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Fenpyroximate for the control of *Tetranychus ogmophallos* and *Mononychellus planki* (Acari: Tetranychidae) in the peanut crop

Fenpyroximate para o controle de *Tetranychus ogmophallos* e de *Mononychellus planki* (Acari: Tetranychidae) na cultura do amendoim

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Abstract

The mites *Tetranychus ogmophallos* and *Mononychellus planki* are emerging pests in the peanut crop and have been causing great economic damage. The objective of this work was to evaluate the acaricide fenpyroximate in the control of *T. ogmophallos* and *M. planki* mites in the peanut crop. The experiments were carried out under laboratory and field conditions. In the laboratory, experiments were performed using peanut leaf discs placed on Petri dishes containing 2% agar-water. Adult *T. ogmophallos* or *M. planki* mites were transferred to each experimental unit and exposed to different concentrations of fenpyroximate using a Potter tower. After defining the most efficient concentrations, a field experiment was carried out in a peanut cultivation area. In this area, infestation with *T. ogmophallos* mites was carried out at 30 days after emergence of the peanut plants, while *M. planki* occurred naturally in the area. Then, fenpyroximate applications were performed with a pressurized costal sprayer. In the laboratory, fenpyroximate was efficient in controlling *T. ogmophallos* and *M. planki* at concentrations above 2.5 g a.i. 100 L^{-1}. Under field conditions, fenpyroximate was effective against these mites at all concentrations evaluated (10, 15, 20 and 30 g a.i. 100 L^{-1}).

Additional keywords: abamectin; *Arachis hypogaea*; emerging pest; peanut red mite; soybean green mite.

Resumo

Os ácaros *Tetranychus ogmophallos* e *Mononychellus planki* são pragas emergentes na cultura do amendoim e vêm causando grandes prejuízos econômicos. O objetivo do trabalho foi avaliar o acaricida fenpyroximate no controle dos ácaros *T. ogmophallos* e *M. planki* na cultura do amendoim. Os experimentos foram realizados em laboratório e campo. Em laboratório, foram realizados experimentos utilizando-se discos de folhas de amendoim colocados sobre placas de Petri contendo ágar-água a 2%. Ácaros adultos de *T. ogmophallos* ou *M. planki* foram transferidos para cada unidade experimental e expostos a diferentes concentrações de fenpyroximate utilizando torre de Potter. Após a definição das concentrações mais eficientes, foi realizado um experimento a campo em área de cultivo de amendoim. Nesta área, efetuou-se uma infestação com ácaros *T. ogmophallos* em 30 dias após a emergência das plantas de amendoim, enquanto que *M. planki* ocorreu naturalmente na área. Em seguida, realizaram-se as aplicações de fenpyroximate com pulverizador costal pressurizado. No laboratório, fenpyroximate foi eficiente no controle de *T. ogmophallos* e *M. planki* nas concentrações acima de 2,5 g i.a. 100 L^{-1}. Em condições de campo, fenpyroximate foi eficiente contra estes ácaros em todas as concentrações avaliadas (10, 15, 20 e 30 g i.a. 100 L^{-1}).

Palavras-chave adicionais: abamectina; ácaro-verde-da-soja; ácaro-vermelho-do-amendoim; *Arachis hypogaea*; praga emergente.

Introduction

Peanut (*Arachis hypogaea* L.) is an oilseed of great economic importance, with a worldwide production of more than 40 million tons of grains to meet both the food and the oleochemical market (Graciano et al., 2011). In the world ranking, Brazil is the 11th largest producer and the 2nd largest exporter of peanuts (USDA, 2016).

If the phytosanitary control is not carried out properly, several pests can reduce peanut yield (Lourenção et al., 2007). In recent years, peanut yield reductions caused by the mites *Tetranychus ogmophallos* Ferreira & Flechtmann (Acari: Tetranychidae) and *Mononychellus planki* (McGregor) (Acari: Tetranychidae) have been causing concern to producers. These mites are considered as emerging pests and can cause irreversible damage to peanuts, leading to the death of plants (Ferreira & Flechtmann, 1997; Lourenção et al., 2001).

Some hypotheses are suggested to explain the outbreaks of these mites occurring in recent years. These include the planting of new varieties that may favor mites, changes in planting systems and prolonged droughts during the summer ("Indian Summers").

The feeding of the mite *T. ogmophallos* results in a widespread silvering of leaves, followed by necrosis and fall (Lourenção et al., 2001). Peanut plants infested with *T. ogmophallos* in the early stages of development may die. If infestation occurs at 90 days after emergence, the yield reduction may reach up to 85% (Melville, 2015). On the other hand, the feeding of *M. planki* results in whitish spots on the leaves and loss of brightness, popularly known as "mottling". According to Moraes & Flechtmann (2008), *M. planki* has a high potential to cause damage to peanut.

