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Control of *Sitophilus zeamais* Mots., 1958 and *Sitophilus oryzae* (L., 1763) weevils (Coleoptera, Curculionidae) in stored rice grain (*Oryza sativa* l.) with insecticide pirimiphos methyl (Actellic 500 CE)

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Abstract

The protection of stored rice grains with the insecticide pirimiphos methyl was studied. The experiment was performed by the Plant Protection Laboratory of Ponta Grossa State University, PR, in the 2005/06 season. The treatments tested were: pirimiphos-methyl (Actellic 500 CE), at 4, 8, 12, 16 and 32 mL c.p./ton (commercial product); bifenthrin (Prostore 24 CE), at 16 mL c.p./ton; deltamethrin (K-obiol 25 CE), at 20 mL c.p./ton) and Control. Each plot consisted of a glass bottle filled in with rice grains treated with insecticides. Each plot was infested with 20 non-sexed adult *Sitophilus zeamais* and *S. Oryzae* weevils in separate tests. The infestations were done monthly and up to 240 days after treatment applications (DAT). The efficacy was evaluated 15 and 45 days after infestation in adults and immature forms, respectively. The organophosphate insecticide pirimiphos methyl, at 8 mL c.p./ton, was efficient up to 180 and 60 DAT for adults and up to 120 and 150 DAT for immature forms of *S. zeamais* and *S. oryzae*, respectively. The rates ranged from 12 to 32 mL c.p./ton with pirimiphos-methyl controlling both adult and young forms of the two weevil species in 82.4 to 100 % with 240 DAT. Immature forms of *S. zeamais* and *S. oryzae* were controlled up to 120 DAT at a rate of 12 c.p./ton in 80.8 and 82.4 %, and up to 240 DAT for rates of 16 to 32 mL c.p./ton, from 90.3 to 98.8 %, respectively. The pyrethroids bifenthrin (16 mL c.p./ton) and deltamethrin (20 mL c.p./ton) standards were not efficient to control these weevils. Both species of weevils presented similar susceptibility to insecticides.

Key words: Stored grain, protectant, chemical control, stored grain pest and organophosphate insecticide.

Introduction

Stored products are attacked by many pests that causes to the products serious damages. It is necessary to render proper importance to such pests, since cares and expenditures for pest control in field crops would be of no use, if the cropped product was attacked and destructed when stored. According to the Food and Agriculture Organization [FAO], the worldwide losses in warehouses reach figures of 10 %; specifically in Brazil, these losses are around 20 % since the storage conditions in the

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countryside are poor (Gallo et al., 2002).

Insects found out in stored products can be classified, according their food habit, into three groups, namely, primary pest, divided in internal or external, secondary pests and associated pests. The primary ones are the most important, because these insects have well-developed jaws with which they break the protective films and penetrate the grains.

Among the primary stored rice pests, we can stand out the *Sitophilus zeamais* Mots., 1865 e *S. oryzae* (L., 1763) weevils (Coleoptera, Curculionidae). The maize weevil *S. zeamais* can be found in the entire world's warm and tropical areas; it is the primary pest for maize, wheat, rice and sorghum. It can also grow in processed cereals, such as pasta, cassava, etc. (Pacheco and De Paula, 1995). The adults for this species are little bugs with 3-4 mm length, dark brown color, with four reddish stains on the elytra, visible after emergency. The larvae are light yellow in color with a darker head, and the pupas show a milky white color. Adult females lay in average 282.2 eggs in 104.3 day of oviposition; and they can live in average 140.5 days. The egg incubation ranges from 3 to 6 days and the cycle from egg to adult is approximately 34 days (Gallo et al., 2002).

The rice weevil *Sitophilus oryzae* is a cosmopolite insect, supposedly originated in India and spread all around the world through infested and ship-transported grains (Metcalf and Flint, 1962). Its morphological and biological characteristics are similar to the *S. zeamais* species (Gallo et al., 2002).

