

Resistance to Abamectin in Field Population of *Tetranychus urticae* Koch (Acari: Tetranychidae) Associated with Cut Rose from State of Mexico, Mexico

Authors: Díaz-Arias, Karen Vianey, Rodríguez-Maciel, J. Concepción, Lagunes-Tejeda, Ángel, Aguilar-Medel, Sotero, Tejeda-Reyes, Manuel Alejandro, et al.

Source: Florida Entomologist, 102(2) : 428-430

Published By: Florida Entomological Society

URL: <https://doi.org/10.1653/024.102.0222>

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Resistance to abamectin in field population of *Tetranychus urticae* Koch (Acari: Tetranychidae) associated with cut rose from state of Mexico, Mexico

Karen Vianey Díaz-Arias¹, J. Concepción Rodríguez-Maciél^{1,*}, Ángel Lagunes-Tejeda¹, Sotero Aguilar-Medel², Manuel Alejandro Tejeda-Reyes¹, and Gonzalo Silva-Aguayo³

One of the major pests that affect stem roses is the twospotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), which attacks more than a thousand species of plants worldwide, and is considered difficult to manage (Grbić et al. 2011; Meena et al. 2013). Worldwide, the most common control method against this pest consists of acaricides (Van Leewen et al. 2010; Ilias et al. 2017). However, its short generation time (7.5 d at 27 ± 1 °C), and high reproductive rate (7.97 eggs per female per d) (Shih et al. 1976; Georghiou 1994), has promoted resistance to most of the compounds used for their control (Van Pottelberge et al. 2009; Ay & Yorulmaz 2010; Ay & Kara 2011; Khalighi et al. 2014; Kwon et al. 2015; Ilias et al. 2017; Pavlidi et al. 2017). This species has been considered one of the arthropod species, displaying the most reports of resistance to insecticides worldwide (Whalon et al. 2012).

For several decades, in the rose-producing region of the state of Mexico, Mexico, 1 of the active ingredients commonly used for combating *T. urticae* is abamectin, which was introduced into the market in the early 1990s. Initially, the biological effectiveness of this acaricide in the control of the two-spotted spider mite was high (> 95%). For this reason, it was used often. In 2009, *T. urticae* populations in this region were collected, and high levels of resistance to abamectin were documented (Aguilar-Medel et al. 2011). However, the growers increased the doses to reestablish the original level of control, leading gradually to higher levels of acaricide resistance, and then to larger numbers of cases of field-efficacy failures. Therefore, the objective of this study was to determine susceptibility to abamectin of 4 *T. urticae* populations from the flower-producing region of the state of Mexico.

Tetranychus urticae was collected in Apr and May of 2017 in commercial greenhouses where cut roses are produced and where records of abamectin use are kept. These greenhouses are located in the municipalities of Villa Guerrero, Tenancingo, Coatepec Harinas, and Ixtapan de la Sal in the state of Mexico. Four greenhouses were selected from each municipality, and at least 100 leaflets infested by two-spotted spider mite were collected from each. The leaflets were deposited in paper bags. They were taken to the Toxicology Laboratory of the Colegio de Postgraduados, Campus Montecillo, state of Mexico, Mexico. The specimens from the collection sites of each municipality were mixed, and the adults were transferred with a paintbrush to

35- to 40-d-old bean plants (*Phaseolus vulgaris* L., var. 'Flor de Mayo'; Fabaceae), which were then placed in cages (70 × 70 × 50 cm), covered with polypropylene fabric, Agribon® (19 g per m², Berry Plastics, San Luis Potosí, San Luis Potosí State, Mexico), to prevent escape of *T. urticae*, or immigration of this or other arthropods. To obtain similar-aged mites, about 300 pairs of unsexed adults of the field-collected specimens were used to infest a bean plant ('Mayflower' var.) and allow them to lay eggs for 24 h. For each field-collection, 5 bean plants were infested. After this time, the adults were removed, so that the plants would be infested with only F1 eggs. As the susceptible population, a *T. urticae* colony was collected in the gardens of the Colegio de Postgraduados, Campus Montecillo; this population had been free of exposure to acaricides for 3 yr. Rearing was conducted under greenhouse conditions at a temperature of 27 ± 5 °C, 60 ± 10% RH, and a 16:8 h (L:D) photoperiod.

The bioassays were conducted with the commercial formulation Biomec® (abamectin, 18 g per L, emulsionable concentrate, Grupo Bioquímico Mexicano S.A de C.V., Saltillo, Coahuila State, Mexico). The required concentrations were prepared with distilled water that contained 0.25 mL per L coadjuvant (Inex-A®, Cosmocel S.A., División Agrícola, San Nicolás de los Garza, Nuevo León, Mexico).