Because they are emerging pests, the management of *T. ogmophallos* and *M. planki* is quite limited and there is little knowledge about these species in the peanut crop (Andrade et al., 2016). Fenpyroximate may be an alternative for the control of these mites, since it is an acaricide that acts to inhibit the NADH-ubiquinone reductase (complex I) of the respiratory chain (Ay & Kara, 2011). This acaricide is interesting for the management of pest mites, as studies demonstrate its efficiency in the control of *Tetranychus kanzawai* Kishida (Acari: Tetranychidae) (Kim & Paik, 1996) and *Tetranychus urticae* Koch (Acari: Tetranychidae) (Veronez et al. 2012). In addition to its efficiency in controlling some insect pests, fenpyroximate is selective to the mite *Neoseiulus womersleyi* (Schicha) (Acari: Phytoseiidae), the main predator of *T. kanzawai* (Kim & Paik, 1996).

In Brazil, fenpyroximate is recorded to control mites in crops of coffee, citrus, coconut, apple, papaya, strawberry, rose and tomato (Agrofit, 2016), and may become an alternative for the control of *T. ogmophallos* and *M. planki* in the peanut crop. Thus, the present study was carried out to evaluate the effect of fenpyroximate on *T. ogmophallos* and *M. planki* in the peanut crop.

Material and methods

Study site

The experiments were carried out in the Laboratory of Acarology and in an experimental area of the Department of Plant Health of the Paulista State University/Faculty of Agrarian and Veterinary Sciences (FCAV/UNESP), Jaboticabal-SP Campus. The experiments were conducted under the authorization of the Ministry of Agriculture, Livestock and Supply (MAPA), through the Temporary Special Registry of Agrochemicals and Allied Products (RET).

Breeding of mites

The breedings were established with *T. ogmophallos* and *M. planki* mites collected in plants of the peanut cv. Granoleico in the experimental area of FCAV/UNESP.

T. ogmophallos mites were breeded in a greenhouse on plants of the peanut cv. Granoleico planted in ten-liter pots. The plants used in the breeding were replaced weekly by healthy plants, to which the mites could migrate easily by just approximating them.

The breeding of *M. planki* was established on leaflets of plants of the peanut cv. Granoleico. The leaflets were placed in 14-cm-diameter Petri dishes containing a 1-cm foam layer, and wrapped with a hydrophilic cotton layer to maintain turgescence and to prevent mite escape. Periodically, the leaflets were replaced to ensure the food of the mites. The breeding was maintained in an air-conditioned room with a temperature of 25 ± 1 ºC, relative humidity of 60 ± 5% and photoperiod of 12 hours.

Laboratory experiments

The laboratory experiments were started in August 2013. For the experiments, 2.5-cm-diameter leaf discs were sectioned from leaflets of plants of the peanut cv. Granoleico with the aid of metal spouts. Then, the discs were surrounded with entomological glue barrier for containing the mites and placed in 14-cm-diameter Petri dishes containing 2% agar-water. Two similar experiments were performed to evaluate the action of the acaricide fenpyroximate on *T. ogmophallos* and *M. planki*. Each experiment was composed of seven treatments with eight replicates. The treatments were fenpyroximate (Ortus 50 SC®) at the concentrations of 1.0, 2.5, 5.0, 7.5 and 10.0 g a.i. 100 L^{-1}, abamectin (Kraft 36 EC®) at 0.54 g a.i. 100 L^{-1} and a control with deionized water. The abamectin concentration used in these experiments was based on studies carried out by Vásquez & Ceballos (2009). Each experimental unit consisted of a leaf disc. Ten adult females of *T. ogmophallos* or *M. planki* with approximately 15 days of age were transferred, with the aid of a single-hair brush, to each experimental unit.

The applications of the acaricides were carried out under a Potter tower at 27.58 kPa (4 lb pol^{-2}). Two militers of syrup were inserted into the Potter tower with a deposition of 1.56 mg cm^{-2}. After the applications, the leaf discs were taken to a climatized chamber with a temperature of 25 ± 1 ºC, relative humidity of 60 ± 5% and photoperiod of 12 hours. The evaluations for quantification of dead mites, live mites and mites retained in the glue barrier were performed at 1, 3 and 5 days after application (DAA). The mites that did not move after the touch of the single-hair brush were considered dead.

