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Baseline Susceptibility of *Tetranychus truncatus* (Prostigmata:Tetranychidae) to acaricides

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ABSTRACT: *Tetranychus truncatus* Ehara (Tetranychidae), a globally distributed phytophagous mite, infests various plants, including many economically important crops. In Kerala, it has been identified as a major pest on vegetable crops. Continuous monitoring of the field populations for susceptibility to various acaricides is needed to understand the status of resistance in them. Studies were conducted to assess the baseline susceptibility of *Tetranychus truncatus* (Prostigmata:Tetranychidae) to acaricides. The present study generated baseline data for *T. truncatus* to acaricides *viz*., spiromesifen (1.2 ppm), fenazaquin (2.9 ppm), diafenthiuron (1.6 ppm), fenpyroximate (2.6 ppm) chlorfenapyr (1.0 ppm), propargite (2.3 ppm) and hexythiazox (36.1 ppm).

Keywords: *Tetranychus truncatus*, spider mite, base line data, acaricides

INTRODUCTION

Spider mites (Acari) inhabit a diverse array of environments and pose a significant threat to numerous commercially cultivated vegetable crops and ornamental plants (Al-Atawi, 2011). Prevalence of extended drought periods and elevated temperatures experienced in the recent past has fostered optimal conditions for these tiny arthropods, enabling their populations to surge at an alarming rate. *Tetranychus truncatus* Ehara (Tetranychidae), a phytophagous mite distributed globally, infests a wide variety of plants, including many that are economically significant for agriculture (Bolland *et al*., 1998; Migeon and Dorkeld 2024). It has been reported from 12 countries across the Afrotropical, Australasian, Oriental and Palearctic regions (Migeon and Dorkeld, 2024). However, its distribution is mostly reported from Asian countries, including Guam, Marianas, China, Indonesia, Philippines, Taiwan, Thailand, Vietnam, Iran, Japan India and Korea (Ullah *et al*., 2021). This mite has a wide range of potential host plants, 92 species in total, which includes many major crops such as rice, maize, cassava, and cotton (Migeon and Dorkland, 2024).

In India, *T. truncatus* was first recorded from the North western Himalayan regions of Jammu and Kashmir and Himachal Pradesh in 1983 on *Dahlia* sp. It was later found in Karnataka on cultivated and wild *Morus* species (Srinivasa *et al*., 2012). In Kerala, it has been identified as a major pest on vegetable crops like okra, cucumber, and amaranthus (Bennur *et al*., 2015), as well as on several ornamental plants (Prakash *et al*., 2022). This species poses a serious threat to crops due to its ability to reproduce rapidly and cause extensive damage through sap extraction.

The mite primarily colonizes the undersides of leaves, feeding on sap and causing yellowing and drying of foliage. Farmers use different novel acaricides to control this pest. However, recent studies have revealed that populations of *T. truncatus* collected from vegetable fields in Kerala exhibited reduced susceptibility to commonly used acaricides, including fenazaquin, spiromesifen and diafenthiuron (Bachhar *et al*., 2019). This trend indicates the development of acaricide resistance in this mite species. To address this issue, it is crucial to introduce alternative acaricides with different modes of action to which the mite populations have not been exposed. Spider mites can develop resistance to newly exposed chemicals after few continuous exposures (Vassiliou and Kitsis, 2013; De Rouck *et al*., 2023). Therefore, continuous monitoring of the field populations for susceptibility to various acaricides is warranted. To assess the level of susceptibility in field populations, bioassay studies to compare the LC_{50} values for field-collected populations with those of susceptible populations (baseline susceptibility), maintained in laboratory conditions is essential.

The present study aimed at determining the baseline susceptibility of *T. truncatus*to different acaricides with different modes of action.

MATERIALS AND METHODS

The culture of *T. truncatus*, which was being maintained in the laboratory without any exposure

to acaricide molecules for about more than ten years (approximately 300 generations), was used in the study as the susceptible population. To generate baseline susceptibility data, the susceptible population was tested for dose response to the seven different acaricides that belong to different chemical classes (Table1).

