PS10-18 – 6193

Control of *Sitophilus zeamais* Mots., 1958 and *Sitophilus oryzae* (L., 1763) weevils (Coleoptera, Curculionidae) in stored wheat (*Triticum aestivum* L.) with insecticide pirimiphos methyl (Actellic 500 ce).

B. Alleoni[1,*], W. Ferreira[2]

Abstract

The protection of stored wheat grains with the insecticide pirimiphos methyl was studied. The experiment was conducted at the 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 f.p./ton (formulated product) (2, 4, 6, 8 and 16 ppm); bifenthrin (Prostore 25 CE), at 16 mL f.p./ton (0,4 ppm); deltamethrin (K-obiol 25 CE), at 20 mL f.p./ton) (0,5 ppm) and Control. Each plot consisted of a glass bottle filled in with wheat grains treated with insecticides. Plots were infested with 20 non-sexed adult *Sitophilus zeamais* and *S. oryzae* weevils in separate tests. The infestations were done monthly and until 240 days after treatment applications (DAT). The efficacy was evaluated 15 and 45 days after infestation for the adults and immature forms, respectively. The insecticide pirimiphos methyl (PM), at a rate of 4 mL f.p./ton, was efficient for adults of both weevils up to 60 DAT; while the rates of the insecticide, from 8 to 32 mL f.p./ton, were efficient up to 240 DAT for both species, controlling adults from 86.5 to 100 %. The young forms of insects were controlled up to 120 DAT by PM rates from 4 to 32 mL f.p./ton; up to 240 and 150 DAT, for *S. zeamais* and *S. oryzae*, respectively, by a rate of 8 mL f.p./ton, and during all the experimental period for the rates of 12 to 32 mL f.p./ton of the insecticide. The standard pyrethroid bifenthrin was efficient to the adult weevils up to 180 and 120 DAT, and up to 120 and 150 DAT to the young forms of *S. zeamais* and *S. oryzae*, respectively.

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

Introduction

The perspective for the national wheat culture in the agricultural year 2005/06 is to continue acting as a coadjutant in the supplying of national mills, with a production responding for nearly 50 % of the demand. The prices will also continue marked out by parity with the Argentinean wheat, very close to the minimum price. Meanwhile, the Brazilian milling industry stands out as one of four major world wheat importers.

Several actions have been taken in the last years in an attempt to reverse the importer's condition. It has been created the National Wheat Culture Revitalization Plan [Plano de

[1] Ponta Grossa State University (UEPG). Department of Plant Protection. Av. Carlos Cavalcanti, 4748. Post Code: 84030-900. Ponta Grossa, PR, Brazil. Fax number: (+55 – 042-3220-3072) - E-mail: balleoni@yahoo.com; [2] Technical Manager Professional Products. Syngenta Proteção de Cultivos Ltda. Av. das Nações Unidas, 18001, Post Code – 04795-900 - São Paulo, SP, Brazil. E-mail: washington.ferreira@syngenta.com

* Corresponding author.

Revitalização da Triticultura Nacional] at the turn of the millennium, utterly unfolded in Regional Plans, in which each producing State developed incentive mechanisms. There has been the Embrapa work on tropicalization of wheat, which is already sowed in the Center West and Bahia, in addition to successive annual corrections in the minimum price up to 2003/04, favoring not only the traditional producing states, but also those where there is a wish to stimulate wheat culture.

The world produces presently 612.5 million tons of cereals. The biggest producer is the European Union, with 127.8 million tons, followed by the countries China (93.0 million), India (72.0 million), United States of America (60.0 million), Russia (47.0 million), etc. Brazil produced 4.77 million tons of wheat grains in 2005 in an area cultivated of 2.33 million hectares, with an importation amount of 5.13 million tons in 2005. Paraná is the major national producer, with approximately 2.82 million tons, followed by Rio Grande do Sul, with 1.46 million, and Mato Grosso do Sul, with 158 thousand tons (Agrianual, 2006).

