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In vitro study on toxicity of hexythiazox against *Panonychus ulmi* Koch (Acari: Tetranychidae) on apple plants

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Abstract
The effect of hexythiazox at different concentrations on apple plants in terms of LT_{50} values against *Panonychus ulmi* was studied in the present investigation. Graded response bioassays were performed with different concentrations of hexythiazox to evaluate this important parameter against *Panonychus ulmi*. Bioassays were performed in the laboratory to establish the persistence of 50% kill of mites i.e. LT_{50} values on apple plants. It was established that the LT_{50} value was 1.44 days at the concentration of 0.001%, while it was 2.34 days at the concentration of 0.002% and the LT_{50} value was highest at the concentration of 0.004% with a value of 3.69 days. The period of effectiveness of killing 50% mite population by hexythiazox reveals how far this pesticide is effective in causing a good/ effective control of mite pests.

Keywords: Hexythiazox, *Panonychus ulmi*, LT_{50}, mortality, apple

Introduction
A number of arthropod pests have been known to attack fruit crops. Among these, those belonging to class Arachnida are cosmopolitan with broad host range. The mites are characterised by presence of four pairs of legs and unsegmented abdomen [7]. Mites play an important role in agricultural and horticultural production. The earliest record of the tetranychid mite in India is that of red spider mite on tea in Assam [10]. Ghai [5] reported 20 tetranychid mites in India, while, Manson [8] reported several tetranychid mites in India. Prasad [12] recorded 40 species of Tetranychoidea in India. European red mite is one important mite that spells dangerous consequences as the tree becomes scorched resulting in reduced yield of fruit and loss of vigour of the trees [9]. The severity of attack and its occurrence during July-September when the fruits are on the tree cause grave concern and anxiety among the growers. In order to improve the production efficiency, attempts were made to control this pest with the help of chemicals, which are the most potent weapons to control the pests of crops. In the absence of proper control recommendations and in desperate attempts to save the crop, most orchardists resort to indiscriminate use of pesticides. This practice is likely to further aggravate the situation and create environmental hazards with serious implications. Today the impending problem is the development of resistance in the mite pest to a wide variety of toxicants making control even more difficult than for any other pest. At least 447 species of insects and mites have been reported to develop resistance to various pesticides by 1986 [4]. Therefore, it is imperative to know about different parameters of pesticides and their detailed study to find out the best possible solutions to control *P. ulmi*. LT_{50} is an important factor governing the efficacy of the pesticides. Therefore, in the present study we selected hexythiazox against *P. ulmi* to find out the persistence of 50% kill by this pesticide.

2. Materials and methods
This study was carried out in the experimental area of Division of Entomology at SKAUST-K, Jammu and Kashmir, India. Three treatments were used in this study and one control in which water was sprayed as given in Table-1. Additionally, the trial was laid out in CRD design with three replications for each treatment. The concentrations of hexythiazox that were sprayed on potted apple plants were 0.001, 0.002 and 0.004%.

Table 1: Acaricide, trade name and concentrations used in the present study

Name of the chemical	Trade name	Concentrations (%)	Treatment codes
Water	-	-	T0
Hexythiazox 5.4% EC	K-aradite	0.001	T_1
		0.002	T_2
		0.004	T_3

In this study adults of *P. ulmi* were used. Hexythiazox 5.4% EC was evaluated for LT_{50} values. The pesticide was diluted with water to get the required concentrations and then sprayed on potted apple plants with foot sprayer till leaves were fully drenched.

In control only water was sprayed. The treated leaves were then excised from the potted plants and kept in Petri plates (100 mm diameter) and about 20 adult mites were released at an interval of 1, 6 and subsequently every 24 hours after the treatment till mortality was observed. A wet cotton ring was placed around the leaf to prevent escape of mites. The petriplates were kept in B.O.D incubator at 27+/- 1^0 and 70% RH for assessment of residual toxic effect. Mortality of mites was recorded after every 24 hours and moribund larvae treated as dead. The mortality data was corrected by the Abbott's formula [1].

$$P_t = \frac{P_O - P_C}{100 - P_C} \times 100$$

Where,

Pt = Corrected per cent mortality

P_O = Observed per cent mortality in treated

P_C = Observed per cent mortality in in control

The data was subjected to probit regression analysis (Finney) [3] for determining the LT_{50} values. LT_{50} values were determined by transforming the percentage mite mortality to probits and plotting these against log transformed time values. Relative persistence and residual toxicity of each acaricide was determined as per Pradhan and Venkatraman [11] by taking the LT_{50} values of least toxic acaricide as unity.

3. Results and discussion

a) LT_{50} of hexythiazox for *Panonychus ulmi* at the concentration of 0.001%

The data in Table 2 revealed that the LT_{50} value of hexythiazox at concentration of 0.001 per cent was 34.67 hours/ 1.44 days. The fiducial limits at 95% confidence were 26.87 and 42.58 as lower and upper limit respectively. The correlation coefficient (r) was worked out to be -0.985 which indicated that there was a negative correlation between time and mortality. The coefficient of determination (R^2) was calculated as 0.97 and the $\chi 2$ value of 4.77 indicated that the data was homogeneous at $p \leq 0.05$