The leaf immersion bioassay for *Tetranychus* spp. adults proposed by the Insecticide Resistance Action Committee (IRAC) was used with slight modifications (IRAC 2009). Leaves were cut from the middle stratum of 35- to 40-d-old *P. vulgaris* var. 'Flor de Mayo' plants. Using a standard hole punch, 30 mm diameter discs were cut and placed underside (abaxial surface) down in a Petri dish that contained 3 mL 2% agar (Bacto™ Agar, Becton, Dickinson and Company, Mexico City, Mexico). With a paintbrush, 20 to 25 adult females 3- to 5-d-old were transferred to each leaf disc. To prevent mortality associated with handling, females that were walking were selected. Approximately 30 min after transfer, the mites were checked to assure they were not damaged, and if they were, the affected individuals were extracted. Later, the infested leaf disc was submerged in the respective concentration of acaricide for 2 s and gently shaken for 20 s to eliminate excess moisture. These submersion and shaking times were determined in preliminary tests, in which it was observed that they had no adverse effects on the treated individuals. Finally, the leaf discs were placed underside down in the Petri dishes.

¹Instituto de Fitosanidad, Programa Entomología y Acarología, Colegio de Postgraduados Campus Montecillo, Texcoco, Estado de Mexico, Mexico; E-mail: diaz.karen@colpos.mx (K. V. D. A.); concho@colpos.mx (J. C. R. M.); alagunes@colpos.mx (A. L. T.); tejeda.manuel@colpos.mx (M. A. T. R.).

²Universidad Autónoma del Estado de Mexico, Centro Universitario Tenancingo, Carretera Tenancingo-Villa Guerrero, Km. 1.5, C. P. 52400, Tenancingo, Estado de Mexico, Mexico; E-mail: soteromex@hotmail.com (S. A. M.)

³Facultad de Agronomía, Universidad de Concepción, Chillán, Chile; E-mail: gosilva@udec.cl (G. S. A.)

*Corresponding author; E-mail: concho@colpos.mx

Initially, the range of concentrations that produced 0 to 100% mortality (biological response window) was determined, and later at least 6 intermediate concentrations were included to cover this range. The treated mites were kept under controlled conditions at $25 \pm 2^\circ\text{C}$, $55 \pm 5\%$ RH, and a 16:8 h (L:D) photoperiod. After 48 h of exposure, the mortality percentage was determined; a female mite was considered dead if it could not move more than twice the distance of its length (Sato et al. 2005). At least 4 replications were conducted on different d for each population; each replication included a control where the leaf disc was submerged in distilled water with 0.25 mL per L coadjuvant with the same procedure described above. The maximum level of mortality accepted for the control without acaricide was 15%, and this was corrected using the Abbott formula (Abbott 1925).

The data on mortality were subjected to a Probit analysis with PROC PROBIT by means of the SAS statistical software (SAS 2016) to estimate slope, lethal concentration (LC) at 50 and 95% mortality and confidence limits at 95%. The values of relative response (RR) at 50 and 95% mortality were obtained with the quotient between $\text{LC}_{50}/\text{LC}_{95}$ of each field population, and between $\text{LC}_{50}/\text{LC}_{95}$ of the susceptible population, respectively. The population response was not considered statistically different when the confidence limits overlapped (Robertson & Preisler 1992).

The LC_{50} value for the susceptible population was 0.0012 mg per L, while LC_{95} was 0.008 mg per L (Table 1). Significant statistical differences were obtained in susceptibility of the field populations evaluated, relative to the susceptible population given that the confidence limits did not overlap either at the LC_{50} level or at the LC_{95} level (Table 1). The LC_{50} levels of the field populations fluctuated between 2.72 (Coatepec Harinas) and 25.37 mg per L (Ixtapan de la Sal), and the RR_{50} values were between 2,266 and 21,141 (Table 1). For LC_{95} , the values oscillated between 185.48 (Tenancingo) and 81,218 mg per L (Coatepec Harinas) with values of RR_{95} between 23,185 and 10,152,250 (Table 1). We consider that the high LC_{95} observed in the Coatepec Harinas population resulted from the small slope (0.36 ± 0.05) of its Log-Doses Probit line, in comparison with the observed value the susceptible one (2.00 ± 0.34). These results indicate high levels of resistance to abamectin in *T. urticae* field populations collected in the flower-producing region, which comprises the municipalities of Villa Guerrero, Tenancingo, Coatepec Harinas, and Ixtapan de la Sal in the state of Mexico, confirming that the control failures documented by growers in this region are due to resistance to abamectin that the two-spotted spider mite has developed. The indicated biotic potential of *T. urticae* expressed in its short life cycle and high reproductive rate, together with factors such as the high use rate of acaricides and low migration in greenhouses (Croft & Van de Baan 1988; Van Leeuwen et al. 2010), contribute to making the problem more severe in this type of production system (Ferreira et al. 2015).