They are considered as the main stored rice pests in Brazil due to the fact that they present a high biotic potential, cross-infestation, are a deep pest, have a high number of hosts and also due to the fact that both larvae and adults cause damage (Gallo et al., 2002). Puzzi (1986) additionally cites other damages caused by weevils in stored grains, such as: formation of heat cavities in the grain mass, pollution of the grain mass, dissemination of molds in the grain mass and depreciation of the product. Pinto Jr. et al. (1997), reports that, due to the poor storage status of grains in Brazil, the losses caused by insects range from 0.2 to 30 % of the grain production. Santos (1993) goes further, reporting that losses caused by insects, either quantitative or qualitative, reach around 50 % of the production.

To control stored grain pests, it has been used insecticides both preventively and curatively. After cleaning, drying and expurgating, the grains must be stored in clean and hygienized warehouses for a variable period of time, depending on the consumption and concern of each warehouse. In storage periods over 60 days, it can be performed the preventive treatment of grains in order to protect against pests. This treatment consists in applying liquid insecticides on the grains, in the conveyer belt while carrying the warehouse, and homogenize them in such a way that the entire grain gets insecticide. This insecticide will protect the grain against the attack of pests trying to fix themselves into the grain mass. The insecticides Pirimiphos methyl, Deltamethrin e Bifenthrin alone or mixed are recommended according to the infesting species-pest.

Several publications show the efficacy of insecticides in the control particularly of coleopteran pests in stored rice, with evidence of high efficacy of the organophosphorated pirimiphos methyl. Zakladnoi (2004) discuss losses and deteriorations caused by *Sitophilus oryzae* in the stored grain, advantages of using contact insecticides replacing the traditional fumigation and the development of a pneumatic sprayer specialized for application of insecticides bifenthrin, pirimiphos methyl, malation, fenitrotion, deltamethrin and cypermethrin; Kabir (2002) reports the performance of the insecticides pirimiphos methyl, deltamethrin, cypermethrin and malation in the protection of sacked grain, against *S. oryzae*; Kogteva and Zakladnoi (2001) studied the effect of the mixture of the insecticide juvenoid methoprene with pirimiphos methyl e malation for the pests *S. oryzae*, *Rhyzopertha dominica* and *Tribolium* spp; Thakur (1998) studied the action of the insecticides bromophos, etrimphos, malation and pirimiphos methyl;

Munoz (1994), the action of insecticides phoxim, methacrifos, fenitrotion, deltamethrin, monocrotophos, and Porntip and Chuwit (1991) reported the existence of 72 pest species with economic importance in Thailand, being *Sitotroga cerealella*, *R. dominica* e *Sitophilus* spp. as the most important ones in paddy rice; *Sitophilus* spp., *Tribolium castaneum* and *Corcyra cephalonica* in processed rice; *Sitophilus* spp. in maize and sorghum; *Araecerus fasciculatus*, *R. dominica* e *Lasioderma serricorne* in cassava and *Callosobruchus maculatus* and *C. Chinensis* in bean, soy and other leguminous. The more used insecticides to protect stored products are pirimiphos methyl, chlorpyrifos methyl and methacrifos and, among fumigants, phosphine and methyl bromide; Bitran et al. (1991) report that the tested insecticides against *S. zeamais* in maize, against *S. oryzae* in rice and wheat, and *R. dominica* in wheat, pirimiphos methyl was the best treatment to protect maize against *S. zeamais*, followed by cypermethrin and phenitrothion. Pirimiphos methyl yielded the best control of *S. oryzae* in wheat and rice, while deltamethrin, cypermethrin and phenitrothion do not show any prolonged residual effect against these pests. However, deltamethrin was the best treatment for *R. dominica* in wheat.

As pirimiphos methyl has been an insecticide broadly employed to control stored grain pests in the last years, this may allow the appearance of foci of pest resistance to it in the commercially recommended doses. Thus, the objective of the present work was to reevaluate this insecticide, aiming to preserve the stored rice grains from the attack of *Sitophilus zeamais* and *S. oryzae*.