b) LT_{50} of hexythiazox for *Panonychus ulmi* at the concentration of 0.002%

The data in Table 3 revealed that the LT_{50} value of hexythiazox at concentration of 0.002 per cent was 56.24 hours/ 2.34 days. The fiducial limits at 95% confidence were 39.12 and 68.49 as lower and upper limit respectively. The correlation coefficient (r) was worked out to be -0.982 which indicated that there was a negative correlation between time and mortality. The coefficient of determination (R^2) was calculated as 0.965 and the $\chi 2$ value of 5.70 indicated that the data was homogeneous at $p \leq 0.05$

c) LT_{50} of hexythiazox for *Panonychus ulmi* at the concentration of 0.004%

The data in Table 4 revealed that the LT_{50} value of hexythiazox at concentration of 0.004 per cent was 88.64 hours/ 3.69 days. The fiducial limits at 95% confidence were 82.23 and 106.87 as lower and upper limit respectively. The correlation coefficient (r) was worked out to be -0.963 which indicated that there was a negative correlation between time and mortality. The coefficient of determination (R^2) was calculated as 0.928 and the $\chi 2$ value of 4.12 indicated that the data was homogeneous at $p \leq 0.05$.

Table 2: LT_{50} of hexythiazox (at 0.001%) for *Panonychus ulmi*

Time interval (hours)	Log dose (x 10^3) (x)	Corrected mortality (%)	LT_{50} (in hours)	LT_{50} (in days)	95% C.I		R	Y=a+bx	R^2	$\chi 2$
					Lower limit	Upper limit				
24	4.38	53.40	34.67	1.44	26.87	42.58	-0.985	Y=315-58.9x	0.97	4.77*
48	4.68	41.00								
72	4.85	30.60								
96	4.98	23.90								
120	5.07	18.70								
144	5.15	6.89								
168	5.22	4.83								

*Significant at $p \leq 0.05$

Table 3: LT_{50} of hexythiazox (at 0.002%) for *Panonychus ulmi*

Time interval (hours)	Log dose (x 10^3) (x)	Corrected mortality (%)	LT_{50} (in hours)	LT_{50} (in days)	95% C.I		R	Y=a+bx	R^2	$\chi 2$
					Lower limit	Upper limit				
24	4.38	68.96	56.24	2.34	39.12	68.49	-0.982	Y=395-73x	0.96	5.70*
48	4.68	58.60								
72	4.85	43.10								
96	4.98	37.93								
120	5.07	27.58								
144	5.15	18.70								
168	5.22	15.10								
192	5.28	4.80								
216	5.33	3.30								

*Significant at $p \leq 0.05$

Table 4: LT_{50} of hexythiazox (at 0.004%) for *Panonychus ulmi*

Time interval (hours)	Log dose (x 10^3) (x)	Corrected mortality (%)	LT_{50} (in hours)	LT_{50} (in days)	95% C.I		R	Y=a+bx	R^2	$\chi 2$
					Lower limit	Upper limit				
24	4.38	82.41	88.64	3.69	82.23	106.87	-0.963	Y=476-86.4x	0.928	4.12*
48	4.68	74.13								
72	4.85	70.51								
96	4.98	53.44								
120	5.07	39.48								
144	5.15	34.31								
168	5.22	23.96								
192	5.28	17.24								
216	5.33	10.00								
240	5.38	3.30								
264	5.42	3.30								

*Significant at $p \leq 0.05$

Our results put forward that hexythiazox provided 50% mortality of mites till 2.34 and 3.69 days in case of recommended dose and double the recommended dose. However, in case of low concentration, persistence of 50% kill was recorded up 1.44 days only. Nevertheless, it was observed that hexythiazox gave good initial control and the 50% mortality persisted till good time as desirable in field i.e. not for much longer period. Wnag *et al*. [14] who carried out field trials of different insecticides against vegetable spider mites and concluded that the acaricide hexythiazox showed effects that reached 82.64% which means that hexythiazox provides good control initially. This verifies and validates our findings of hexythiazox providing good control in 24 hours. Smolarz [13] tested hexythiazox spray against *P. ulmi* on apple. Hexythiazox at recommended rates was applied at the green cluster, pink bud or after blossom stage and the best result was obtained for treatment at pink bud stage of apple trees. After this treatment, *P. ulmi* population was below the economic threshold over the whole vegetative season. Reducing dosage rates by one-half in laboratory test did not result in significant reduction in effectiveness. This was evident in our findings as well. Babar *et al*. [2] studied relative efficacy of different acaricides against mushroom mites. The acaricide was used at different concentrations i.e, hexythiazox 10 WP @ (0.25g/L, 0.35g/L and 0.45g/L). Hexythiazox gave significant reduction in the mite population and gave satisfactory results as compared to untreated check. On numerical basis high mite population suppression of 90.11% was recorded by the application of a hexythiazox 10 WP at 0.35g/L. However, very long persistence in terms of 50% kill was not observed which is also desirable in many cases. Long persistence of acaricides or insecticides is not always an encouraging thing for their use as reported by Hill and Foster [6] who put forward that use of acaricides with long residual period may promote resistance in spider mite population. Therefore, all in all hexythiazox is one good and safe acaricide for management of mites.

4. Conclusion

This study depicts an important parameter of hexythiazox wherein its LT_{50} values were computed at different concentrations. Considerable differences in LT_{50} values were recorded at different concentrations. As the dose was increased, the pesticide showed higher mortality rates and 50% kill of mites to a longer duration. However, it was observed that in terms of acute toxicity, hexythiazox showed satisfactory response but in terms of persistence of 50% kill, it did not persist much which is again a desirable factor in conditions where we do not want longer stay of a pesticide in field. Overall, hexythiazox can be used as a good control management option for mites when immediate control is needed.

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