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RELATIVE TOXICITY OF SELECTED ACARICIDES ON TWO SPOTTED SPIDER MITE (*TETRANYCHUS URTICAE*) OF BRINJAL

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ABSTRACT
Relative toxicity of eleven commercially available newer acaricides was tested against two spotted spider mite, *Tetranychus urticae* (Koch) under laboratory condition. Abamectin was found most action ovicidal with the lowest LC_{50} value of 2.63 ppm having growth regulating activity among this Hexythiazox and Buprofezin, Hexythiazox was more toxic to eggs and other developmental stages. Abamectin and Fenpyroximate were more toxic to adult females, while HMO was least toxic (with LC_{50} values of 0.01, 1.91 and 424.10 ppm, respectively). All the acaricides tested under laboratory conditions were proved superior over control and Abamectin and Fenpyroximate were more toxic to eggs and adults with the lowest LC_{50} values compared to other acaricides.

INTRODUCTION

Vegetable crops were found to be attacked by phytophagous mites, among the various species of mites, spider mites are mostly polyphagous species (Reddy *et al.,* 2014). Spider mites problem increased when natural enemies are destroyed by applications of broad spectrum insecticides, applied against other pests (Singh *et al.,* 2014). Now a days, the two spotted spider mite, *Tetranychus urticae* Koch is a cosmopolitan agricultural pest belonging to an assemblage of web-spinning mites (Jeppson *et al.,* 1975). These mites are minute, found in large colonies on the underside of leaves underneath fine silky webs, they feed and damages plant cells and tissues, their by affecting the quality and quantitative of yield of brinjal (Brandenburg and Kennedy, 1987; Martinez *et al.,* 2006). Recently in 2013, estimated avoidable loss in the yield of brinjal ranged from 26 to 39% under Bangalore conditions (Mutthuraju, 2013). Hence, the problem was selected to find out suitable solution for effective management of *T. urticae* by spraying selected acaricides.

MATERIALS AND METHODS

T. urticae culture maintained on potted brinjal plants in the glass house of Entomology Department was used for bioassay studies to determine the relative toxicity of acaricides against to eggs, immature and adzult females of *T. urticae*. Details of acaricides used are presented in Table 1.

Bioassay on eggs

For ascertaining the ovicidal action of acaricides, concentrations used in the bioassay of adults were made used. Few active female mites were released on a brinjal leaf bit measuring 2 cm x 2 cm kept on moist cotton wad in a Petri plate and allowed to lay eggs for 12-16h. About 30 eggs laid were retained on the leaf bit, which served as one replication. Three such replications were maintained for each dose/ concentration along with water sprayed control. One mL of the desired concentration was used for treating the eggs using Potter's spray tower operated at 15-20 lbs/inch^2. The eggs were observed for hatching every 24 h up to 120 h till all the eggs in water sprayed control hatched. Data on the percentage of eggs hatched after 120 h were used for determining median lethal concentration (LC_{50}) values by Probit Analysis (Finney, 1971) and relative ovicidal activity of different acaricides were ascertained based on LC_{50} values.

Bioassay on immature stages

For ascertaining the larvicidal and nymphicidal action of buprofezin and hexythiazox different concentrations were decided based on preliminary assays that gave range of mortalities from 10%-90%. Thirty larvae, protonymphs and deutonymphs were released on separate brinjal leaf bit measuring 2 cm x 2 cm kept on wet cotton wad in a Petri plate served as one replication. Three replications were maintained for each concentration along with a water sprayed control. One mL of the desired concentration was used for treating the immatures under Potter's spray tower. Observations on mortality were recorded at 24 h, 48 h and 72 h after treatment. The mortality data recorded were corrected using Abbott's formula (1925). The corrected mortalities were then subjected to Probit Analysis (Finney, 1971) for calculation of median

lethal concentration values (LC_{50}).

Bioassay on adult females

For bioassay studies on adult females also, concentrations of various acaricides were decided based on preliminary assays that gave range of mortalities from 10% to 90%. One mL of desired concentration of the test acaricide prepared using water was used for spraying brinjal leaf bit measuring 4 cm^2 leaf area. Thirty active females released on treated brinjal leaf bits kept on wet cotton wad in a Petri plate served as one replication. Three replications were maintained for each concentration along with a water sprayed control. Observations on mite mortality were recorded at 24h, 48h and 72h after treatment. Mites that remained inactive or moribund were also considered as dead.

The mortality data recorded were corrected using Abbott's formula (1925) depending upon the mortality in the water sprayed control. The corrected mortalities were then subjected to Probit Analysis (Finney, 1971) for calculating median lethal concentration values (LC_{50}) for each of the test acaricide and based on the LC_{50} values relative toxicity of different acaricides was determined.