Material and methods

The experiment was developed in the Phytotechnical Laboratory of the School Farm “Capão da Onça” of the Ponta Grossa State University, Ponta Grossa, PR, during the period from April 2005 to January 2006. The grains of rice used were the Guarani variety, which did not presented any residues from former insecticide applications and had approximately 13 % of moist. Before using the grains, a fumigation with phosphine was performed, with the dose of 2.0 g a.i./m^3 for 120 h, to eliminate completely all biological forms of insects present. The application of insecticides was performed with a sprayer coupled to a air compressor, with constant work pressure of 1.5 kg/cm^2, using a broth volume of 4 mL for each 2.0 kg of grains (2.0 L/ton); the spraying is performed in plastic bags with dimensions of 40 x 50 cm. The grains were put in 5-liter paper bags and stored in a ventilated place under environmental conditions.

The residual activity study of insecticides on *S. zeamais* e *S. Oryzae* adults was performed taking a rice grain sample of approximately 100 grams, of each repetition (2.0 kg), which was placed in a 300-ml-volume glass bottle, with screened lid and infested with 20 non-sexed adults of each laboratory-bred weevil species, whose tests were conducted separately. Each bottle of grains represented a experimental plot. The infestations were made monthly and up to 240 days after the application. After 15 days of weevil infestation in the experimental plot, the number of living and dead insects was evaluated. After counting and removing the adult weevils, the grains were returned to the respective bottles and these were left in the breeding room until the emergency of F_1 generation adults, for a new counting of emerged insects, with the data being used to calculate the treatment efficacy on adult insects and insects in immature form.

Treatments used in the assay, active ingredient and commercial product doses/ton, ways of action, as well as concentrations and formulations, can be found in Table 1.

Data were submitted to analysis of variance by the F test and differences between the treatment’s averages were compared by the Tukey 5% test, after the data have been transformed into $\sqrt{X + 0,5}$. The efficacy % of the treatments was calculated by the Abbott’s formula.

Table 1. Treatments, doses, ways of action, concentrations, and formulations of the products used in the treatment of rice grains. Ponta Grossa - PR, 2005.

Treatment	Dose/ton[1]		Commercial Name	Chemical Group	Formulation
	g a.i.	mL c.p.			
1. Pirimiphos methyl 500 CE	2.0	4.0	Actellic 500 CE	Organo-phosphorated	CE[2]
2. Pirimiphos methyl 500 CE	4.0	8.0			
3. Pirimiphos methyl 500 CE	6.0	12.0			
4. Pirimiphos methyl 500 CE	8.0	16.0			
5. Pirimiphos methyl 500 CE	16.0	32.0			
6. Bifenthrin 25 CE[3]	0.4	16.0	Prostore 25 CE	Pyrethroid	CE
7. Deltamethrin 25 CE [(3)]	0.5	20.0	K-obiol 25 CE		
8. Control	-	-	-	-	-

[1] Grams of the active ingredient or milliliters of the commercial product per ton of rice grain; [2] Days after treatment; [3] Treatment efficiency % according to Abbott's formula; [4] Products used as standards; [5] Coefficient of variance for the transformed data.

Results and discussion

Results have shown that the dose of 4.0 mL c.p./ton (commercial product) of the insecticide pirimiphos methyl 500 CE (Actellic 500 CE) was not efficient in the control of *S. zeamais* e *S. oryzae* adults present in rice. On the other hand, the dose of 8.0 ml c.p./ton of pirimiphos methyl 500 CE controlled weevils up to 180 and 60 days after application (DAA), respectively. The average commercial dose of 12.0 mL c.p./ton (6,0 ppm) and the doses of 16.0 and 32.0 mL c.p./ton of pirimiphos methyl 500 CE were efficient for the whole experimental period of 240 DAA, providing control of weevils in the interval of 82.4 to 100 % (Tables 2 and 4). Pyrethroids bifenthrin 25 CE, in the dose of 16.0 mL c.p./ton and deltamethrin 25 CE (20,0 mL c.p./ton), used as comparison standards, have not shown minimum efficacy of control of *S. zeamais* e S. *oryzae* adults during the whole experimental period. The efficient doses of pirimiphos methyl 500 CE differed from the standards in all the evaluations, showing superiority of this insecticide as protector of the rice grain from the attack of these two pest species, which, considering the average commercial dose of 6.0 ppm (12.0 mL c.p./ton), have shown equally susceptible to the insecticide.

