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Acaricide Resistance in Field Populations of Broad Mite, *Polyphagotarsonemus latus* (Banks) (Acari : Tarsonemidae)

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ABSTRACT

The broad mite, *Polyphagotarsonemus latus* (Banks), has assumed a key pest status in several crops like chilli, capsicum, mulberry, jute, tea, sesame and cotton in recent years. In spite of the increasing cases of outbreaks and reports of chemical control failures, the prevalence of acaricide resistance in broad mite remains under studied. In this context, five major acaricides were used to ascertain the resistance development in three field-collected populations of broad mite from Karnataka. A laboratory strain (NBAIR-GR-TAR-01a) of broad mite being maintained at ICAR-NBAIR showed high susceptibility to propargite 57 per cent EC (LC_{50} of 0.37 ppm), diafenthiuron 50 per cent WP (0.40 ppm), fenazaquin 10 per cent EC (0.44 ppm), spiromesifen 22.9 per cent SC (0.58 ppm) and dicofol 18.5 per cent EC (0.70 ppm). Among the field populations screened, the Haveri population showed higher resistance to the tested acaricides as compared to Chikkaballapur and Tumkur populations. Upon categorizing the resistance levels, resistance to spiromesifen was observed to be extremely high (162.55folds) in broad mites collected from Haveri on chilli crop. The acaricide which recorded the lowest levels of resistance was propargite (8.81 folds) in Tumkur population. Dicofol and fenazaquin registered moderate to high levels of resistance, while diafenthiuron recorded high levels of resistance across the populations studied.

Keywords : Resistance, Acaricides, Broad mite, Field populations

THE broad mite also called as yellow mite, *Polyphagotarsonemus latus* (Banks), is an important pest infesting several crops around the globe. It is reported to have more than 250 hosts including plants of agricultural and horticultural importance like chilli, capsicum, jute, mulberry, tea, sesame, cotton, potato, eggplant, beans, melons, celery, cotton, pears, guava, passion fruit, tea, flower crops like chrysanthemum, dahlia etc. In recent years, the infestation of *P. latus* (Banks) on several crops has significantly increased in India with a severe reduction in the quality and quantity of economic parts (Rai *et al*., 2007).

Among vegetables, chilli and capsicum are the most affected by *P. latus* often compromising the entire crop in massive infestations. On these crops, they habituate and multiply on the lower leaf surface causing curling of leaf margins downwards (Rao *et al*., 2020). The damage due to mites in chilli had been estimated to the tune of 60 per cent (Srinivasan *et al*., 2003) and can cause cent per cent yield loss under polyhouse conditions. Several bio-ecological factors of *P. latus* like microscopic nature, cryptic habitat, abundant progeny production, monoculture of host plants and their ability to reach damaging densities within a very short time demand the repeated application of pesticides in a prophylactic fashion both under open as well as polyhouse conditions that can lead to the rapid development of resistance (Leeuwen *et al*., 2010). Despite these facts, there are no studies on acaricide resistance in broad mite populations in India and abroad. Hence, the present study was undertaken to monitor the resistance development to major acaricides in field populations of *P. latus* in Karnataka.

Material and Methods

The isofemale susceptible population of *P. latus* (national accession number NBAIR-GR-TAR-01a) is being maintained on potted mulberry plants in nethouse at ICAR-National Bureau of Agricultural Insect Resources for more than 70 generations without exposure to chemicals. The population has reached the inbred stage and is used in comparative studies with the field populations.

In order to assess the status of acaricide resistance in field populations, roving surveys were conducted in chilli and capsicum fields both under open fields and polyhouses in three districts of Karnataka. Samples of *P. latus* were collected from Hosahalli, Chikkaballapur (13.1432° N, 77.6428° E); Hedigonda, Haveri (14.6834° N, 75.3849° E) and Koratagere, Tumkur (13.4489° N, 76.1678° E). The collected mites were released in large numbers on fresh uninfested mulberry plants and allowed to multiply. The mite progeny from the F_1 generation were used for bioassay studies.

Five acaricides recommended by the Central Insecticide Board for the control of broad mites were used for assessing the resistance level, *viz*., diafenthiuron 50 per cent WP, dicofol 18.5 per cent EC, fenazaquin 10 per cent EC, propargite 57 per cent EC and spiromesifen 22.9 per cent SC. The leaf dip bioassay recommended by the Insecticide Resistance Action Committee (IRAC, 2009) was used with suitable modifications. Different concentrations were established on the basis of preliminary bioassays to determine five and 95 per cent mortality concentrations and a minimum of five required concentrations were prepared by serial dilution from the stock solution of respective acaricides.

