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Persistence and residual toxicitiy of propargite against *Panonychus ulmi* Koch (Acari: Tetranychidae) on *Malus domestica* Borkh

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Abstract
The present investigation entitled "Persistence and residual toxicity of propargite against *Panonychus ulmi* Koch (Acari: Tetranychidae) on *Malus domestica* Borkh" was undertaken at the Division of Entomology, SKUAST-Kashmir, Shalimar. Propargite was sprayed on apple plants at three concentrations, following which bioassay was performed in the laboratory to establish persistence and residual toxicity. The period of effectiveness of propargite against *P. ulmi* was computed at each concentration and it was established that in case of highest concentration/ double the recommended concentration of propargite i.e. @ 0.1%, the mortality was observed till 15 days. This was followed by persistence till 13 days against the concentration of 0.05% which is the recommended concentration of propargite and the least persistence of 11 days was observed against the concentration of 0.025%. It was observed that double the recommended dose persisted for more time than the corresponding recommended and below the recommended doses.

Keywords: Propargite, European red mite, bioassay, mortality, persistence

1. Introduction
Malus domestica, Apple (also known as orchard apple and table apple) is a small deciduous tree in the Rosaceae (rose family) that originated in western Asia and is now one of the most widely cultivated fruit trees. In fact it is the fourth most widely produced fruit in the world after bananas, oranges and grapes [23]. About 63 Million tonnes of apple were produced worldwide in 2016 and China ranks as the world's leading producer [10]. In India, the area under apple cultivation is 3.15 lakh hectares and the production is 25.44 lakh tonnes [7]. Jammu and Kashmir is the major apple producing state in India with 1.61 lakh hectares under its cultivation and production of 16.47 lakh tonnes [4]. Jammu and Kashmir offers a share of around 70.39 per cent in the national market [16]. Apple production contributes more than Rs. 6000 crore to economy of Jammu and Kashmir and is considered to be the backbone of the state's economy [4].

Panonychus ulmi is one mite pest that constitutes one of the major constraints in apple cultivation. Among arthropod pests, mites damage and devastate the apple crop. Mites are morphologically and ecologically very diverse assemblage of tiny invertebrates, belonging to class Arachnida (together with spiders and scorpions), sub-phylum Chelicerata and phylum Arthropoda. Among mite pests, European red mite, *Panonychus ulmi*, has assumed a pest status ever since the outbreak in 1993 in apple orchards of Kashmir valley and continues to pose a threat to successful production of apples [3]. European red mite was first recorded in Oregon in 1911 [6]. It has become the most common pest of apple in recent years. In spite, of occurrence of several species of mites on fruits in Kashmir, none of the mite spp. was considered a major pest of apple till 1993, when European red mite (*P. ulmi* Koch) and Two spotted spider mite (*Tetranychus urticae* Koch) broke out as pests in epidemic form on apple in entire Kashmir valley [2, 20]. It has assumed the status of major apple disease in some important apple growing countries and its severity is known to increase with increase in mite population on the foliage [11, 14]. Effective control of *P. ulmi* may be achieved by timely spray applications to coincide with the most susceptible stages. However, as generation overlap, sprays may become less effective [8]. Thus a regular schedule of miticide applications is necessary. Farmers however, opt for a number of sprays to combat this nasty pest every season. The problem is that the growers do not know how many rounds of pesticides to go for and they keep on spraying the crops with many and untimely sprays to get rid of the pest. This in turn causes a devastating problem of continued development of resistance to a wide range of chemical groups [9] and this will lead to a time where no amount or dosage of pesticide will affect the insect pests.

This has necessitated the study of persistence and residual toxicity of some major acaricides used widely for management of ERM. Efficacy of various preparations for control of the mites have been investigated by many authors [15, 21, 22]. A lot of acaricides are being used to control European red mite, and one amongst them is propargite, an organosulfur acaricide. The pesticidal mechanism of action of this acaricide involves the inhibition of magnesium-stimulated ATP-ase. This acaricide is much beneficial in controlling a variety of phytophagous mites on many crops including cotton, vines, fruit trees, vegetables, hops and nuts, etc. [18]. The quality and production of apple crop plays a pivotal role in deciding the economy of horticultural market. A set back to apple industry can be of serious concern to apple producing states as well as to the nation's economy as a whole. Therefore, it becomes significant to keep the quality and good production of this fruit crop up to the mark and because of which different indices of pesticides that are used against different pests need to be evaluated.

2. Materials and Methods

2.1 Experimental Location: This research was carried out from the year 2013-2015 in the experimental field of SKUAST-K at Shalimar campus, Srinagar and in the experimental laboratories at the Division of Entomology, SKUAST-K, J & K. These experimental areas were located at an altitude of 1535 meters and the experimental site recorded maximum temperature of 34º C to minimum of 18º C with a relative humidity of 37- 44%.