The immature forms of *S. zeamais* and *S. oryzae* of F_1 generation were not efficiently controlled in rice grains with the dose of 4.0 mL c.p./ton of pirimiphos methyl 500 CE. On the other hand, the dose of 8.0 mL c.p./ton of the insecticide was efficient for the two species up to 120 and 150 DAA, respectively (Tables 3 and 5). The average commercial dose of pirimiphos methyl 500 CE, of 12.0 mL c.p./ton (6,0 ppm), kept the population of the two species of weevil under the damage level for 210 DAA, with mortalities from 80.8 to 82.4 %, respectively. Doses of 16.0 and 32.0 mL c.p./ton were efficient up to 240 DAA, with levels of efficiency of 81.8 to 98,8 % for the two species. The bifenthrin 25 CE standard was efficient for *S. oryzae* up to 30 DAA and inefficient for *S. zeamais*; thus, deltamethrin 25 CE was inefficient for the two species during the whole experimental period. Pirimiphos methyl 500 CE has showed more efficient than the standards for the control of young forms of this two weevil species. No susceptibility difference of *S. zeamais* e *S. oryzae* was noted with the average commercial dose of 12.0 mL c.p./ton of pirimiphos methyl 500 CE.

These results prove that stored rice pests *Sitophilus zeamais* and *S. oryzae* can be efficiently controlled, in all their development phases, with the residual insecticide pirimiphos methyl 500 CE (Actellic 500 CE), in doses from 8.0 mL c.p./ton of grains (4.0 ppm), according the period of protection desired to be given to grains.

Table 2. Adults of *Sitophilus zeamais* sieved from rice grains after 15 days of infestation and long-term treatment efficiency % (average of 4 repetitions) (Adult control). Ponta Grossa. PR. 2005.

Treatment	Dose/ton[1] g a.i.	Dose/ton[1] mL c.p.	1 DAA[2] Mean	1 DAA[2] %EF[3]	30 DAA Mean	30 DAA % EF	60 DAA Mean	60 DAA % EF	90 DAA Mean	90 DAA % EF	120 DAA Mean	120 DAA % EF
1. Pirimiphos methyl 500CE	2.0	4.0	2.5 b	86.1	5.5 d	65.6	7.5 b	58.3	15.3 a	11.6	10.5 b	44.7
2. Pirimiphos methyl 500CE	4.0	8.0	0.0 c	100.0	0.0 e	100.0	2.0 c	88.9	7.5 bc	56.5	2.8 d	85.5
3. Pirimiphos methyl 500CE	6.0	12.0	0.0 c	100.0	0.0 e	100.0	0.3 d	98.6	5.5 c	68.1	0.0 e	100.0
4. Pirimiphos methyl 500CE	8.0	16.0	0.0 c	100.0	0.0 e	100.0	0.0 d	100.0	0.8 d	95.7	0.0 e	100.0
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 c	100.0	0.0 e	100.0	0.0 d	100.0	0.0 d	100.0	0.0 e	100.0
6. Bifenthrin 25 CE[4]	0.4	16.0	3.8 b	79.2	8.8 c	45.3	7.5 b	58.3	10.3 b	40.6	7.3 c	61.8
7. Deltamethrin 25 CE[4]	0.5	20.0	14.8 a	18.1	14.8 b	7.8	9.5 b	47.2	10.3 b	40.6	16.5 a	13.2
8. Control	-	-	18.0 a	-	16.0 a	-	18.0 a	-	17.3 a	-	19.0 a	-
C.V. %[5]	-	-	16.36		3.16		9.20		8.41		7.48	