Abbott's formula (1925)

$$\% \text{ mortality} = \frac{(\% \text{ mortality in treatment} - \% \text{ mortality in control})}{100 - \% \text{ mortality in control}} \times 100$$

RESULTS AND DISCUSSION

Ovicidal activity

The ovicidal activity of selected acaricide molecules was studied by observing the hatchability of treated eggs upto 120 h (till all the eggs in water sprayed control hatched). Data in respect of relative ovicidal activity of different acaricides determined by the LC_{50} values are presented in Table 2. Among the different acaricidal compounds studied abamectin was more toxic to eggs (ovicidal) with the lowest LC_{50} value of 2.63 ppm followed by fenpyroximate (4.59 ppm) buprofezin was least toxic with the highest LC_{50} value of 641.81 ppm. The descending order of ovicidal activity of different acaricides on *Tetranychus urticae* is abamectin (2.63 ppm) > fenpyroximate (4.59 ppm) > Hexythiazox (4.82 ppm) > fenazaquin (8.86 ppm) > fenpropathrin (10.83 ppm) > chlorfenapyr (40.44 ppm) > dicofol (44.17 ppm) > propargite (74.01 ppm) > diafenthiuron (168.89 ppm) > spiromesifen (234.59 ppm) > buprofezin (641.81 ppm). The lowest LC_{50} value of 2.63 ppm determined for abamectin in the present study is comparable to LC_{50} value of 3.77 ppm reported by Aji *et al.* (2007) for another avermectin compound milbemectin.

Toxicity to other developmental stages

Growth regulating activity of buprofezin and hexythiazox was studied by treating the developmental stages namely larvae and nymphs (protonymphs and deutonymphs) of *T. urticae* with different concentrations separately. The dosage mortality response data of immature stages *i.e.,* larvae, protonymph and deutonymph of *T. urticae* are presented in Table 3. Hexythiazox and buprofezin are growth regulators and are expected to be ovicidal directly or indirectly by affecting the viability of eggs laid by exposed or treated females. The adverse activity of these compounds on other post embryonic stages of the mite *i.e.,* larvae and nymphs was evident. Compared to buprofezin, hexythiazox was more toxic to immature stages with the LC_{50} values of 8.69 ppm, 7.24 ppm and 6.90 ppm for larvae, protonymphs and deutonymphs, respectively. The corresponding LC_{50} values of buprofezin to these immature stages were 36.49 ppm, 42.73 ppm and 265.40 ppm. Marshmalla and Preea (1991) recorded toxicity of clofentezine and hexythiazox to eggs and nymphs, but not to adults of *T. urticae*. They also observed that though treated nymphs developed into deutochrysalis and teliochrysalis stages, but were unable or fail to eclose from the quiescent stages. Similarly, Alzoubi and Cobanoglu (2008) also noticed ovicidal and ovo-larvicidal activity of hexythiazox on *T. urticae*. As suggested by these workers application of hexythiazox early in the season or during the period of abundant egg population might significantly check the further build up of mites in the later part of the crop or season.

Toxicity to adult females

The dosage mortality responses of *T. urticae* adult females to selected acaricides are presented in Table 4. LC_{50} values of different acaricides were determined by mortality data recorded 72 h after treatment. It was evident that abamectin was most toxic to adult females with the lowest LC_{50} value of

Table 1: Details of acaricides used in relative toxicity studies

Sl.No.	Acaricide	Trade name with formulation	Doses (ppm) used	Source
1	Abamectin	Abacin 1.9 EC	0.001, 0.002, 0.004, 0.008, 0.01, 0.02 and 0.03	Crystal Phosphate Limited, Azadpur, New Delhi
2	Buprofezin	Applaud 25 EC	10, 30, 50, 100, 200, 300 and 400	Rallis India Limited, Mumbai
3	Chlorfenapyr	Intrepid 10 EC	20, 30, 40, 50, 60, 80 and 90	BASF India Limited, Gujarat
4	Diafenthiuron	Pegasus 50 WP	20, 30, 40, 50, 60, 80 and 100	Syngenta India Limited, Pune
5	Fenazaquin	Magister 10 EC	2, 4, 6, 7, 8, 9 and 10	E.I. Dupont India pvt. Ltd., Gurgaon
6	Fenpropathrin	Rodi 10 EC	0.5, 1, 1.5, 3, 4, 6 and 7	New Chemi Industries, Gujarat
7	Fenpyroximate	Neon 5 EC	0.25, 0.5, 1, 2, 3, 4 and 5	Rallis India Ltd., Mumbai
8	Hexythiazox	Maiden 5.45 EC	2.5, 5, 10, 15, 20, 25 and 30	Nippon, Soda Co, Ltd., Japan
9	Propargite	Omite 57 EC	5, 10, 20, 40, 80, 120 and 140	Dhanuka Agritech Ltd., Gurgaon
10	Spiromesifen	Oberon 240 SC	25, 50, 250, 500, 750, 1000 and 1250	Bayer Crop Science Ltd., Mumbai
11	Dicofol	Commando 18.5 EC	5, 10, 20, 30, 40 and 50	Anu Products Ltd., Faridabad
12	HMO	Mak All Season	4000, 6000, 8000, 10000, 12000 and 14000	R and D Center, BPCL, Mumbai

