, 39% and 44%, respectively, while it was 97-100% after 14 days of exposure, without significant statistical differences between deposit ages. After seven days of recovery, the mortality of adults exposed for 2 days to fresh deposit was 15-21%, while the highest mortality after 7 days of exposure was recorded on fresh deposit, 85%, and 98-100% after 14 days of exposure.

Table 1. Efficacy (% ± SE) of deltamethrin against *S. oryzae* after 2, 7 and 14 days of adult exposure to treated wheat grain

Deposit age (days)	Efficacy (% ± SE) after exposure (days)			*F*	*p*
	2	7	14		
		Before recovery			
0	0.7±0.4 Ba*	90.7±1.9 Aa	95.3±1.1 Aa	667.90	< 0.001
7	0.7±0.4 Ba	54.0±3.7 Abc	50.0±2.0 Ac	55.25	< 0.001
14	0.0±0.0 Ba	66.0±3.4 Ab	65.3±2.3 Ab	93.12	< 0.001
30	0.0±0.0 Ba	50.0±2.2 Ac	49.3±1.5 Ac	132.81	< 0.001
F	0.67	14.80	55.77		
p	0.58	< 0.001	< 0.001		
		After 7 days of recovery			
0	37.3±2.4 Ba	90.7±1.9 Aa	95.3±1.1 Aa	112.41	< 0.001
7	23.3±3.3 Bb	55.3±3.7 Abc	51.3±2.1 Ac	11.83	< 0.001
14	21.3±2.4 Bb	66.7±3.4 Ab	66.7±2.5 Ab	32.11	< 0.001
30	7.3±0.4 Bc	52.0±2.4 Ac	50.7±1.6 Ac	86.15	< 0.001
F	10.06	13.24	45.94		
p	< 0.001	< 0.001	< 0.001		

*Means in columns marked by the same lowercase letter and means in rows marked by the same uppercase letter are not significantly different, Fisher's LSD test at P > 0.05.

Table 2. Efficacy (% ± SE) of deltamethrin against *R. dominica* after 2, 7 and 14 days of adult exposure to treated wheat grain

Deposit age (days)	Efficacy (% ± SE) after exposure (days)			*F*	*p*
	2	7	14		
		Before recovery			
0	0.0±0.0 Ca*	38.7±2.0 Ba	96.7±1.2 Aa	508.89	< 0.001
7	0.0±0.0 Ca	6.0±1.0 Bc	96.7±0.5 Aa	2.518.66	< 0.001
14	0.7±0.4 Ca	20.0±3.2 Bb	98.0±0.5 Aa	285.40	< 0.001
30	0.0±0.0 Ca	44.0±2.3 Ba	100 Aa	543.46	< 0.001
F	1.00	22.69	1.49		
P	0.41	< 0.001	0.25		
		After 7 days of recovery			
0	21.3±1.8 Ca	85.3±2.3 Ba	98.0±0.5 Aa	236.54	< 0.001
7	15.3±1.7 Ca	56.0±4.5 Bb	100 Aa	86.33	< 0.001
14	14.7±2.5 Ca	38.0±2.4 Bc	100 Aa	179.85	< 0.001
30	20.0±3.3 Ca	71.3±3.7 Bab	100 Aa	75.23	< 0.001
F	0.71	14.00	5.00		
P	0.56	< 0.001	0.01		

*Means in columns marked by the same lowercase letter and means in rows marked by the same uppercase letter are not significantly different, Fisher's LSD test at P > 0.05.

Table 3. Efficacy (% ± SE) of deltamethrin against *T. castaneum* after 2, 7 and 14 days of adult exposure to treated wheat grain

Deposit age (days)	Efficacy (% ± SE) after exposure (days)			*F*	*p*
	2	7	14		
		Before recovery			
0	0.0±0.0 Ca*	18.0±1.5 Bb	99.3±0.4 Aa	1.301.58	< 0.001
7	0.0±0.0 Ca	6.7±0.8 Bc	98.0±0.8 Aa	2.468.17	< 0.001
14	0.0±0.0 Ca	2.7±0.8 Bc	98.0±0.5 Aa	3.627.10	< 0.001
30	0.0±0.0 Ca	64.0±1.1 Ba	100 Aa	2.405.00	< 0.001
F	-	249.26	1.29		
p	-	< 0.001	0.31		
		After 7 days of recovery			
0	0.7±0.4 Cb	54.0±3.3 Bb	99.3±0.4 Aa	248.70	< 0.001
7	5.3±1.2 Cab	48.0±4.3 Bb	98.7±0.5 Aa	121.99	< 0.001
14	0.7±0.4 Cb	26.7±1.8 Bc	100 Aa	923.25	< 0.001
30	10±1.6 Ca	84.0±1.1 Ba	100 Aa	665.00	< 0.001
F	6.65	25.18	1.40		
p	0.003	< 0.001	0.27		

*Means in columns marked by the same lowercase letter and means in rows marked by the same uppercase letter are not significantly different, Fisher's LSD test at P > 0.05.