Treatment	Dose/ton[1] g a.i.	Dose/ton[1] mL c.p.	150 DAA Mean	150 DAA %EF	180 DAA Mean	180 DAA % EF	210 DAA Mean	210 DAA % EF	240 DAA Mean	240 DAA % EF
1. Pirimiphos methyl 500CE	2.0	4.0	6.3 c	65.3	5.0 b	66.1	6.0 b	65.7	12.8 ab	31.1
2. Pirimiphos methyl 500CE	4.0	8.0	2.8 d	84.7	1.8 bc	88.1	4.0 bc	77.1	8.8 b	52.7
3. Pirimiphos methyl 500CE	6.0	12.0	0.0 e	100.0	0.0 c	100.0	2.0 c	88.6	2.8 c	85.1
4. Pirimiphos methyl 500CE	8.0	16.0	0.0 e	100.0	0.0 d	100.0	0.0 d	100.0	1.3 c	93.2
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 e	100.0	0.0 d	100.0	0.0 d	100.0	1.3 c	93.2
6. Bifenthrin 25 CE	0.4	16.0	6.8 c	62.5	4.5 b	69.5	5.5 b	68.6	12.5 ab	32.4
7. Deltamethrin 25 CE	0.5	20.0	10.5 b	41.7	5.8 b	61.0	6.5 b	62.9	12.8 ab	31.1
8. Control	-	-	18.0 a	-	14.8 a	-	17.5 a	-	18.5 a	-
C.V. %	-	-	11.16		11.40		10.93		11.90	

Means followed by the same letter in the column do not differ statistically between each other. Tukey 5 %.
[1] Grams of the active ingredient or milliliters of the commercial product per rice grain ton; [2] Days after application; [3] Treatment efficiency % according to Abbott's formula; [4] Products used as standards; [5] Coefficient of variance for the transformed data.

Table 3. Adults of *S. zeamais* F_1 generation sieved from rice grains and long-term treatment efficiency % (Average of 4 repetitions) (Immature form control). Ponta Grossa. PR. 2005.

Treatment	Dose/ton[1] g a.i.	Dose/ton[1] mL c.p.	1 DAA[2] Mean	1 DAA[2] %EF[3]	30 DAA Mean	30 DAA % EF	60 DAA Mean	60 DAA % EF	90 DAA Mean	90 DAA % EF	120 DAA Mean	120 DAA % EF
1. Pirimiphos methyl 500CE	2.0	4.0	5.5 c	77.1	3.0 cd	78.2	7.5 b	53.1	6.0 b	67.1	2.0 cd	83.0
2. Pirimiphos methyl 500CE	4.0	8.0	0.5 d	97.9	1.0 de	92.7	3.0 c	81.3	3.0 c	83.6	1.0 de	91.5
3. Pirimiphos methyl 500CE	6.0	12.0	0.0 d	100.0	0.5 e	96.4	1.8 c	89.1	0.3 d	98.6	0.0 e	100.0
4. Pirimiphos methyl 500CE	8.0	16.0	0.0 d	100.0	0.0 e	100.0	1.8 c	89.1	0.0 d	100.0	0.0 e	100.0
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 d	100.0	0.0 e	100.0	1.3 c	92.2	0.0 d	100.0	0.0 e	100.0
6. Bifenthrin 25 CE[4]	0.4	16.0	3.5 c	85.4	3.8 bc	72.7	8.0 b	50.0	7.8b	57.5	3.5 bc	70.2
7. Deltamethrin 25 CE[4]	0.5	20.0	11.0 b	54.2	7.3 b	47.3	11.5 ab	28.1	16.3 a	11.0	6.5 b	44.7
8. Control	-	-	24.0 a	-	13.8 a	-	16.0 a	-	18.3 a	-	11.8 a	-
C.V. %[5]	-	-	18.91		19.07		18.65		12.85		17.56	

Continue...

Table 3. Continue.

Treatment	Dose/ton[1] g a.i.	mL c.p.	150 DAA Mean	%EF	180 DAA Mean	% EF	210 DAA Mean	% EF	240 DAA Mean	% EF
1. Pirimiphos methyl 500CE	2.0	4.0	5.3 bc	67.2	5.3 bc	65.0	17.0 ab	31.3	39.5 a	15.1
2. Pirimiphos methyl 500CE	4.0	8.0	3.5 c	78.1	3.5 bcd	76.7	13.8 bc	44.4	34.8 a	25.3
3. Pirimiphos methyl 500CE	6.0	12.0	2.0 cd	87.5	2.0 cd	86.7	4.8 d	80.8	13.5 b	71.0
4. Pirimiphos methyl 500CE	8.0	16.0	0.0 e	100.0	0.0 e	100.0	2.5 de	89.9	4.5 c	90.3
5. Pirimiphos methyl 500CE	16.0	32.0	0.8 de	95.3	1.5 de	90.0	1.0 e	96.0	1.3 c	97.3
6. Bifenthrin 25 CE	0.4	16.0	5.3 bc	67.2	5.8 ab	61.7	10.0 c	59.6	39.3 a	15.6
7. Deltamethrin 25 CE	0.5	20.0	8.0 b	50.0	5.0 bc	66.7	13.0 bc	47.5	31.5 a	32.3
8. Control	-	-	16.0 a	-	15.0 a	-	24.8 a	-	46.5 a	-
C.V. %	-	-	16.11		14.89		12.39		11.66	