Several factors, such as Brazilian agricultural policy adopted presently relative to wheat culture, climatic and phytosanitary factors concur to deter producers in adopting the culture. Among the phytosanitary problems, the conservation of the stored wheat, have the warehouse pests as the main damage causers, highlighting mainly the *Sitophilus zeamais* Mots., 1865 and *S. oryzae* (L., 1763) weevils (Coleoptera, Curculionidae) (Gallo et al. 2002).

The maize weevil *S. zeamais* is found out 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 & 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 wheat pests in Brazil due to the fact that they present a high biotic potential and 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.

The efficacy of pirimiphos methyl in controlling coleopteran pests in stored wheat has been reported in a number of publications. Huang & Subramanyam (2005) reported damage caused by coleopteran insects in the range of 9 to 99 % in non-treated wheat grains and that doses from 4 to 8 ppm of pirimiphos methyl have reduced the damages to less than 1 %; El-Lakwah & Abdel-Latif (1998) showed that the *S. oryzae* population and its damage in wheat and maize have been significantly reduced during 12 months of storage due to the treatment with pirimiphos methyl; Daglish (1998) has tested the organophosphorated insecticides phenitrothion, chlorpiriphos methyl, pirimiphos methyl, juvenoid methoprene and the synergized pyrethroid deltamethrin + piperonil butoxide, alone or in mixtures, in the control of the pests *Rhyzopertha dominica* in maize and wheat and *S. oryzae* e *Tribolium castaneum* in stored wheat; Collins & Cook (1998) cited that the microencapsulated formulation of pirimiphos methyl was the more efficient for the control of *T. castaneum, Oryzaephilus surinamensis* and *S. granarius* in wheat, with etrimphos as the more efficient for *R. dominica*; Aldana et al. (1993) reported the efficacy of pirimiphos methyl, deltamethrin and phenitrothion, at 4,0; 0,37 and 4,0 mg/kg against *S. Oryzae* and *Sitotroga cerealella* in stored wheat; Chawla and Bindra (1976) cited the existence of eight species of grain pests, resistant to the malation and that from seven organophosphorated insecticides and two pyrethroids tested for the control of *Trogoderma granarium* and *Sitophilus* spp in wheat, the best result was obtained with pirimiphos methyl and phoxim; Bitran et al. (1991) report that, from the tested insecticides for *S. zeamais* in maize, for *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 fenitrothion. Pirimiphos methyl yielded the best control of *S. oryzae* in wheat and rice, while deltamethrin, cypermethrin and fenitrothion have not shown 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 wheat 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. It was used wheat grains from the cultivar Alcover, with no residues of former insecticides and with approximately 14 % of moist. Before using the grains, a fumigation with phosphine was performed, in 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 pulverization 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 wheat 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 wheat grains. Ponta Grossa - PR, 2005.

Treatment	Dose/ton[1] g a.i.	Dose/ton[1] mL c.p.	Commercial Name	Chemical Group	Formulation
1. Pirimiphos methyl 500 CE	2.0	4.0	Actellic 500 CE	Organo-phosphorated	CE
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[2]	0.4	16.0	Prostore 25 CE	Pyrethroid	CE
7. Deltamethrin 25 CE[2]	0.5	20.0	K-obiol 25 CE		
8. Control	-	-	-	-	-

[1] Grams of the active ingredient or milliliters of the commercial product per wheat grain ton.
[2] Products used as standards.

Results and discussion

It is noted by the results that the dose of 4.0 mL c.p./ton (commercial product) of the insecticide pirimiphos methyl 500 CE (Actellic 500 CE) was efficient in the control of *S. zeamais* e *S. oryzae* adults up to 60 days after application (DAA). The dose of 8.0 ml c.p./ton, as well as 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 levels superior to 86.5 % in the last evaluation (Tables 2 and 4). Pyrethroid bifenthrin (Prostore 25 CE) in the dose of 16.0 mL c.p./ton, used as a comparison standard, was efficient in the control of *S. zeamais* e *S. oryzae* up to 180 DAA and 120 DAA, respectively, with the also pyrethroid deltamethrin (K-obiol 25 CE) (20.0 mL c.p./ton) being inefficient during the whole experimental period. The efficient doses of pirimiphos methyl 500 CE differed from the standards after 90 DAA, showing superiority of this insecticide as protector of wheat grains from the attack of these two pest species, which, considering the average commercial dose of 6.0 ppm, have showed equally susceptible to the insecticide.