Table 4. Efficacy (% ± SE) of deltamethrin against *S. cerealella* after 2, 7 and 14 days of adult exposure to treated wheat grain

Deposit age (days)	Efficacy (% ± SE) after exposure (days)			*F*	*p*
	2	7	14		
0	28.4±1.0 Cab*	60±0.5 Bab	100 Aa	228.78	< 0.001
7	23.4±1.0 Cb	58.4±0.4 Bbc	100 Aa	258.24	< 0.001
14	27.8±1.2 Ca	75±0.4 Ba	100 Aa	149.39	< 0.001
30	30.4±1.8 Ba	20±0.5 Cc	100 Aa	47.40	< 0.001
F	3.61	6.41	-		
p	0.03	0.003	-		

*Means in columns marked by the same lowercase letter and means in rows marked by the same uppercase letter are not significantly different, Fisher's LSD test at P > 0.05.

The efficacy of deltamethrin deposits of all ages after 2 days of *T. castaneum* exposure to treated wheat grain was 0% (Table 3). After 7 days of exposure, the highest beetle mortality of 64% was recorded on 30 days old deposit, while beetle mortality was 98-100% after 14 days of exposure and without significant statistical differences between deposit ages. After recovery for 7 days, the mortality of adults exposed for two days to all age deposits was 1-10%, while the highest beetle mortality after 7 days of exposure was again on 30 days old deposit, 84%, while it was 99-100% after 14 days of exposure.

Deltamethrin efficacy against *S. cerealella* after 2 days of insect exposure to treated wheat grain was within 23-30% (Table 4). After 7 days of exposure, the highest mortality was shown on all deposits up to 14 days old, 58-75%, while it was lowest on 30 days old deposit, only 20%. After 14 days of exposure, insect mortality on deposits of all ages (0-30 days) was 100%.

Progeny counts of *S. oryzae* were the highest, 139 adults, after their parents had contact with 14 days old deposit of deltamethrin, than after contact with 7 and 30 days old deposit, 71 and 79 adults, respectively, and the least after contact with fresh deposit, 25 adults (Table 5). Consequently, the greatest reduction in *S. oryzae* progeny by deltamethrin was found on fresh deposit, 95%, and the least on 14 days old deposit, 76%. However, *R. dominica* and *T. castaneum* produced no progeny (PR, 100%) in wheat treated with deltamethrin, and the means of *S. cerealella* progeny were very low, ranging from 0.2-1.8 adults on deposits of all ages, which resulted in a high progeny reduction of 99%.

Table 5. Progeny counts (means, $\bar{x} \pm SE$) for *S. oryzae*, *R. dominica*, *T. castaneum* and *S. cerealella* parents exposed for 14 days to wheat grain treated with deltamethrin, and progeny reduction (PR, %)

Deposit age (days)	Progeny							
	S. oryzae ($\bar{x} \pm SE$)	PR (%)	*R. dominica* ($\bar{x} \pm SE$)	PR (%)	*T. castaneum* ($\bar{x} \pm SE$)	PR (%)	*S. cerealella* ($\bar{x} \pm SE$)	PR (%)
0	24.8±8.7 C*b*	95.2	0.0±0.0 Ab	100	0.0±0.0 Ab	100	1.3±1.0 Ab	98.8
Control	520.5±48.2 a	-	154.8±21.1 a	-	5.5±1.0 a	-	108±65.5 a	-
7	71.3±22.5 Bb	87.3	0.0±0.0 Ab	100	0.0±0.0 Ab	100	1.8±1.0 Ab	98.7
Control	563.7±40.1 a	-	283±33.9 a	-	6±3.1 a	-	139.5±67.4 a	-
14	139.2±68.7 Ab	76.2	0.0±0.0 Ab	100	0.0±0.0 Ab	100	0.2±0.4 Ab	99.9
Control	584.2±33.0 a	-	237±31.6 a	-	12.8±1.5 a	-	129.5±24.2 a	-
30	79.3±45.1 Bb	85.4	0.0±0.0 Ab	100	0.0±0.0 Ab	100	0.8±1.5 Ab	99.4
Control	541.7±28.4 a	-	79.2±35.0 a	-	3.5±3.1 a	-	136.5±60.1 a	-