Means followed by the same letter in the column do not differ statistically between each other. Tukey 5 %.
[1] Grams of the active ingredient or milliliters of the commercial product per rice grain ton; [2] Days after treatment; [3] Treatment efficiency % according to Abbott's formula; [4] Products used as standards; [5] Coefficient of variance for the transformed data.

Table 4. Adults of *Sitophilus oryzae* sieved from rice grains after 15 days of infestation and long-term treatment efficiency % (Average of 4 repetitions) (Adult control). Ponta Grossa. PR. 2005.

Treatment	Dose/ton[1] g a.i.	mL c.p.	1 DAA[2] Mean	%EF[3]	30 DAA Mean	% EF	60 DAA Mean	% EF	90 DAA Mean	% EF	120 DAA Mean	% EF
1. Pirimiphos methyl 500CE	2.0	4.0	2.3 c	88.0	4.5 c	71.4	7.0 b	59.4	3.5 c	80.3	7.8 b	55.7
2. Pirimiphos methyl 500CE	4.0	8.0	0.0 d	100.0	0.0 d	100.0	2.0 c	88.4	7.5 b	57.7	5.3 bc	70.0
3. Pirimiphos methyl 500CE	6.0	12.0	0.0 d	100.0	0.0 d	100.0	0.3 d	98.6	3.8 c	78.9	3.3 cd	81.4
4. Pirimiphos methyl 500CE	8.0	16.0	0.0 d	100.0	0.0 d	100.0	0.0 d	100.0	0.8 d	95.8	1.8 d	90.0
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 d	100.0	0.0 b	100.0	0.0 d	100.0	0.0 d	100.0	0.0 e	100.0
6. Bifenthrin 25 CE[4]	0.4	16.0	3.5 c	81.3	9.0 b	42.9	7.5 b	56.5	10.5 b	40.8	8.3 b	52.9
7. Deltamethrin 25 CE[4]	0.5	20.0	13.5 b	28.0	14.3 a	9.5	9.5 b	44.9	10.8 b	39.4	7.5 b	57.1
8. Control	-	-	18.8 a	-	15.8 a	-	17.3 a	-	17.8 a	-	17.5 a	-
C.V. %[5]	-	-	10.24		6.49		12.25		10.65		13.39	

Treatment	Dose/ton[1] g a.i.	mL c.p.	150 DAA Mean	%EF	180 DAA Mean	% EF	210 DAA Mean	% EF	240 DAA Mean	% EF
1. Pirimiphos methyl 500CE	2.0	4.0	6.3 bc	64.8	9.5 bc	50.0	6.8 bc	62.0	11.5 b	37.8
2. Pirimiphos methyl 500CE	4.0	8.0	5.3 bc	70.4	5.8 cd	69.7	5.3 cd	70.4	6.8 c	63.5
3. Pirimiphos methyl 500CE	6.0	12.0	3.0 cd	83.1	2.8 de	85.5	2.5 de	85.9	3.3 d	82.4
4. Pirimiphos methyl 500CE	8.0	16.0	1.8 de	90.1	2.0 e	89.5	2.0 e	88.7	1.8 d	90.5
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 e	100.0	1.0 e	94.7	0.0 f	100.0	0.0 e	100.0
6. Bifenthrin 25 CE	0.4	16.0	6.5 b	63.4	11.3 b	40.8	10.3 b	42.3	13.5 b	27.0
7. Deltamethrin 25 CE	0.5	20.0	7.3 b	59.2	10.5 b	44.7	9.3 bc	47.9	14.0 ab	24.3
8. Control	-	-	17.8 a	-	19.0 a	-	17.8 a	-	18.5 a	-
C.V. %	-	-	13.78	12.62	13.35	8.65				

Means followed by the same letter in the column do not differ statistically between each other. Tukey 5 %.
[1] Grams of the active ingredient or milliliters of the commercial product per rice grain ton; [2] Days after application; [3] Treatment efficiency % according to Abbott's formula; [4] Products used as standards; [5] Coefficient of variance for the transformed data.