Freshly cut mulberry leaf discs devoid of mite infestation were immersed in the respective test chemical solutions for 30 seconds. The discs were allowed to air dry at room temperature and then placed on a wet cotton wad in petri plates. Adult female mites were chosen for bioassays on account of their comparative larger size and female-biased sex-ratio. Thirty adult females were transferred onto the treated leaf discs and incubated in a BOD chamber at 25±1 °C and RH 75±5 per cent. Each concentration and the control treatments had three such replications and mite mortality was recorded under a stereo binocular microscope. Mites that were not able to make any movement when poked with a brush after 24 hours of acaricide treatment were considered dead.

The median lethal concentrations (LC_{50}) were determined by Probit analysis (Finney, 1971) using Polo Plus 2.0 software and resistance ratios (RR) were computed by dividing the LC_{50} of the field population by that of the susceptible population. On the basis of RR values, the intensity of resistance was grouped as low (RR less than 10), moderate (RR between 10 and 40), high (RR between 40 and 160) and extremely high (RR greater than 160) (Kim *et al*., 2004).

Results and Discussion

The laboratory susceptible mite population (NBAIR-GR-TAR-01a) was highly susceptible to propargite with an LC_{50} of 0.37 ppm, followed by diafenthiuron (0.40 ppm), fenazaquin (0.44 ppm), spiromesifen (0.58 ppm) and dicofol (0.70 ppm). The resistance level to different acaricides varied among the three field populations.

The LC_{50} values for diafenthiuron were 26.00 ppm, 32.38 ppm and 32.00 ppm for Chikkaballapur, Haveri, and Tumkur populations, respectively. All the populations showed significantly high level of resistance as compared to the susceptible strain, based on non-overlapping of 95 per cent fiducial limits (Table 1). All the field populations were highly resistant to diafenthiuron with the highest RR for the populations collected from Haveri (80.95 folds), followed by Tumkur (80.00 folds) and Chikkaballapur (65.00 folds). Ranjeethkumar (2008) and Mohin (2020) also reported high levels of resistance to diafenthiuron in *Tetranychus urticae* populations on tomato.

TABLE 1

Dose-response mortality of *Polyphagotarsonemus latus* populations to diafenthiuron

Population	LC_{50} (ppm)	95% fiducial limits (ppm)	Slope ± SEM	χ^2 (df)	Hetero-geneity	RR	Class
Chikkaballapur	26.00	3.48 - 44.04	1.45 + -0.17	5.88 (3)	1.96	65.00	High
Haveri	32.38	25.80 - 40.52	1.48 ± 0.17	4.42 (3)	1.47	80.95	High
Tumkur	32.00	26.34 - 38.57	1.78 + -0.18	1.03 (3)	0.34	80.00	High
NBAIR-GR-TAR-01a	0.40	0.68 - 0.95	2.02 ± 0.18	1.17 (4)	0.39	-	-

df- degrees of freedom, RR- resistance ratio

TABLE 2

Dose-response mortality of *Polyphagotarsonemus latus* populations to dicofol

Population	LC_{50} (ppm)	95% fiducial limits (ppm)	Slope ± SEM	χ^2 (df)	Hetero-geneity	RR	Class
Chikkaballapur	34.65	20.45 - 60.27	2.52 ± 0.19	4.97 (3)	1.66	49.50	High
Haveri	58.68	47.17 - 72.70	1.61 + -0.19	1.88 (3)	0.63	83.83	High
Tumkur	19.23	11.47 - 37.29	1.45 ± 0.18	5.18 (4)	1.73	27.47	Moderate
NBAIR-GR-TAR-01a	0.70	0.59 - 0.83	1.72 ± 0.16	2.42 (3)	0.81	-	-

df- degrees of freedom, RR- resistance ratio

TABLE 3

Dose-response mortality of *Polyphagotarsonemus latus* populations to fenazaquin

Population	LC_{50} (ppm)	95% fiducial limits (ppm)	Slope ± SEM	χ^2 (df)	Hetero-geneity	RR	Class
Chikkaballapur	14.64	11.87 - 17.77	1.68 ± 0.18	2.31 (3)	0.77	33.27	Moderate
Haveri	19.90	16.18 - 24.38	2.84 ± 0.21	0.84 (4)	0.28	45.22	High
Tumkur	13.48	10.81 - 16.47	1.77 + -0.18	0.970(3)	0.32	30.63	Moderate
NBAIR-GR-TAR-01a	0.44	0.37 - 0.51	1.84 ± 0.17	0.34 (3)	0.11	-	-

df- degrees of freedom, RR- resistance ratio

The bioassays with dicofol indicated high level of resistance development in Haveri (LC_{50} 58.68 ppm) and Chikkaballapur populations (34.65 ppm). However, there was a lower level of resistance in case of Tumkur population (LC_{50} 19.23 ppm). The RRs varied from 27.47 to 83.83 folds indicating moderate to high levels of resistance (Table 2). Extremely high resistance of upto 1038.70 and 2231.8 folds were recorded by Najeer-E-Noor and Srinivasa (2018) and Mohin (2020) respectively in *T. urticae* populations on tomato. This might be because of the intensive use and high persistence of dicofol or related chemicals in tomato fields of Karnataka.