The immature forms of *S. zeamais* and *S. oryzae* of F_1 generation were controlled in wheat grains with the dose of 4.0 mL c.p./ton of pirimiphos

methyl 500 CE, up to 120 days after application (DAA). The dose of 8.0 mL c.p./ton of the insecticide was efficient for the two species up to 240 and 150 DAA, respectively. 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 the entire experimental period, as well as the doses of 16.0 and 32.0 mL c.p./ton, with levels of efficiency from 88.3 to 100 % of control at 240 DAA (Tables 3 and 5). The bifenthrin 25 CE standard was efficient for *S. zeamais* up to 120 DAA and up to 150 DAA for *S. oryzae*, while deltamethrin 25 CE (20.0 mL pc./ton) did not provide satisfactory control of the two pests during the whole experimental period. The efficient doses of pirimiphos methyl have differed from the bifenthrin 25 CE standard after 150 DAA, showing a superior residual of control of the young forms of these two weevil species. It has not been noted any difference of susceptibility of *S. zeamais* and *S. oryzae* to the average commercial dose of 12.0 mL c.p./ton of Actellic 500 CE.

These results prove that stored wheat pests *Sitophilus zeamais* and *S. oryzae* can be efficiently controlled, in all their development phases, with the residual insecticide pirimiphos methyl (Actellic 500 CE), in doses starting 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 wheat grains after 15 days of the infestation and long-term treatment efficiency % (mean of 4 repetitions) (Control of adults). 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	2.5 c	86.3	0.8 c	96.2	2.8 c	86.1	7.3 c	61.3	5.0 b	73.7
2. Pirimiphos methyl 500CE	4.0	8.0	0.5 cd	97.3	0.0 d	100.0	0.0 d	100.0	0.0 e	100.0	2.5 c	86.8
3. Pirimiphos methyl 500CE	6.0	12.0	0.3 cd	98.6	0.0 d	100.0	0.0 d	100.0	0.3 e	98.7	0.0 d	100.0
4. Pirimiphos methyl 500CE	8.0	16.0	0.3 cd	98.6	0.0 d	100.0	0.0 d	100.0	0.0 e	100.0	0.0 d	100.0
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 d	100.0	0.0 d	100.0	0.0 d	100.0	0.0 e	100.0	0.0 d	100.0
6. Bifenthrin 25 CE[4]	0.4	16.0	1.0 cd	94.5	0.0 d	100.0	0.5 d	97.5	5.0 d	73.3	2.8 c	85.5
7. Deltamethrin 25 CE[4]	0.5	20.0	12.0 b	34.2	11.3 b	42.3	11.5 b	41.8	14.0 b	25.3	6.3 b	67.1
8. Control	-	-	18.3 a	-	19.5 a	-	19.8 a	-	18.8 a	-	19.0 a	-
C.V. %[5]	-	-	18.18		7.03		7.95		8.63		11.43	

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	7.0 b	58.8	8.8 b	50.0	6.5 b	63.9	7.3 b	60.8
2. Pirimiphos methyl 500CE	4.0	8.0	3.0 c	82.4	0.0 d	100.0	1.5 c	91.7	2.5 c	86.5
3. Pirimiphos methyl 500CE	6.0	12.0	1.0 d	94.1	0.0 d	100.0	0.0 d	100.0	0.0 d	100.0
4. Pirimiphos methyl 500CE	8.0	16.0	0.0 d	100.0	0.0 d	100.0	0.0 d	100.0	0.0 d	100.0
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 d	100.0	0.0 d	100.0	0.0 d	100.0	0.0 d	100.0
6. Bifenthrin 25 CE	0.4	16.0	3.0 c	82.4	3.3 c	81.4	5.0 b	72.2	5.5 b	70.3
7. Deltamethrin 25 CE	0.5	20.0	6.5 b	61.8	7.5 b	57.1	7.8 b	56.9	7.0 b	62.2
8. Control	-	-	17.0 a	-	17.5 a	-	18.0 a	-	18.5 a	-
C.V. %	-	-	13.81		9.87		11.31		11.38	