The bioassay studies were performed on adult mites using the leaf dip method (Roy *et al.,* 2010) for all acaricides, except spiromesifen and hexythiazaox where protonymphs were tested for susceptibility (Mattupurath *et al.,* 2023). Technical grade chemicals purchased from Sigma-Aldrich were used for the bioassay. A stock solution (10 ml) of each acaricide was prepared using acetone and distilled water (1:1), and five different required concentrations (decided based on a broad range bioassay) were obtained by the serial dilution method.

Mulberry leaf disc of 3x3cm^2 was dipped in the respective test solution for 15 seconds and left for shade drying for 20 minutes. In the control treatment, leaf disc was dipped in a mixture of acetone and distilled water (1:1). After shade drying, leaf disc was placed on a wet cotton pad kept in a Petri dish (150x15mm). Three replications were maintained for each treatment. Twenty-five adult female mites collected from the laboratory culture were released onto each leaf disc, using a camel hair brush. A thin layer of Vaseline was applied along the edges of the leaf disc, to prevent the mites from moving out of the disc (Alzoubi and Cobanoglu, 2010). In the case of spiromesifen and hexythiazox, nymphicidal assay was conducted with 25 protonymphs by topical application method. Potters tower was used to spray the chemical on 2x2 cm^2 mulberry leaf bit (Van Pottelberge *et al*., 2009).

Observations on the mortality of the mites were recorded after 24 and 48 h of treatment, following the criteria given by Beers *et al.* (1998). Mites that could move freely on gentle probing with a fine brush were considered alive, while dead and moribund mites that could not move beyond their body length were considered dead. Mortality data recorded at 24 h were used to determine concentration-mortality responses for all acaricides except spiromesifen and hexythiazox. For these two chemicals, the mortality data at 48 h were used. The median lethal concentration (LC_{50}) values were calculated by Probit analysis (Finney, 1971) using Polo Plus 2.0 software (LeOra software, 2002).

Table 1. Acaricides used for bioassay studies on *Tetranychustruncatus*

Insecticide	Chemical group	IRAC MoA Group
Chlorfenapyr	Halogenated pyrroles	Uncouplers of oxidative phosphorylation via disruption of the proton gradient (13)
Diafenthiuron	Thiourea	Inhibitors of mitochondrial ATP synthase (12, 12A)
Propargite	Sulfite ester	Inhibitors of mitochondrial ATP synthase (12, 12C)
Spiromesifen	Tetramic acid derivatives	Lipid synthesis regulation (23)
Fenazaquin	Quinazoline	Mitochondrial complex I electron transport inhibitors (21)
Hexythiazox	Thiazolidinone	Mite growth inhibitors affecting CHS1 (10)
Fenpyroximate	Phenoxypyrazole	Mitochondrial complex I electron transport inhibitors (21)

(IRAC, 2024)

RESULTS AND DISCUSSION

The baseline data generated in the present study for spiromesifen, fenazaquin, diafenthiuron, chlorfenapyr, diafenthiuron, propargite and hexythiazox are furnished in Table 2. The acaricides varied in their toxicity to *T. truncatus*. Among the tested acaricides, chlorfenapyr exhibited the lowest LC_{50} value of 1.0 ppm, indicating its potency even at minimal concentrations. This halogenated pyrrole compound disrupts ATP production by targeting oxidative pathways in mitochondria, leading to the mortality of exposed mites. Nicastro *et al.* (2013) studied the stability of resistance and cross relationships for chlofenapyr in *T. urticae* collected from cotton and papaya, by comparing susceptibility with laboratory maintained population. Results showed LC_{50} value of 1.478 (mg l $^{-1}$ of a.i) for chlorfenapyr in susceptible population which is higher than the value obtained in the present study. Herron *et al.* (2004) documented the first chlorfenapyr control failure against *T. urticae*attributing

it to resistance development. They compared the LC_{50} values between resistant and susceptible populations, noting that the susceptible population exhibited an LC_{50} value of 0.017 ppm.

