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Investigation note

Susceptibility of *Tetranychus urticae* Koch (Acari: Tetranychidae) to acaricides in roses

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Abstract

Tetranychus urticae Koch is the most important pest in rose crops, since it reduces the quality of production and increases management costs, consequently, acaricides have been widely used for its control. Therefore, susceptibility tests were performed to determine resistance in adult females of *T. urticae* to acaricides, abamectin, acequinocyl, chlorfenapyr, and extract of *Cinnamomum zeylanicum* J. Presl, on three populations of Tenancingo, State of Mexico and a susceptible line. The research was carried out in 2021 in the Department of Agricultural Parasitology, the leaf immersion technique was used for the evaluation of the pesticides (IRAC, 2009). The results demonstrated that the population that showed a tendency to develop resistance to the pesticide abamectin was L3 (Rancho Lizflor), while the populations L1 (Rancho Los Pilares) and L2 (Rancho Isoflor) had a tendency towards the acaricide acequinocyl, so it is recommended to reduce the applications and rotation of pesticides of different toxicological group. For the rest of the pesticides, no resistance was reported in any of the populations under study, for this reason they can be considered effective for the control of *T. urticae* in Tenancingo, State of Mexico.

Keywords:

Cinnamomum zeylanicum, two-spotted spider mite, resistance.

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The two-spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae) has a wide range of host plants and is a serious pest of several crops worldwide (Tehri, 2014). *T. urticae* feeds mainly on the content of mesophyll cells, where it significantly reduces stomatal resistance, photosynthetic and respiratory rate, as well as growth, flowering and productive potential of crops (Goff *et al*., 2014). Due to the economic impact produced by the attack of *T. urticae* in different agricultural production systems, the control strategy is based, almost exclusively, on the use of agrochemicals; however, their effectiveness is variable (Modarres, 2012).

One of the main problems faced by chemical control is the rapid ability to create resistant populations after a few generations (Pascual, 2014). Given this circumstance and due to the degree of importance of this pest, it is necessary to know the levels of tolerance to pesticides, therefore, it is necessary to carry out toxicological studies to determine dose-mortality response lines and with it, identify the most efficient products and the most appropriate management recommendations. Therefore, the objective of the present research was to determine the susceptibility of four acaricides in three populations of *T. urticae* from rose crops of Tenancingo, State of Mexico.

The present research was carried out in the Laboratory of Toxicology of the Department of Agricultural Parasitology of the Antonio Narro Autonomous Agrarian University, Saltillo, Coahuila. Three acaricides were evaluated: Abamectin (Agrimec® 1.8% EC), Acequinocyl (Kanemite® 15 SC), Chlorfenapyr (Sunfire® 2 SC) and *Cinnamomum zeylanicum* extract, (Cinnax®), six doses of each product with three repetitions of each were evaluated. The populations used were mites from the greenhouse of Agricultural Parasitology free of selection pressure by pesticides for 10 years as a susceptible reference population, and three field populations with different management of acaricides, from greenhouses of three farms in rose crops of Tenancingo, State of Mexico: Rancho Los Pilares (L1) with acaricide rotation, Rancho Isoflor (L2) with acaricide rotation and Rancho Lizflor (L3) without acaricide use.

The collection in the field was carried out manually, they were placed in plastic containers and coolers for transfer to the Laboratory of Toxicology, where they were placed in plants of *Phaseolus vulgaris* of the Lima variety for feeding, they were kept under controlled conditions at a temperature of 25 ±2 °C, relative humidity of 60 to 70% and 12 h of daily light provided with white light bulbs. For the preparation of the different concentrations, distilled water and the Bionex® product as a dispersant were used in a ratio of 1 ml: 1L water.

The range of concentrations used was 10 ppm to 10 000 ppm, except for abamectin which ranged from 0.01 ppm to 6 ppm due to the high specificity of the product. The leaf immersion technique was used for the evaluation of the acaricides. Mortality was evaluated at 24, 48 and 72 hours, as a criterion of death the mites were moved with a brush, those that did not respond to the action were considered dead. A completely randomized experimental design was used, with six treatments and a blank control which was water plus adherent, with three repetitions each and 30 to 45 adults for each repetition.

With the data obtained from the bioassays, a mortality correction was made with the formula proposed by Henderson and Tilton (1955). The results were subjected to a Probit Analysis (Finney, 1971), to obtain the curve of concentration-mortality response and thus determine the lethal concentration (LC50), by means of the statistical program SAS System for Windows 9.0.

Once the LC50 for the field lines and the susceptible line was obtained, the resistance ratio (RR) was determined by dividing the values of the LC50 of the field lines by the LC50 of the susceptible line (Georghiou, 1962). Table 1 shows the susceptibility to acaricides in the different populations of *T. urticae*. Under the influence of abamectin, the L1 population obtained an LC50 of 0.074 ppm, so it was more vulnerable since the susceptible line (SL) presented an LC50 of 0.29 ppm, while L2 and L3 showed an LC50 of 0.389 and 1.23 ppm, respectively. The results of the SL and L2 are consistent with those reported by Kwon *et al*. (2011), who indicated an LC50 of 0.24 ppm in a susceptible line exposed to abamectin; for their part, Choi *et al*. (2020) in two field lines, reported an LC50 of 0.065 and 0.56 ppm, similar in L1 and L3.

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Table 1. Determination of lethal concentration, fiducial limits, prediction equation, resistance ratio of acaricides applied to different populations of adult females of *T. urticae*.