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 wheat 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 wheat grains and long-term treatment efficiency % (mean of 4 repetitions) (Control of immature forms). 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	94.7	2.8 c	93.1	9.8 c	90.5	58.0 b	41.3	9.5 c	90.6
2. Pirimiphos methyl 500CE	4.0	8.0	0.5 cd	98.8	1.0 cd	97.5	5.5 cd	94.6	4.5 c	95.4	2.8 d	97.3
3. Pirimiphos methyl 500CE	6.0	12.0	0.0 d	100.0	0.0 d	100.0	2.0 de	98.0	1.5 c	98.5	0.0 e	100.0
4. Pirimiphos methyl 500CE	8.0	16.0	0.0 d	100.0	0.0 d	100.0	0.3 e	99.8	1.5 c	98.5	0.0 e	100.0
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 d	100.0	0.0 d	100.0	0.3 e	99.8	0.5 c	99.5	0.0 e	100.0
6. Bifenthrin 25 CE[4]	0.4	16.0	0.8 cd	98.2	0.3 d	99.4	1.8 de	98.3	7.0 c	92.9	1.3 de	98.8
7. Deltamethrin 25 CE[4]	0.5	20.0	12.0 b	71.6	24.0 b	40.0	56.8 b	44.5	65.8 b	33.4	50.0 b	50.4
8. Control	-	-	42.3 a	-	40.0 a	-	102.3 a	-	98.8 a	-	100.8 a	-
C.V. %[5]	-	-	16.36		17.28		18.06		18.59		13.86	

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	19.5 c	74.1	16.5 b	52.9	68.3 b	58.9	160.5 b	35.0
2. Pirimiphos methyl 500CE	4.0	8.0	8.8 d	88.4	5.8 c	83.6	29.0 c	82.5	34.3 d	86.1
3. Pirimiphos methyl 500CE	6.0	12.0	3.0 de	96.0	1.5 d	95.7	12.8 d	92.3	0.0 e	100.0
4. Pirimiphos methyl 500CE	8.0	16.0	0.0 e	100.0	0.3 d	99.3	0.0 e	100.0	0.0 e	100.0
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 e	100.0	0.0 d	100.0	0.0 e	100.0	0.0 e	100.0
6. Bifenthrin 25 CE	0.4	16.0	19.3 c	74.4	20.0 b	42.9	54.8 b	67.0	70.3 c	71.5
7. Deltamethrin 25 CE	0.5	20.0	40.8 b	45.8	25.0 ab	28.6	65.3 b	60.7	101.0 c	59.1
8. Control	-	-	75.3 a	-	35.0 a	-	166.0 a	-	246.8 a	-
C.V. %	-	-	14.05		13.21		10.96		11.05	

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 wheat 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 4. Adults of *Sitophilus oryzae* sieved from wheat grains after 15 days of infestation and long-term treatment efficiency % (mean of 4 repetitions) (Control of adults). 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	88.3	0.8 c	96.1	2.8 c	85.7	9.8 c	48.0	8.0 c	58.4
2. Pirimiphos methyl 500CE	4.0	8.0	0.5 d	97.4	0.0 c	100.0	0.0 d	100.0	0.0 e	100.0	0.8 e	96.1
3. Pirimiphos methyl 500CE	6.0	12.0	0.3 d	98.7	0.0 c	100.0	0.0 d	100.0	0.0	100.0	0.5 e	97.4
4. Pirimiphos methyl 500CE	8.0	16.0	0.3 d	98.7	0.0 c	100.0	0.0 d	100.0	0.0	100.0	0.0 e	100.0
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 d	100.0	0.0 c	100.0	0.0 d	100.0	0.0	100.0	0.0 e	100.0
6. Bifenthrin 25 CE[4]	0.4	16.0	1.0 cd	94.8	0.0 c	100.0	0.5 d	97.4	4.5	76.0	3.5 d	81.8
7. Deltamethrin 25 CE[4]	0.5	20.0	11.5 b	40.3	11.0 b	42.1	11.5 b	40.3	14.0	25.3	12.3 b	36.4
8. Control	-	-	19.3 a	-	19.0 a	-	19.3 a	-	18.8	-	19.3 a	-
C.V. %[5]	-	-	14.18		9.98		9.59		7.70		12.81	

Continue...