The LC_{50} values for fenazaquin ranged from 13.48 ppm to 19.90 ppm in the field populations and they differed significantly from the susceptible strain. The RR values of Chikkaballapur (33.27 folds), Haveri (45.22 folds) and Tumkur (30.63 folds) indicated moderate to high levels of resistance to fenazaquin in the tested populations (Table 3). Similar trend was observed (12.00 to 75 folds) in *T. urticae* populations on tomato by Najeer-E-Noor and Srinivasa (2018). Nevertheless, extremely high levels of resistance (988.77 to 1028.05 folds) were reported by Mohin (2020) from Chikkamagaluru and Shivamogga districts of Karnataka.

TABLE 4

Dose-response mortality of *Polyphagotarsonemus latus* populations to propargite

Population	LC_{50} (ppm)	95% fiducial limits (ppm)	Slope ± SEM	χ^2 (df)	Hetero-geneity	RR	Class
Chikkaballapur	5.75	4.52 - 7.18	2.45 ± 0.17	2.87 (3)	0.96	15.54	Moderate
Haveri	5.05	1.97 - 9.35	1.40 ± 0.18	6.42 (3)	2.14	13.64	Moderate
Tumkur	3.26	2.63 - 4.04	1.55 ± 0.17	1.64 (3)	0.55	8.81	Low
NBAIR-GR-TAR-01a	0.37	0.23 - 0.55	1.20 ± 0.13	4.95 (4)	1.24	-	-

df- degrees of freedom, RR- resistance ratio

TABLE 5

Dose-response mortality of *Polyphagotarsonemus latus* populations to spiromesifen

Population	LC_{50} (ppm)	95% fiducial limits (ppm)	Slope ± SEM	χ^2 (df)	Hetero-geneity	RR	Class
Chikkaballapur	53.90	30.19 -103.44	1.85 ± 0.19	9.07 (3)	3.02	92.93	High
Haveri	94.28	64.93 -136.55	1.97 + -0.19	4.68 (4)	1.56	162.55	Extremely high
Tumkur	58.45	28.09 -149.49	1.51 ± 0.18	9.17 (3)	3.06	100.78	High
NBAIR-GR-TAR-01a	0.58	0.49 - 0.68	1.91 + -0.18	0.60 (3)	0.20	-	-

df- degrees of freedom, RR- resistance ratio

For propargite, the highest LC_{50} was observed in Chikkaballapur population (5.75 ppm) followed by Haveri (5.05 ppm) and the least was in Tumkur population (3.26 ppm) (Table 4). The range of RRs was comparatively narrow (8.81 to 15.54 folds) and indicated low to moderate levels of resistance. Roy *et al*. (2018) and Titiksha and Sood (2019) reported low resistance to propargite in *Oligonychus coffeae* (11.94 folds) and *T. urticae* (3.54 to 5.63 folds), respectively which are in line with the present findings. However, high resistance (43.80 to 60.63 folds) was recorded by Naveena *et al*. (2022) and extremely high resistance upto 164 and 3,725 folds were recorded by Mohin (2020) and Hany *et al*. (2020), respectively on different *T. urticae* populations.

Spiromesifen was observed to have the widest LC_{50} range from 53.90 ppm to 94.28 ppm across the tested populations (Table 5). Chikkaballapur and Tumkur populations recorded RRs of 92.93 and 100.78 folds, respectively, indicating high resistance levels while Haveri population evidenced extremely high levels of resistance to spiromesifen, with RR being 162.55 folds. The results are in accordance with the findings of Najeer-E-Noor and Srinivasa (2018), Naveena *et al*. (2022) and Mohin (2020) who reported extremely high resistance to spiromesifen in *T. urticae* populations.

The successful management of a pest requires effective monitoring of the levels of resistance and examining the possible mechanisms involved. The present investigation is the first report of acaricide resistance in various field populations of broad mite. The results of the present study forewarn the rapid development of resistance in field populations of *P. latus* to various groups of acaricides. The variations in resistance levels in field populations depend on the nature and extent of acaricides usage by the farmers in different areas. The high level of resistance in the Haveri population might be because of mono-cropping of chilli year-round and frequent treatments with insecticide/acaricides.

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