Studies conducted in Mexico by Aguilar-Medel et al. (2011) have documented the response of twospotted spider mite populations to abamectin in this region, and suggest that the problem has become acute because of increasing dosages, and possibly to shortened intervals of application and scarce rotation of acaricides with different modes of action. Among the recommendations for minimizing the level of resistance, exclusion of abamectin from *T. urticae* management programs is proposed for sites where control failures have been observed. In addition, conventional acaricides with different modes of action (Georghiou 1994; IRAC 2018) and biorational products that have shown acceptable biological effectiveness (Silva-Flores et al. 2005; Attia et al. 2013) should be used, as well as other important factors in pest management, such as the use of natural enemies (Nicetic et al. 2001).

Resistance to abamectin is unstable in absence of selection pressure (Sato et al. 2005). Therefore, if its use is excluded for a given time, it is possible to decrease resistance to undetectable levels (Dennehy et al. 1990), and abamectin can be used again in two-spotted spider mite management. However, these actions should be grounded in studies that justify the renewed use of this acaricide, and the conditions of restriction of use to mitigate the evolution of resistance (Kwon et al. 2010).

In conclusion, the *T. urticae* populations collected in the municipalities of Villa Guerrero, Tenancingo, Coatepec Harinas, and Ixtapan de la Sal in the state of Mexico have high levels of resistance to abamectin, making it urgently necessary to implement integrated management programs to control this pest.

KVDA is grateful to the Consejo Nacional de Ciencia y Tecnología (CONACYT) for financial support for this research.

Summary

Cut rose growers in the municipalities of Villa Guerrero, Tenancingo, Coatepec Harinas, and Ixtapan de la Sal, in the state of Mexico, Mexico, have reported low effectiveness of abamectin in the control of *Tetranychus urticae*, possibly due to development of resistance. The objective of this study was to determine the response of 4 field populations and 1 population susceptible to this acaricide. The values of the lethal concentration (LC) at 50% of mortality fluctuated between 0.0012 to 25.37 mg per L, while the relative response (RR) at 50% of mortality of the field populations varied from 2,226 to 21,141. The values of LC at 95% mortality varied from 0.008 to 81,218 mg per L, while the RR at 95% varied from 23,185 to 10,152,250. These results reflect the levels of resistance to abamectin, and therefore, implementation of other alternatives in the management of *T. urticae* are recommended.

Key Words: resistance; ornamentals; macrocyclic lactone; acaricide

Table 1. Susceptibility to abamectin of populations of *Tetranychus urticae* Koch collected in cut rose in the state of Mexico, Mexico.

| Population | n ^a | b ± SE ^c | LC ₅₀ ^d (CL 95%) ^e | RR ₅₀ ^f | LC ₉₅ ^d (CL 95%) ^e | RR ₉₅ ^f | χ ² (df) ^g |
|-------------------|----------------|---------------------|--|-------------------------------|--|-------------------------------|----------------------------------|
| Susceptible | 747 | 2.00 ± 0.34 | 0.0012 (0.0008–0.0020) | — | 0.008 (0.003–0.0404) | — | 36.80 (6) |
| Villa Guerrero | 970 | 1.01 ± 0.17 | 3.40 (1.75–18.89) | 2,833 | 490.99 (56.37–4,087,153) | 61,373 | 15.60 (4) |
| Tenancingo | 1,371 | 0.78 ± 0.17 | 6.45 (4.02–11.46) | 5,375 | 185.48 (67.36–1,227) | 23,185 | 22.20 (5) |
| Coatepec Harinas | 894 | 0.36 ± 0.05 | 2.72 (0.54–18.68) | 2,266 | 81,218 (2,579–173,052,588) | 10,152,250 | 20.40 (5) |
| Ixtapan de la Sal | 967 | 0.58 ± 0.12 | 25.37 (7.37–375.84) | 21,141 | 16,349 (766–648,970,731) | 2,043,625 | 32.12 (5) |

^a = number of treated mites; b = slope value; ^c = Standard Error of slope; ^d = Lethal concentration = mg per L; ^e = Confidence limits at 95%; ^f = RR = Relative response (LC_{50} or LC_{95} of each field population; LC_{50} or LC_{95} of susceptible population); ^g = degrees of freedom.