Table 4. Continue.

Treatment	Dose/ton[1] g a.i.	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	7.3 bc	59.7	5.0 b	72.2	4.5 c	73.5	5.5 c	71.1
2. Pirimiphos methyl 500CE	4.0	8.0	1.5 d	91.7	0.0 c	100.0	1.5 d	91.2	0.5 d	97.4
3. Pirimiphos methyl 500CE	6.0	12.0	0.8 d	95.8	0.0 c	100.0	0.0 e	100.0	0.8 d	96.1
4. Pirimiphos methyl 500CE	8.0	16.0	0.3d	98.6	0.0 c	100.0	0.5 de	97.1	0.0 d	100.0
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 d	100.0	0.0 c	100.0	0.0 e	100.0	0.0 d	100.0
6. Bifenthrin 25 CE	0.4	16.0	4.0 c	77.8	6.5 b	63.9	5.8 c	66.2	9.3 b	51.3
7. Deltamethrin 25 CE	0.5	20.0	8.0 b	55.6	15.0 a	16.6	9.3 b	45.6	12.0 b	36.8
8. Control	-	-	18.0 a	-	18.0 a	-	17.0 a	-	19.0 a	-
C.V. %	-	-	17.73		10.85		11.87		11.35	

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 wheat 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 wheat grains and long-term treatment efficiency % (mean of 4 repetitions) (Control of immature forms). Ponta Grossa. PR. 2005.

Treatment	Dose/ton[1] g a.i.	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	2.0 c	94.2	2.8 c	93.0	6.5 c	90.4	35.3 b	61.5	18.3 c	81.7
2. Pirimiphos methyl 500CE	4.0	8.0	0.3 c	99.3	0.8 d	98.1	2.5 cd	96.3	4.0 cd	95.6	1.0 d	99.0
3. Pirimiphos methyl 500CE	6.0	12.0	0.0 c	100.0	0.0 d	100.0	1.0 de	98.5	1.3 cd	98.6	0.0 d	100.0
4. Pirimiphos methyl 500CE	8.0	16.0	0.0 c	100.0	0.0 d	100.0	0.0 e	100.0	1.0 d	98.9	0.0d	100.0
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 c	100.0	0.0 d	100.0	0.0 e	100.0	0.3 d	99.7	0.0 d	100.0
6. Bifenthrin 25 CE[4]	0.4	16.0	0.8 c	97.8	0.5 d	98.7	1.0 de	98.5	7.8 c	91.5	1.3 d	98.7
7. Deltamethrin 25 CE[4]	0.5	20.0	8.3 b	75.9	18.0 b	54.1	21.3 b	68.5	53.8 b	41.3	45.5 b	54.4
8. Control	-	-	34.3 a	-	39.3 a	-	67.5 a	-	91.5 a	-	99.8 a	-
C.V. %[5]	-	-	20.43		13.06		15.12		18.10		14.48	

Treatment	Dose/ton[1] g a.i.	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	21.3 b	68.8	36.0 c	62.5	37.5 cd	61.5	34.3 d	75.0
2. Pirimiphos methyl 500CE	4.0	8.0	11.0 c	83.8	28.8 c	70.1	29.0 d	70.3	34.0 d	75.2
3. Pirimiphos methyl 500CE	6.0	12.0	6.8 c	90.1	11.8 d	87.8	13.8 e	85.9	16.0 e	88.3
4. Pirimiphos methyl 500CE	8.0	16.0	1.5 d	97.8	3.0 e	96.9	3.0 f	96.9	0.0 f	100.0
5. Pirimiphos methyl 500CE	16.0	32.0	0.0 d	100.0	0.0 e	100.0	0.0 f	100.0	0.0 f	100.0
6. Bifenthrin 25 CE	0.4	16.0	10.5 c	84.6	43.8 bc	54.4	49.3 bc	49.5	69.3 c	49.5
7. Deltamethrin 25 CE	0.5	20.0	25.8 b	62.1	60.8 b	36.7	59.3 b	39.2	110.0 b	19.9
8. Control	-	-	68.0 a	-	96.0 a	-	97.5 a	-	137.3 a	-
C.V. %	-	-	13.11		10.62		11.24		8.24	

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 wheat 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.