Means in columns per species marked by the same letter are not significantly different, Fisher's LSD test at $P > 0.05$.
*Uppercase - progeny compared for different age deposits
*Lowercase - progeny compared for each deposit age against the control

DISCUSSION

In our tests with laboratory populations of the stored-product insect pests *S. oryzae*, *R. dominica*, *T. castaneum* and *S. cerealella*, we found that deltamethrin efficacy increased with increasing duration of exposure, which is consistent with numerous other reports of insecticide effects on various stored-products species (Athanassiou et al., 2004; Kljajić & Perić, 2009; Andrić et al., 2014; Kavallieratos et al., 2015, 2017). After 2 days of exposure to deposits of all ages, deltamethrin caused only 0-10% mortality to the test coleopterans, and 23-30% mortality to *S. cerealella*, while the mortality of *S. oryzae*, *R. dominica*, *T. castaneum* and *S. cerealella* after 7 days of exposure was 90-50%, 39-44%, 18-64% and 60-20%, respectively. After 14 days of exposure, mortality of *S. oryzae* was 95-50%, *R. dominica* 97-100%r, *T. castaneum* 99-100%, while *S. cerealella* mortality was 100%. Synthetic pyrethroid insecticide products characteristically cause initial knock-down effect or incapacitation of adults of these species due to exposure to treated grains or other surfaces. This knock-down response to insecticide exposure is commonly associated with insects lying on their backs and different degrees of movement (Arthur, 2018). Data from many recent studies have shown that adults of stored-product insects may recover from that knock-down effect when removed from the surface treated with deltamethrin and placed on an untreated surface. Therefore, delayed effects are highly desirable in these cases (Kavallieratos et al., 2015, 2016, 2017). Considering all deposit ages, we observed a trend of these insecticides mostly increasing their efficacy after 7 days of insect recovery, i.e. causing a delayed effect, especially after briefer periods of insect exposure, which is consistent with earlier data on pyrethroid residual efficacy, e.g. cypermethrin and deltamethrin on concrete surface (Andrić et al., 2014; Kavallieratos et al., 2016). In our present study, the highest delayed mortality was revealed for *S. oryzae* after 2 day exposure to fresh deposit of deltamethrin, causing adult mortality increase after recovery from 0.7% to 37%, while there was no significant difference in mortality before and after recovery following 7 and 14 days of exposure. However, *R. dominica* and *T. castaneum* showed some 2-9 times higher adult mortality on untreated substrate after the 7 days recovery period than after 7 days of exposure to deposits of any age.

Our research showed that *S. oryzae* was the least susceptible to deltametrin of all tested stored-product insect species. This is consistent with data from similar previous studies, such as Nicholas et al. (1991) indicating that deltamethrin applied at 0.125 and 0.375 ppm + 2.5 ppm piperonyl butoxide on wheat grain during 6 months caused 100% mortality of *R. dominica*, while the mortality of *S. oryzae* was 12%. Arthur (1994) concluded that deltamethrin residues of 0.5, 0.75 or 1.0 ppm treatments of wheat provided 100% control of *R. dominica* for at least 10 months, while an application rate of at least 1.0 ppm was necessary to give an equivalent control of *S. oryzae*. Daglish (1998) concluded that synergised deltamethrin (0.25 mg/kg) can provide complete control of *R. dominica* and *T. castaneum*, but not of *S. oryzae,* throughout a storage period of 30 weeks. Testing the residual efficacy of synergized deltamethrin (0.25 mg AI/kg of wheat grain) on a laboratory population of granary weevil *Sitophilus granarius* (L.), Kljajić and Perić (2009) found 40% mortality of adults exposed for 2 days to a deposit that was 2 days old, and around 93% in those exposed for 7 days, which indicates that deltametrin is less effective against *S. oryzae* since

our present results show 0.7% adult mortality after 2 days of exposure, and 54% after 7 days of exposure to 7 days old deposit. Also, based on a comparison of LC_{99} values, Paudyal et al. (2016) tested deltamethrin contact toxicity on glass surface and found that *S. oryzae* was twice as tolerant to deltamethrin as *T. castaneum*.

Data about the residual effects of insecticide treatments of *S. cerealella* in wheat grain are scarce. Pražić Golić et al. (2017) tested the residual efficacy of cypermethrin (1.6 AI mg/kg of wheat grain) and found 100% mortality of *S. cerealella* imagoes after as early as 7 days of exposure to 30 days old deposit, while the same effect was achieved in our present study after 14 days of exposure, and progeny reduction from parents exposed to deposits of all ages (0-30 days) was high (≥ 99%).