Field Experiment

For the installation of the field experiment, an area cultivated with the peanut cv. Granoleico, located at FCAV/UNESP (coordinates: 48°17'11.65" W latitude, 21°14'22.20" S longitude and altitude of 589 meters), was selected. 30 days prior to planting, in the soil preparation stage, correction fertilization was performed with 50 kg ha^{-1} P_2O_5, 50 kg ha^{-1} K_2O and 10 kg ha^{-1} N in the formula 4-20-20 (N-P-K). The spatial arrangement of sowing was 90 cm between rows and density of 15 seeds per meter. In this area, peanut sowing was performed on November 19, 2013. Twenty-four experimental plots were demarcated, each plot being 6 meters long by 4 meters wide.

The artificial infestation of the area with *T. ogmophallos* mites was performed thirty days after the germination of the plants, and leaves of peanut plants collected in the breeding area containing large numbers of mites were distributed. *M. planki* mite infestation occurred naturally in the area. A preliminary evaluation was performed three days before the application of the acaricides. After estimating the initial population density of mites, the plots were distributed among the treatments to maintain their uniformity.

The experiment was carried out in a randomized complete block design with 6 treatments and 4 replicates. Four treatments contained different concentrations of fenpyroximate (Ortus 50 SC®) (10, 15, 20 and 30 g a.i. 100 L^{-1}), in addition to a treatment with abamectin (Kraft 36 EC®) (4.32 g a.i. 100 L^{-1}) and a control without application. The acaricide concentrations used in the experiments were based on recommendations of the commercial products available for other crops. The concentrations of fenpyroximate and abamectin were based on the concentrations used for the control of the two-spotted spider mite in rose and cotton, respectively (Agrofit, 2013).

The applications of the acaricides were carried out on March 1, 2014. A CO_2 costal sprayer was used, equipped with a bar with 6 spray tips (type XR11002) spaced 50 cm apart and under a pressure of 241.32 kPa (35 lb pol^{-2}). The volume of syrup applied in the treatments was equivalent to 250 L ha^{-1}. Evaluations of tetranychid mite populations were performed at 7, 14 and 21 DAA. Two samples of 10 leaves (40 leaflets) were collected per plot, one sample being collected in the basal region and the other in the apical region of the plants.

Throughout the development of the crop, treatments with the fungicides epoxiconazole (Opera 50 SE®) and chlorothalonil (Bravonil 500 SC®) were carried out at 35, 45, 60 and 90 days after sowing. The fungicide concentrations used were 0.6 L. c.p. ha^{-1} epoxiconazole and 2.5 L c.p. ha^{-1} chlorothalonil. Except for fungicides and acaricides (treatments), no other pesticides were applied during the development of the crop.

Data Analysis

Mortality percentages in the laboratory experiments were calculated by the Abbott formula (1925) and transformed into Arc sine (Root (x/100)) to be submitted to analysis of variance (ANOVA), with means compared by Tukey test ($P<0.05$).

Mortality percentages in the field experiment were calculated by the Henderson & Tilton formula (1955). Subsequently, these percentages were transformed into Arc sine (Root (x/100)) to be submitted to analysis of variance (ANOVA), with means compared by Tukey test ($P<0.05$).

Results and discussion

Laboratory experiments

In these experiments, the acaricidal action of fenpyroximate on *T. ogmophallos* and *M. planki* was confirmed. In general, after the third day of application, there was a high mortality of *T. ogmophallos* and *M. planki* mites in all treatments (Table 1). Fenpyroximate at 1.0 g a.i. 100 L^{-1} at 1 DAA was the only treatment that did not reach mortality values above 50% on both mites (Table 1). In addition, fenpyroximate concentrations of 1.0 and 2.5 g a.i. 100 L^{-1} on the green mite *M. planki* showed lower values than the other treatments in the first two evaluations. Notwithstanding, the concentration of 1.0 g a.i. 100 L^{-1} was the only one that did not result in 100% mortality at 5 DAA on the green mite (Table 1).

Fenpyroximate concentrations above 5.0 g a.i. 100 L^{-1} and treatment with abamectin caused 100% mortality on *T. ogmophallos* at 1 DAA (Table 1). Also on *T. ogmophallos*, the concentration of 2.5 g a.i. 100 L^{-1} fenpyroximate caused 100% mortality at 3 DAA. On the other hand, treatment with 1.0 g a.i. 100 L^{-1} resulted in 89.3% mortality only at 5 DAA (Table 1). Similar results were verified by Ghaderi et al. (2012) and by Veronez et al. (2012). Ghaderi et al. (2012) studied the effect of fenpyroximate at the concentration of 1.9 g a.i. 100 L^{-1} on the two-spotted spider mite *T. urticae* under laboratory conditions. These authors also verified a high mortality of *T. urticae* with the mentioned concentration of the product. Likewise, Veronez et al. (2012) obtained mortality values superior to 83% with fenpyroximate at the concentration of 5 g a.i. 100 L^{-1} for *T. urticae* kept on common bean.