Sumario

Productores de los municipios de Villa Guerrero, Tenancingo, Coatepec Harinas e Ixtapan de la Sal en el Estado de México, México han reportado una baja efectividad de abamectina en el control de *Tetranychus urticae* la cual posiblemente se deba al desarrollo de resistencia. El objetivo de esta investigación fue determinar la respuesta, a este acaricida, en cuatro poblaciones de campo y una susceptible. Los valores de la concentración letal (CL) al 50% de mortalidad fluctuaron de 0.0012 (Susceptible) a 25.37 mg por L (Ixtapan de la Sal), mientras que la respuesta relativa (RR) al 50% de mortalidad de las poblaciones de campo varió de 2,226 (Coatepec Harinas) a 21,141 (Ixtapan de la Sal). Los valores de la CL al 95% de mortalidad variaron de 0.008 (Susceptible) a 81,218 mg por L (Coatepec Harinas), mientras que la RR al 95% de mortalidad varió de 23,185 (Tenancingo) a 10,152,250 (Coatepec Harinas). Estos resultados demuestran un alto nivel de resistencia a abamectina, por lo que se recomienda la implementación de otras alternativas de manejo de *T. urticae*.

Palabras Clave: resistance; ornamentals; macrocyclic lactone; acaricide

References Cited

- Abbott WS. 1925. A method of computing the effectiveness of an insecticide. *Journal of Economic Entomology* 18: 267–267.
- Aguilar-Medel S, Díaz-Gómez O, Rodríguez-Maciel JC, González-Camacho JE, García-Velasco R, Martínez-Carrillo JL, Reséndiz-García B. 2011. Resistencia de *Tetranychus urticae* Koch a acaricidas usados en la producción de rosas de invernadero en México. *Southwestern Entomologist* 36: 363–371.
- Attia S, Grissa KL, Lognay G, Bitume E, Hance T, Mailleux AC. 2013. A review of the major biological approaches to control the worldwide pest *Tetranychus urticae* (Acari: Tetranychidae) with special reference to natural pesticides. *Journal of Pest Science* 86: 361–386.
- Ay R, Kara EK. 2011. Toxicity, inheritance of fenpyroximate resistance, and detoxification-enzyme levels in a laboratory-selected fenpyroximate-resistant strain of *Tetranychus urticae* Koch (Acari: Tetranychidae). *Crop Protection* 30: 605–610.
- Ay R, Yorulmaz S. 2010. Inheritance and detoxification enzyme levels in *Tetranychus urticae* Koch (Acari: Tetranychidae) strain selected with chlorpyrifos. *Journal of Pest Science* 83: 85–93.
- Croft BA, Van de Baan HE. 1988. Ecological and genetic factors influencing evolution of pesticide resistance in tetranychid and phytoseiid mites. *Experimental & Applied Acarology* 4: 277–300.
- Dennehy TJ, Nyrop JP, Martinson TE. 1990. Characterization and exploitation of instability of spider mite resistance to acaricides, pp. 77–91 *In* Green MB, LeBaron HM, Moberg WK [eds.], *Managing Resistance to Agrochemicals*. ACS Symposium Series, American Chemical Society, Washington, DC, USA.
- Ferreira CBS, Andrade FHN, Rodrigues ARS, Siqueira HAA, Gondim Jr MGC. 2015. Resistance in field population of *Tetranychus urticae* to acaricides and characterization of the inheritance of abamectin resistance. *Crop Protection* 67: 77–83.
- Georgiou GP. 1994. Principles of insecticide resistance management. *Phytoprotection* 75: 51–59.
- Grbić M, Van Leeuwen T, Clark RM, Rombauts S, Rouzé P, Grbić V, Osborne EJ, Dermauw W, Ngoc PCT, Ortego F, Hernández-Crespo P, Diaz I, Martinez M, Navajas M, Sucena E, Magalhães S, Nagy L, Pace RM, Djuranović S, Smagghe G, Iga M, Christiaens O, Veenstra JA, Ewer J, Mancilla-Villalobos R, Hutter JL, Hudson SD, Velez M, Yi SV, Zeng J, Pieres-daSilva A, Roch F, Cazaux M, Navarro M, Zhurov V, Acevedo G, Bjelica A, Fawcett JA, Bonnet E, Martens C, Baele G, Wissler L, Sanchez-Rodriguez A, Tirry L, Blais C, Demeestere K, Henz SR, Gregory TR, Mathieu J, Verdon L, Farinelli L, Schmutz J, Lindquist E, Feyereisen R, Van de Peer Y. 2011. The genome of *Tetranychus urticae* reveals herbivorous pest adaptations. *Nature* 479: 487–492.