2.2 Host Plant and Test Insect: Potted apple plants cv. Red delicious were planted in large pots and were irrigated time to time as per the schedule of SKUAST-K. Heavy infestation load of European red mite (*Panonychus ulmi*) was seen in different abandoned orchards of Kashmir and this pest infestation was used to establish culture on the potted apple plants that were used in this experiment. Only the adult forms of the pest were exposed to the pesticides for bioassay.

2.3 Experimental Layout: The experiment was conducted in pots which were randomly arranged with three replications for each treatment. The total number of treatments were 3 and one control were only water was sprayed

2.4 Bioassay: Propargite was evaluated at different concentrations against the motile adult forms of *Panonychus ulmi* on apple. The concentrations are presented in Table-1**.** There were 3 concentrations (prepared in water) in geometrical progression besides control where only water was sprayed. The concentrations of propargite were 0.025%, 0.05% and 0.1%. There were three treatments and each treatment replicated thrice and control where only water was sprayed as presented in Table 1

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

Name of the chemical	Trade name	Concentrations (%)	Treatment codes
Water	-	-	T0
Propargite 57% EC	Mitex	0.025	T1
		0.050	T2
		0.100	T3

Different concentrations of propargite were sprayed on potted apple plants with foot sprayer till the run off started from leaves in order to provide uniform coverage of the leaves with spray fluid. The treated leaves were then plucked 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 Petri plates 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].

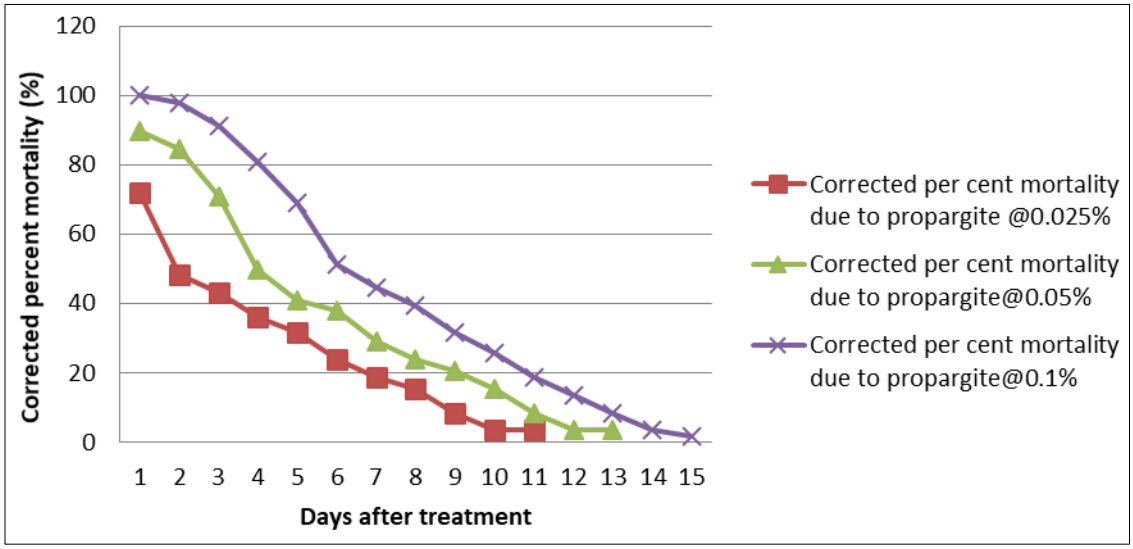
$$P_t = \frac{P_O - P_C}{100 - P_C} \times 100$$

Where,
Pt = Corrected per cent mortality
P_O = Observed per cent mortality in treated
P_C = Observed per cent mortality in in control

Persistent residual toxicity was determined by the methods of Sarup *et al* [19]. The average persistent toxicity (T) was determined by adding the values of corrected percentage mortalities of each observation and dividing the total by the total number of observations. The persistent toxicity (PT) was calculated by multiplying the average toxicity by the period (P) for which the toxicity persisted. On the basis of PT values the order of relative efficacy of each treatment was determined. For comparing the residual toxicity of different acaricides, the relative residual toxicity of acaricides (RRT) was worked out (Table 3) by taking the persistent toxicity (PT) value of least toxic acaricide as unity.

3. Results and discussions

The data on the persistence of residual toxicity to propargite was recorded after every 24 hours. The persistent toxicity at various concentrations was computed revealing some important data. Perusal of data revealed that the mortality was observed up to 15 days at the concentration of 0.1%, 13 days at the concentration of 0.05% and 11 days against the concentrations of 0.025 *per cent* respectively. Graph-1 reflects the mortalities and trends of decrease of mortalities at all the concentrations.