Field experiment

The preliminary evaluation performed 3 days prior to the applications showed no significant difference between the treatments in the initial number of mites, indicating uniformity in the experimental area in the *T. ogmophallos* ($F_{5,18}$ = 0.43; P = 0.82) and *M. planki* ($F_{5,18}$ = 0.53; P = 0.75) infestations. The mean number of mites per leaflet recorded in the preliminary evaluation was 3.05 ± 1.06 for *T. ogmophallos* and 3.1 ± 0.59 for *M. planki*.

Immediately after application of the products, *T. ogmophallos* and *M. planki* mite populations were reduced in all treatments, with the population level of both species remaining low until the end of the experiment (Table 2). All treatments with fenpyroximate showed similar control to the treatment with abamectin, except for *M. planki*. In this experiment, the mortality results obtained for abamectin in the control of the green mite were inferior to the other treatments in the first two evaluations (Table 2).

Table 1 - Percentage of mortality (mean ± SEM) of *Tetranychus ogmophallos* and *Mononychellus planki* at 1, 3 and 5 days after application (DAA) of fenpyroximate and abamectin under Potter spray tower.

Tetranychus ogmophallos				
Treatments	Concentration (g a.i. $100L^{-1}$)	1 DAA	3 DAA	5 DAA
Fenpyroximate	1.00	44.2 ± 7.79 b	72.7 ± 7.66 b	89.3 ± 6.04 b
Fenpyroximate	2.50	91.5 ± 4.68 a	100.0 ± 0.00 a	100.0 ± 0.00 a
Fenpyroximate	5.00	100.0 ± 0.00 a	100.0 ± 0.00 a	100.0 ± 0.00 a
Fenpyroximate	7.50	100.0 ± 0.00 a	100.0 ± 0.00 a	100.0 ± 0.00 a
Fenpyroximate	10.0	100.0 ± 0.00 a	100.0 ± 0.00 a	100.0 ± 0.00 a
Abamectina	0.54	100.0 ± 0.00 a	100.0 ± 0.00 a	100.0 ± 0.00 a
F test		29.5**	11.4**	3.9**
C.V. (%)		13.2	10.3	7.9
Mononychellus planki				
Treatments	Concentration (g a.i. $100L^{-1}$)	1 DAA	3 DAA	5 DAA
Fenpyroximate	1.00	33.2 ± 2.3 c	53.8 ± 1.6 c	65.3 ± 7.3 b
Fenpyroximate	2.50	54.5 ± 4.9 c	91.8 ± 5.5 b	100.0 ± 0.0 a
Fenpyroximate	5.00	78.6 ± 7.1 b	100.0 ± 0.0 a	100.0 ± 0.0 a
Fenpyroximate	7.50	93.5 ± 4.0 ab	100.0 ± 0.0 a	100.0 ± 0.0 a
Fenpyroximate	10.0	94.8 ± 4.1 ab	100.0 ± 0.0 a	100.0 ± 0.0 a
Abamectina	0.54	98.7 ± 2.4 a	100.0 ± 0.0 a	100.0 ± 0.0 a
F test		22.5**	54.5**	19.3**
C.V. (%)		18.8	8.1	9.9

The average mortalities obtained by the formula of Abbott (1925) presented are the original ones. Means followed by the same letter in the column do not differ according to Tukey test (P≥0.05). (**) significant at 1% probability. Original data transformed into Arc sine (Root (x / 100)). C.V.- Coefficient of Variation.

Table 2 - Percentage of mortality (mean ± SEM) of Tetranychus ogmophallos and Mononychellus planki at 7, 14 and 21 days after application (DAA) in field using a hand operated knapsack sprayer.