Acknowledgements

The authors would like to thank the Company Syngenta Proteção de Cultivos Ltda, for sponsoring this work.

References

Agrianual, 2006. Anuário da Agricultura Brasileira (The yearbook of Brazilian Agriculture). Trigo (Wheat). p. 483 - 492. Ed. por FNP Consultoria e Agro Informativos. São Paulo - SP, 2005.

Aldana, H., Pinto, R., Acuna, C., Cabezas, M., 1993. Comparison of six protectant insecticides in the control of *Sitophilus oryzae* (L.) and *Sitotroga cerealella* (Oliver) in stored wheat. Agronomia Colombiana 10, 144-150.

Bitran, E.A., Campos, T.B., Suplicy-Filho, N., Chiba, S., 1991. Avaliação da ação residual de alguns inseticidas na proteção de grãos de milho, trigo e arroz contra pragas de armazenamento (Evaluation of the residual efficacy of some insecticides in the protection of corn, wheat and rice grains against the stored products pest). Arquivos do Instituto Biológico São Paulo, 58, 43-50.

Chawla, R.P., Bindra, O.S., 1976. Laboratory screening of some safe insecticides as grain protectants. Pesticides (India) 10, 29-31.

Collins, D.A., Cook, D.A., 1998. Periods of protection provided by different formulations of pirimiphos-methyl and etrimfos, when admixed with wheat, against four susceptible storage beetle pests. Crop Protection 17, 521-528.

Daglish, G.J., 1998. Efficacy of six grain protectants applied alone or in combination against three species of Coleoptera. Journal of Stored Products Research 34, 263-268.

El-Lakwah, F.A., Abdel-Latif, A.M., 1998. Effect of surface treatment of grain bags with the botanical insecticide Neemazal-T and certain plant extracts on weight loss of stored wheat and maize grains due to infestation with *Sitophilus oryzae* (L.). Egyptian Journal of Agricultural Research 76, 1003-1015.

Gallo, D., Nakano, O., Silveira Neto, S., Carvalho, R.P.L., Baptista, G.C. de, Berti Filho, E., Parra, J.R.P., Zucchi, R.A., Alves, S.B., Vendramin, J.D., 2002. Entomologia Agrícola (Agricultural Entomology). Piracicaba, Fealq, 920 p.

Huang, F., Subramanyam, B., 2005. Management of five stored-product insects in wheat with pirimiphos-methyl and pirimiphos-methyl plus synergized pyrethrins. Pest Management Science 61, 356-362.

Metcalf, C.L., Flint, W.P., 1962. Destructive and useful insects: their habit and control. New York: London: Mc Graw Hill, 1087 p.

Pacheco, I.A., De Paula, D.C., 1995. Insetos de grãos armazenados, Identificação e biologia. (Stored grain insects, identification and biology). Campinas, Fundação Cargil, 228p.

Pinto Jr. A.R., Furiatti, R.S., Pereira, P.R.V.S., Lazzari, F.A., 1997. Avaliação de inseticidas no controle de *Sitophilus oryzae* (L.) (Col., Curculionidade) e *Rhyzopertha dominica* (F.) (Col., Bostrichidae) em arroz armazenado (Evaluation of insecticides in the control of *Sitophilus oryzae* (L.) (Col., Curculionidade) and *Rhyzopertha dominica* (F.) (Col., Bostrichidae) in stored rice). Anais da Sociedade Entomológica do Brasil 26, 285-290.

Puzzi, D., 1986. Abastecimento e armazenamento de grãos (Supplying and storing grains). São Paulo: Instituto Campineiro de Ensino Agrícola, 191p.

Santos, J.P., 1993. Perda de peso em grãos armazenados devido ao ataque de insetos (Weight loss in the stores grains due to the insects attack). Sete Lagoas: Embrapa, CNPMS, 6p. (Comunicado Técnico).