R. dominica and *T. castaneum* produced no progeny (PR, 100%) in wheat grain containing deltamethrin deposits of all tested ages, while the progeny of *S. cerealella* was low (PR, 99%). However, the production of *S. oryzae* progeny was highest after parents contacted with 14 days old deposit of deltamethrin (PR, 76%), and lowest after their contact with fresh deposit (PR, 95%). In tests with non-synergised deltamethrin (0.25 ppm), Athanassiou et al. (2004) found 90% mortality of *S. oryzae* exposed to 30 days old deposit in wheat grain with around 15 times lower progeny counts than in our tests, which may be attributed to differences in population susceptibility to insecticides. Arthur (1994, 1999) reported that *S. oryzae* had a greater capability for progeny production in pyrethroid-treated wheat than *R. dominica* and *T. castaneum*. That was attributed to the short developmental period of *S. oryzae*, which allows any survivors of exposure to rapidly produce progeny and build up their population level. Any explanation of this should also take into consideration that sublethal doses of contact insecticides may stimulate progeny production of stored-product insect pests, as confirmed by Kljajić and Perić (2010) for *S. granaries,* or induce hormesis, which Guedes et al. (2010) and Velez et al. (2018) revealed in their studies with maize weevils *Sitophilus zeamais* (Motch.). Also, when insects of stored-product pest species from populations with altered susceptibility to insecticides get in contact with deltamethrin-treated wheat grain, its efficacy may be reduced or missing altogether, which has been noted in various studies worldwide (Collins & Wilson, 1987; Daglish, 1998; Ribeiro et al, 2003; Chen & Chen, 2013) and in Serbia (Kljajić & Perić, 2007, 2009).

In conclusion, the results of our study showed that the synergised pyrethroid deltamethrin applied at 0.25 mg/kg has high initial and residual efficacy against several stored-product insects in wheat grain, namely the coleopterans *S. oryzae, R. dominica* and *T. castaneum*, and the lepidopteran *S. cerealella*, while a higher dose is required for successful residual control of *S. oryzae*. The findings contribute significantly to the existing IPM programmes for safety protection of stored plant products.

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Rezidualna efikasnost deltametrina u suzbijanju *Sitophilus oryzae* (L.), *Rhyzopertha dominica* (F.), *Tribolium castaneum* (Herbst) i *Sitotroga cerealella* (Oliv.) u tretiranoj pšenici

REZIME

Ispitivana je rezidualna efikasnost deltametrina, EC formulacije sa 25 g/L a.s. + 225 g/L PBO (piperonil butoksid) u suzbijanju laboratorijskih populacija *Sitophilus oryzae*, *Rhyzopertha dominica*, *Tribolium castaneum* i *Sitotroga cerealella* nanošenjem vodenog rastvora insekticida (0.25 mg a.s./kg) na pšenicu u zrnu u laboratorijskim uslovima (25±1°C i 60±5 % r.v.v). Smrtnost adulta na depozitima starosti 0, 7, 14 i 30 dana je utvrđivana posle 2, 7 i 14 dana izlaganja u tretiranoj pšenici i 7 dana oporavka adulta (izuzev *S. cerealella*) u netretiraoj pšenici. Takođe je utvrđivana i produkcija potomstva izlaganih roditelja (PR, %). Posle 2 dana izlaganja bez obzira na starost depozita, deltametrin je prouzrokovao 0-10% smrtnosti tvrdokrilaca (posle oporavka do 37%) i 23-30% smrtnosti *S. cerealella*, dok je posle 14 dana izlaganja smrtnost *S. oryzae* pre i posle perioda oporavka bila 95-50%, *R. dominica* 97-100%, *T. castaneum* 99-100% i *S. cerealella* 100%. Najveći broj potomaka *S. oryzae* je utvrđen posle kontakta roditelja sa 14 dana starim depozitom deltametrina (PR, 76%), a najmanji posle kontakta sa svežim depozitom (PR, 95%), dok u tretiranoj pšenici, bez obzira na starost depozita, nije bilo potomaka *R. dominica* i *T. castaneum* (PR, 100%), dok je kod *S. cerealella* zabeležen mali broj potomaka (PR, 99%). Na osnovu dobijenih rezultata može se zaključiti da je sinergizovani deltametrin primenjen u količini 0,25 mg/kg pšenice visoko efektivan u suzbijanju skladišnih insekata, dok je za dužu zaštitu pšenice od *S. oryzae* potrebno primeniti veću dozu ovog insekticida.

Ključne reči: Insekticidi; Rezidualna efikasnost; Potomstvo; Štetni insekti; Pšenica