Spiromesifen (Tetramic acid derivative) and Diafenthiuron (Thiourea compound) exhibited high efficacy against *T. truncatus* with LC_{50}values of 1.2 ppm and 1.6 ppm, respectively. Naveena *et al.* (2022) evaluated the magnitude of resistance developed in two spotted spider mite, *T. urticae* in Tamil Nadu. They conducted bioassays on susceptible populations and compared the LC_{50} with field collected populations. The study reported anLC_{50} of 0.15 ppm for chlorfenapyr, 2 ppm for spiromesifen and 0.22 ppm for diafenthiuron in a susceptible population maintained in the laboratory, without any exposure to chemicals. Additionally, baseline studies conducted on *Polyphagotarsonemus latus* after 70 generations without chemical exposure revealed an LC_{50} value of 0.4 ppm for diafenthiuron (Augustine *et al*., 2022).

In the present study, Fenazaquin and Fenpyroximate demonstrated effective acaricidal properties with LC_{50} values of 2.9 ppm and 2.6 ppm, respectively. Noor and Sreenivasa (2020) generated baseline data for *T. urticae* assessing its susceptibility to various acaricides in susceptible population. Their study recorded an LC_{50} of 0.22 ppm for fenazaquin and 0.92 ppm for spiromesifen after the 90th generation. Mohin *et al.* (2018) evaluated the susceptibility of *T. urticae* to selected acaricides in a laboratory-maintained susceptible culture (128th generation). They reported LC_{50} values of 0.18 ppm for fenazaquin, 0.20 ppm for propargite, 0.42 ppm for chlorfenapyr, 0.30 ppm for dicofol, 0.30 ppm for diafenthiuron, 0.29 ppm for spiromesifen, and 0.32 ppm for abamectin. In the present study, hexythiazox showed least toxicity compared to others. Hexythiazox, a chitin synthesis inhibitor, exhibited significantly elevated LC_{50} values of 36.1 ppm in the present nymphicidal assay, indicating that while it remains effective, it requires higher concentrations compared to the more potent options.

Kumari *et al.* (2017) generated baseline data for *T. urticae* and evaluated the adulticidal and nymphicidal effects of various newer and conventional acaricides on susceptible laboratory strain of *T. urticae*. The study identified abamectin as the most toxic to adults, with an LC_{50} of 0.39 ppm, followed by fenpyroximate (5.67 ppm), spiromesifen (12.53 ppm), chlorfenapyr (32.24 ppm), propargite (77.05 ppm) and dicofol (146.65 ppm). Hexythiazox showed the least adult toxicity. For nymphal mortality, abamectin again led with 96.05%, followed closely by dicofol (94.51%), hexythiazox (90.24%), propargite (90.00%), chlorfenapyr (89.33%), and fenpyroximate (86.84%).

The baseline susceptibility data generated for *T. truncatus* in the present study can serve as a reference data for monitoring susceptibility trends in field populations of the mite species, periodically. Development of resistance in the field populations can be thus be detected at a very early stage, so that corrective measures can be initiated.

Table 2: Baseline Susceptibility of *Tetranychus truncatus* to acaricides

Acaricide	LC_{50} (ppm)	Slope ± SEM	χ2	df
Fenazaquin	2.9 (2.2-3.8)	1.209 ± 0.271	2.519	3
Spiromesifen	1.2 (1.0-1.3)	2.149 ± 0.325	2.830	3
Diafenthiuron	1.6 (1.4-1.9)	2.611 ± 0.524	1.450	3
Fenpyroximate	2.6 (2.4-3.1)	2.844 ± 0.775	0.342	3
Propargite	2.3 (2.1-2.7)	2.358 ± 0.413	1.912	3
Chlorfenapyr	1.0 (0.9-1.2)	2.625 ± 0.415	2.110	3
Hexythiazox	36.1 (33.5-39.5)	3.993 ± 0.751	0.600	3
Dicofol	24.6 (19.7-29.9)	1.733 ± 0.294	0.661	3

LC_{50} = Concentration (ppm) calculated to give 50% mortality

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