Graph 1: Persistence of toxicity of propargite in terms of corrected percent mortality at different concentrations

In case of the highest concentration i.e. 0.1%, corrected mortality was recorded to be 100% on first day and till sixth day 50% mortality was witnessed which gradually came down to insignificance on 15th day. On the contrary, in case of recommended dose of 0.05%, corrected *per cent* mortality of 89.65% was recorded and 50% control lasted between 3rd and 4th day. The graph of mortality came down to insignificance on 13th day. In case of lowest concentration i.e. 0.025%, corrected mortality of 72.06% was observed on 1st day of spray and 50% mortality lasted almost till 2nd day and gradually the control diminished and came down to zero on 11th day (Graph-1 and Table-2).

Table 2: Corrected mortality of European red mite (*Panonychus ulmi*) at three concentrations of propargite depicting persistence of the pesticide treatment

Conc (%)[a]	Corrected per cent mortality[b] (Days after treatment)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0.025	72.06	48.27	43.10	35.86	31.67	23.96	18.79	15.17	8.45	3.30	3.30	0	0	0	0	0
0.05	89.65	84.48	70.67	49.82	41.03	37.93	29.14	23.96	20.34	15.17	8.45	3.30	3.30	0	0	0
0.1	100.00	97.93	91.20	80.86	68.96	51.38	44.65	39.48	31.67	25.51	18.79	13.62	8.45	3.30	1.72	0

[a]on the basis of geometrical progression
[b] Each figure is an mean of three replications

The average residual toxicity (ART) was found to be 45.16, 36.71 and 45.16 for the concentrations of 0.1, 0.05 and 0.025 *per cent* respectively. The index of persistent toxicity (PT) was worked out to be 677.52, 477.23 and 303.93 in concentrations of 0.1, 0.05 and 0.025 per cent respectively. Based on persistent toxicity values the order of relative efficacy (ORE) was found to be 1, 2, 3 for concentrations of 0.1, 0.05 and 0.025 per cent respectively revealing that 0.1 per cent concentration persisted for longer duration as compared to 0.05 and 0.025 per cent (Table-3)

Table 3: Period of persistence, average residual toxicity, persistent toxicity and order of relative efficacy of propargite at three concentrations

Conc (%)[a]	Period of persistence	Average Residual Toxicity	Persistent Toxicity	Order of Relative Efficacy
0.025	11	27.63	303.93	3
0.05	13	36.71	477.23	2
0.1	15	45.16	677.52	1

[a]on the basis of geometrical progression

This study clearly established the fact that propargite has an excellent acute toxicity against *P. ulmi* at all three concentrations that were tested and can therefore serve as a promising miticide. This finding is in agreement to the findings of Bhardwaj *et al.* [7] who studied efficacy of new miticides on apple against motile stages *P. ulmi* under field conditions. and reported excellent control by propargite. Apart from acute toxicity, the chronic toxicity of propargite was also exceptional even at lower concentration. However, at lower concentration of propargite, the mortality was not significant after third day and therefore that dose was not sufficient for good control. Nevertheless, the persistence was recorded up to 11th day. This observation draws its support from the studies of Gupta *et al.* [12]. who evaluated bioefficacy of some new acaricides against mixed population of phytophagous apple mites, *P. ulmi* and *T. urticae* infesting apple crop and found that propargite showed good control till 15 days after which the population started building up and that minimum infestation was recorded in propargite treatment at concentrations of 0.085, 0.057 and 0.028 per cent.

Residual efficacy of propargite was undoubtedly found to be very good. This may be due to its new and twin mode of action and the property of binding to cuticle. Ashley *et al.* [5] studied toxicity of acaricides to *Tetranychus urticae* and *Orius insidiosus* and reported that propargite caused 100% mortality and after 14 days < 30% mortality was reported. However, long persistence of acaricides or insecticides is not always an encouraging thing for their use as reported by Hill and Foster [13] who put forward that use of acaricides with

long residual period may promote resistance in spider mite population. However, the concentrations that were tested in these studies are good enough for excellent control and the persistence is desirable in terms of long term control and for reduction of rounds of sprays to lesser number. Persistence beyond this is quite questionable.

4. Conclusion

From the present investigations, it was concluded that some new pesticides and modes of action need to be evaluated well to establish their persistence, which could help in long term control and lessening of rounds of sprays. One such pesticide, propargite was tested in this study against *P. ulmi* which reflected an excellent persistence on apple plants against this pest and can be considered in pest management programmes especially for the control of mites.

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