Tetranychus ogmophallos				
Treatments	Concentration (g a.i. $100L^{-1}$)	7 DAA	14 DAA	21 DAA
		Efic. (%)	Efic. (%)	Efic. (%)
Fenpyroximate	10	99.5 ± 1.7 a	100.0 ± 0.0 a	99.3 ± 2.3 a
Fenpyroximate	15	99.3 ± 2.4 a	100.0 ± 0.0 a	98.1 ± 4.1 a
Fenpyroximate	20	99.6 ± 1.8 a	69.0 ± 21.2 a	100.0 ± 0.0 a
Fenpyroximate	30	100.0 ± 0.0 a	75.0 ± 22.5 a	92.8 ± 8.1 a
Abamectina	4.32	100.0 ± 0.0 a	96.2 ± 5.7 a	100.0 ± 0.0 a
F test	-	0.7^{NS}	0.9^{NS}	0.6^{NS}
C.V. (%)	-	3.4	35.9	9.6
Mononychellus planki				
Treatments	Concentration (g a.i. $100L^{-1}$)	7 DAA	14 DAA	21 DAA
		Efic. (%)	Efic. (%)	Efic. (%)
Fenpyroximate	10	99.7 ± 1.6 a	98.7 ± 3.4 a	88.6 ± 10.6 a
Fenpyroximate	15	100.0 ± 0.0 a	100.0 ± 0.0 a	93.7 ± 7.5 a
Fenpyroximate	20	100.0 ± 0.0 a	95.0 ± 5.5 a	100.0 ± 0.0 a
Fenpyroximate	30	96.7 ± 5.3 a	100.0 ± 0.0 a	97.1 ± 5.0 a
Abamectina	4.32	72.0 ± 7.2 b	48.5 ± 7.8 b	90.5 ± 9.5 a
F test	-	9.9**	18.6**	0.31^{NS}
C.V. (%)	-	9.8	11.6	18.0

The average mortalities obtained by the Henderson & Tilton formula (1955) presented are the original ones. Means followed by the same letter in the column do not differ according to the Tukey test (p≥0.05); NS - not significant; (**) significant at 1% probability; Original data transformed into Arc sine (Root (x / 100)). C.V.- Coefficient of Variation.

The treatments with fenpyroximate did not differ significantly in relation to the number of mites for both species (Table 2). The control percentages of fenpyroximate for *T. ogmophallos* varied from 69.0 to 100.0%, while for *M. planki* the percentages ranged from 88.6 to 100% (Table 2). Similar results were found by Lima et al. (2013), who evaluated the effect of fenpyroximate on the coconut eriophyid mite *Aceria guerreronis* Keifer (Acari: Eriophyidae) and found that the 90% lethal concentration (90LC) of this product was 1.0138 g a.i. 100 L^{-1}. Another study, developed Kim et al. (2006), evaluated the residual and sublethal effect of fenpyroximate on the instantaneous growth rate of *T. urticae* under laboratory conditions, being noted that concentrations above 0.62 g a.i. 100 L^{-1} caused a high mortality of *T. urticae*.

The lowest concentration of fenpyroximate evaluated in the present study was sufficient to substantially reduce the mite populations. In general, one should choose the lowest possible concentration that is efficient over the target for the recommendation of field pesticides, since the negative impact on the environment and man will probably be lower (Américo et al., 2015). Moreover, the cost of the application also tends to decrease with the reduction in concentration. Frequently, the pesticide concentrations used in the field are much higher than the doses evaluated in the laboratory. This fact can be explained by the abiotic factors that may affect the efficiency of the product, such as rain, temperature, wind, among others (Guedes et al., 2015). Factors related to the application technology and the technical capacity of the professional responsible for the application can also considerably affect the efficiency of a pesticide under field conditions (Baesso et al., 2014).

The efficiency of fenpyroximate for the control of *T. ogmophallus* and *M. planki* mites was observed in the present study and the recognition of the potential use of a phytosanitary product for the control of pest mites is of great importance for the management thereof. As abamectin is a commonly used product for the control of pest mites, knowledge of the potential use of fenpyroximate is an advantage for the management of mites in the peanut crop, since the availability of different products with different modes of action is desirable for the management of the resistance evolution of pest mites (Franco et al., 2007).

Fenpyroximate is a molecule with toxicity to other phytophagous tetranychids and selective for certain predatory mites (Motoba et al., 2000; Desai et al., 2014). However, probably due to the diversity of predatory mites, the use of fenpyroximate is not always safe for this group of beneficial organisms such as *Phytoseiulus macropilis* (Banks) (Acari: Phytoseiidae) (Veronez et al., 2012), *Phytoseius plumifer* (Canestrini & Fanzago) (Acari: Phytoseiidae) (Hamedi et al., 2010) and *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae) (Nadimi et al., 2008).

Despite the potential of the acaricide fenpyroximate for the control of *T. ogmophallos* and *M. planki* mites in the peanut crop, a more detailed understanding on the toxicity of fenpyroximate to non-target organisms and the evaluation of product-resistance for pests present in this crop are critical before the recommendation and inclusion of fenpyroximate in IPM programs in the peanut crop.

Conclusions

Fenpyroximate is efficient in controlling the emerging pest mites *T. ogmophallos* and *M. planki* and may be a future option for the management of these arthropods in the peanut crop.

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