- IRAC (Insecticide Resistance Action Committee). 2009. Susceptibility Test Methods Series: Method 4 “*Tetranychus* spp.”. http://www.irac-online.org/content/uploads/Method_004_v3_june09.pdf (last accessed 13 Feb 2019).
- IRAC (Insecticide Resistance Action Committee). 2018. Mode of action classification scheme, v. 8.4, May 2018, <https://www.irac-online.org/modes-of-action/> (last accessed 19 Feb 2019).
- Ilias A, Vassiliou VA, Vontas J, Tsagkarakou A. 2017. Molecular diagnostic for detecting pyrethroid and abamectin resistance mutation in *Tetranychus urticae*. *Pesticide Biochemistry and Physiology* 135: 9–14.
- Khalighi M, Tirry L, Van Leeuwen T. 2014. Cross-resistance risk of the novel complex II inhibitors cyenopyrafen and cyflumetofen in resistant strains of the two-spotted spider mite *Tetranychus urticae*. *Pest Management Science* 70: 365–368.
- Kwon DH, Clark JM, Lee SH. 2015. Toxicodynamic mechanism and monitoring of acaricide resistance in the two-spotted spider mite. *Pesticide Biochemistry and Physiology* 121: 97–101.
- Kwon DH, Seong GM, Kang TJ, Lee SH. 2010. Multiple resistance mechanisms to abamectin in the two-spotted spider mite. *Journal of Asia Pacific Entomology* 13: 229–232.
- Meena NK, Rampal, Barman D, Medhi RP. 2013. Biology and seasonal abundance of two-spotted spider mite, *Tetranychus urticae*, on orchids and rose. *Phytoparasitica* 41: 597–609.
- Nicetic O, Watson DM, Beattie GAC, Meats A, Zheng J. 2001. Integrated pest management of two-spotted mite *Tetranychus urticae* on greenhouse roses using petroleum spray oil and the predatory mite *Phytoseiulus persimilis*. *Experimental & Applied Acarology* 25: 37–53.
- Pavlidis N, Khalighi M, Myridakis A, Dermauw W, Wybouw N, Tsakireli D, Stephanou EG, Labrou NE, Vontas J, Van Leeuwen T. 2017. A glutathione-S-transferase (TuGSTd05) associated with acaricide resistance in *Tetranychus urticae* directly metabolizes the complex II inhibitor cyflumetofen. *Insect Biochemistry and Molecular Biology* 80: 101–115.
- Robertson JL, Preisler HK. 1992. *Pesticide Bioassays with Arthropods*. CRC, Boca Raton, Florida, USA.
- SAS. 2016. SAS User's Manual 9.4. SAS Institute, Cary, North Carolina, USA.
- Sato ME, Da Silva MZ, Raga A, Souza-Filho MF. 2005. Abamectin resistance in *Tetranychus urticae* Koch (Acari: Tetranychidae): selection, cross-resistance and stability of resistance. *Neotropical Entomology* 34: 991–998.
- Shih CIT, Poe SL, Cromroy HL. 1976. Biology, life table, and intrinsic rate of increase of *Tetranychus urticae*. *Annals of the Entomological Society of America* 69: 362–364.
- Silva-Flores MA, Rodríguez-Maciel JC, Díaz-Gómez O, Bautista-Martínez N. 2005. Efectividad biológica de un derivado de ácido graso para el control de *Macrosiphum rosae* L. (Homoptera: Aphididae) y *Tetranychus urticae* Koch (Acari: Tetranychidae). *Agrociencia* 39: 319–325.
- Van Leeuwen T, Vontas J, Tsagkarakou A, Dermauw W, Tirry L. 2010. Acaricide resistance mechanisms in the two-spotted spider mite *Tetranychus urticae* and other important Acari: a review. *Insect Biochemistry and Molecular Biology* 40: 563–572.
- Van Pottelberge S, Van Leeuwen T, Nauen R, Tirry L. 2009. Resistance mechanisms to mitochondrial electron transport inhibitors in a field-collected strain of *Tetranychus urticae* Koch (Acari: Tetranychidae). *Bulletin Entomological Research* 99: 23–31.
- Whalon ME, Mota-Sanchez D, Hollingworth RM, Duynslager L. 2012. Arthropod pesticide resistance database. (online) <https://www.pesticideresistance.org> (last accessed 13 Feb 2019).