Population	Acaricide	N	LC50	LFL-UFL	LC90	Prediction Eq.	R. R.
SL	Abamectin	223	0.29	0.11-0.78	3.52	Y= 0.6344+1.183	<0.0001
	Acequinocyl	239	35.56	17.82-60.56	268.76	Y=-2.263+1.459	<0.0001
	Chlorfenapyr	222	765.82	2.56-852	5245	Y=-2.0136+0.698	<0.0001
	Cinnamon	235	300.88	15.45-532	617	Y=-1.3736+0.554	<0.0001
L1	Abamectin	238	0.074	0.01-0.2	1.118	Y= 1.228+1.0914	0.25
	Acequinocyl	238	106.21	45.76-288.99	1884	Y=-2.0792+1.026	2.98
	Chlorfenapyr	251	706.97	48.47-3133	1159	Y=-1.136+0.3986	0.92
	Cinnamon	236	647.58	118.19-3177	5544	Y=-1.2285+0.437	2.15
L2	Abamectin	237	0.389	0.211-0.783	5.448	Y= 0.4576+1.119	1.3
	Acequinocyl	238	176	81.759-562.1	5520	Y=-1.923+0.8564	4.9
	Chlorfenapyr	227	699.88	44.429-6464	38193	Y=-2.099+0.7378	0.91
	Cinnamon	229	240.48	8.009-1135	5105	Y=-2.2997+0.966	0.79
L3	Abamectin	235	1.23	0.475-11.11	76.65	Y=-0.0644+0.714	4.2
	Acequinocyl	248	15.49	1.783-52.945	837.48	Y=-0.88+0.7395	1.03
	Chlorfenapyr	228	442.14	17.23-2963	27856	Y=-1.8842+0.712	1.02
	Cinnamon	235	213.43	0.165-1443	4061	Y=-2.333+1.0017	0.7

SL= susceptible line; L1= Rancho Los Pilares; L2= Rancho Isoflor; L3= Rancho Lizflor; N= number of adult females; LC= lethal concentration; LFL= lower fiducial limit; UFL= upper fiducial limit; R. R.= resistance ratio.

Regarding acequinocyl, the most susceptible population was L3, it obtained an LC50 of 15.49 ppm compared to SL, which needed 35.56 ppm, while L1 and L2 require 106.21 and 176 ppm, respectively. These results are similar to a field line exposed by Fotoukkiaii *et al*. (2019), where they mention an 18.09 ppm for *T. urticae*, similar to the L3 of this study. In the case of chlorfenapyr, the population that presented more susceptibility was L3 (442.14 ppm), followed by L2 and L1 (699.88 and 706.97 ppm), where SL (765.82 ppm) was the most tolerant to this acaricide, the above may be due to the fact that it has resistance genes.

However, these results resemble those mentioned by Ferreira *et al*. (2015) in a field population collected in crops of *Rosa* sp., in which they showed an LC50 of 735 ppm, close to L2 and L1. Regarding the *C. zeylanicum* extract, the most exposed population was L3 with an LC50 of 213.43 ppm, followed by L2 and SL (240.48 and 300.88 ppm), while in L1, 647.58 ppm are required, respectively, these results agree with Shahrima and Khalequzzaman (2015), where they reached a higher LC50 (510.53 ppm) when they applied *C. zeylanicum* oil to a laboratory line similar to L1 and SL.

Table 1 shows the results of the resistance ratio (R. R. 50) of the populations under study as a function of the susceptible line. This variable allows us to discriminate populations with resistance problems, those that have a factor of 10 times when comparing the field lines and the susceptible line are considered resistant. In this study, resistance to abamectin was found in L1 (0.25 times), L2 (1.3 times), while the L3 line (4.2 times), which coincided with Monteiro *et al*. (2015) in a field line exposed to abamectin for three consecutive years, where they reported a resistance that was 1.4 to 9.7 times. Therefore, L3 showed a tendency to develop resistance, so it is recommended to start with rotation of acaricide applications with different toxicological groups.

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For the acaricide acequinocyl, the resistance ratios in L1 (2.98 times), L2 (4.9 times) and L3 (1.03 times) for *T. urticae* coincided with Yorulmaz and Saritas (2014), who reported a field line with a resistance ratio of 4.8 times, while Choi *et al*. (2020) mention that, in a population exposed for more than six consecutive years, the ratio of resistance is greater than 1 798.6 times. It is appreciated that L1 and L2 tend to develop resistance, this because constant applications of this product are made according to the log corresponding to the management of these populations in the field.

Regarding the acaricide chlorfenapyr, Kumari *et al*. (2017), when applying this product to the same species, mentioned a resistance of 82.67 times, for their part, Ferreira *et al*. (2015) indicate a resistance of 2.2, 570 and 3 600 times respectively, these data differ from those found in this study, where for L1 (0.92 times), L2 (0.91 times) and L3 (1.02 times). Regarding *C. zeylanicum*, in this study there was no resistance, where the lowest value was for L3 (0.7) and the highest corresponded to L1 (2.15 times), these data are similar to those presented by Noha (2019), where applying cinnamon oil caused a high ratio of mortality in *T. urticae*, for their part, Roya *et al*. (2013) concluded that the essential oil affected age-specific fertility, life expectancy and pre-adult developmental period and decreased longevity of adult female mites.

Conclusions

According to the information generated in this research, L3 (Rancho Lizflor) was the one that presented a tendency to develop resistance to the acaricide abamectin, while the populations L1 (Rancho Los Pilares) and L2 (Rancho Isoflor) showed a tendency towards the acaricide acequinocyl, so it is recommended to decrease the applications and rotation of acaricides of different toxicological group for this area. For the rest of the acaricides, no resistance was reported in any of the populations in this study, for this reason they can be considered effective for the control of *T. urticae* in Tenancingo, State of Mexico.

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