Table 5. Adults of *S. oryzae* F_1 generation sieved from rice grains and long-term treatment efficiency % (Average of 4 repetitions) (Immature form control). Ponta Grossa. PR. 2005.

Treatment	Dose/ton[1] g a.i.	mL c.p.	1 DAA[2] Mean	%EF[3]	30 DAA Mean	% EF	60 DAA Mean	% EF	90 DAA Mean	% EF	120 DAA Mean	% EF
1. Pirimiphos methyl 500CE	2.0	4.0	5.8 bc	78.9	4.3 c	77.3	8.0 bc	63.2	5.8 cd	72.9	5.3 b	65.0
2. Pirimiphos methyl 500CE	4.0	8.0	0.8 de	97.2	1.5 cd	92.0	3.0 cd	86.2	3.0 d	85.9	0.0 d	100.0
3. Pirimiphos methyl 500CE	6.0	12.0	0.0 e	100.0	0.3 d	98.7	2.0 d	90.8	0.3 e	98.8	0.0 d	100.0
4. Pirimiphos methyl 500CE	8.0	16.0	0.0 e	100.0	0.0 d	100.0	1.8 d	92.0	0.0 e	100.0	0.0 d	100.0
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 e	100.0	0.0 d	100.0	1.5 d	93.1	0.0 e	100.0	0.0 d	100.0
6. Bifenthrin 25 CE (4)	0.4	16.0	3.0 cd	89.0	3.5 c	81.3	7.8 bc	64.4	7.3 c	65.9	2.5 c	83.3
7. Deltamethrin 25 CE (4)	0.5	20.0	10.0 b	63.3	10.8 b	42.7	11.5 b	47.1	12.3 b	42.4	7.0 b	53.3
8. Control	-	-	27.3 a	-	18.8 a	-	21.8 a	-	21.3 a	-	15.0 a	-
C.V. % (5)	-	-	17.20		18.16		17.84		12.44		11.27	

Treatment	Dose/ton[1] g a.i.	mL c.p.	150 DAA Mean	%EF	180 DAA Mean	% EF	210 DAA Mean	% EF	240 DAA Mean	% EF
1. Pirimiphos methyl 500CE	2.0	4.0	7.3 b	66.3	6.8 bc	60.3	16.5 b	35.3	29.0 ab	31.8
2. Pirimiphos methyl 500CE	4.0	8.0	4.3 bc	80.2	4.5 bcd	73.5	9.8 c	61.8	24.3 bc	42.9
3. Pirimiphos methyl 500CE	6.0	12.0	2.8 c	87.2	3.3 cd	80.9	4.5 d	82.4	13.5 cd	68.2
4. Pirimiphos methyl 500CE	8.0	16.0	1.8 cd	91.9	2.0 d	88.2	4.3 d	83.3	7.8 d	81.8
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 d	100.0	0.0 e	100.0	2.0 d	92.2	0.5 e	98.8
6. Bifenthrin 25 CE	0.4	16.0	5.0 bc	76.7	8.8 b	48.5	11.5 bc	54.9	35.3 ab	17.1
7. Deltamethrin 25 CE	0.5	20.0	8.0 b	62.8	7.5 b	55.9	12.8 bc	50.0	31.3 ab	26.5
8. Control	-	-	21.5 a	-	17.0 a	-	25.5 a	-	42.5 a	-
C.V. %	-	-	16.41		14.46		11.96		12.30	

Means followed by the same letter in the column do not differ statistically between each other. Tukey 5 %.

[1] Grams of the active ingredient or milliliters of the commercial product per rice grain ton; [2] Days after application; [3] Treatment efficiency % according to Abbott's formula; [4] Products used as standards; [5] Coefficient of variance for the transformed data.

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