Table 2: Relative toxicity of selected acaricides an eggs of two spotted spider mite, *Tetranychus urticae*

Acaricides	LC_{50}(ppm)	Fiducial limit (ppm)	Regression equation	χ^2 value (df)
Abamectin	2.63	0.29 - 10429.48	$\hat{Y}$ = -0.21+0.50X	4.08 (5)
Fenpyroximate	4.59	4.04 - 5.44	= -1.76+2.67X	6.36 (5)
Hexythiazox	4.82	2.59 - 6.91	= -1.08+1.58X	12.33 (5)
Fenazaquin	8.86	7.55 - 12.79	= -4.80+5.06X	26.64 (5)
Fenpropathrin	10.83	8.16 - 16.81	= -1.58+1.53X	6.95 (5)
Chlorfenapyr	40.44	38.01 - 42.85	= -7.50+4.67X	6.31 (5)
Dicofol	44.17	39.76 - 50.60	= -5.33+3.24X	2.27 (4)
Propargite	74.01	64.43 - 86.06	= -3.70+1.98X	4.09 (5)
Diafenthiuron	168.89	132.67 - 263.13	= -6.84+3.07X	0.53 (5)
Spiromesifen	234.59	114.07 - 407.39	= -4.23+1.78X	35.86 (5)
Buprofezin	641.81	433.18 - 1138.57	= -2.83+1.00X	9.89 (7)

Table 3: Relative toxicity of buprofezin and hexythiazox an developmental stages of two spotted spider mite, *Tetranychus urticae*

Mite stages	Acaricides	LC_{50}(ppm)	Fiducial limit (ppm)	Regression equation	χ^2 value (df=4)
Larva	Hexythiazox	8.69	6.16 - 10.83	= -1.19+1.27X	3.36
	Buprofezin	36.49	23.93 - 51.65	= -2.34+1.49X	7.11
Protonymph	Hexythiazox	7.24	5.68 - 8.61	= -1.68+1.95X	1.06
	Buprofezin	42.73	30.18 - 69.31	= -2.76+1.69X	9.98
Deutonymph	Hexythiazox	6.90	3.56 - 11.42	= -1.52+1.81X	19.77
	Buprofezin	265.40	210.29 - 358.22	= -2.97+1.22X	3.88

Table 4: Relative toxicity of selected acaricides an adult females of two spotted spider mite, *Tetranychus urticae*

Acaricides	LC_{50}(ppm)	Fiducial limits (ppm)	Regression equation	$\chi 2$ value (df = 5)
Abamectin	0.01	0.008 - 0.01	= 4.08+2.02X	5.82
Fenpyroximate	1.91	1.47 - 2.46	= -7.48+2.65X	15.69
Fenpropathrin	2.14	1.88 - 2.43	= -0.66+2.00X	3.97
Fenazaquin	7.17	6.34 - 8.01	= -6.12+7.15X	21.09
Dicofol	27.84	20.78 - 37.75	= -4.99+3.45X	18.19
Propargite	31.73	25.96 - 38.38	= -4.03+2.68X	8.25
Chlorfenapyr	38.59	34.28 - 42.82	= -7.42+4.67X	9.30
Diafenthiuron	47.89	45.41 - 50.42	= -9.11+5.42X	5.61
Spiromesifen	298.79	184.79 - 469.07	= -3.04+1.22X	13.54
Horticulture Mineral Oil	424.10	317.58 – 505.74	= -5.62+2.14X	6.17

0.01 ppm followed by fenpyroximate, fenpropathrin and fenazaquin with the corresponding LC_{50} values of 1.91 ppm, 2.14 ppm and 7.17 ppm. Horticulture Mineral Oil (LC_{50}=424.10 ppm) was least toxic. Aji *et al.* (2007) also observed superiority of milbemectin (1.05 ppm) or abamectin (1.44 ppm) in their toxicity to adult females of *T. urticae* infesting tomato and next in the order were fenpyroximate (20.82 ppm) and fenazaquin (32.75 ppm), as observed in the present study (Table 4). However, the LC_{50} values in respect of these compounds recorded in the present study may be attributed to the difference of the host crop, brinjal, also to frequency of acaricide application on the crop and the influence of plant-leaf characteristics.

LC_{50} values of dicofol for three different population of *T. urticae* on lima bean ranged from 71-666 ppm compared to LC_{50} value of 15-128 ppm for propargite, which indicated greater toxicity of propargite to spider mite on lima bean (Schiffhauer and Mizell 1988). But *T. urticae* population from brinjal in present study showed almost similar mortality response to dicofol (LC_{50} of 27.84 ppm) and propargite (LC_{50} of 31.73 ppm). Reasonable toxicity of fenpropathrin (2.14 ppm) to adults in present study may be attributed to its ability to induce dispersal or runoff of mites from the treated surface, observed frequently. Riedl and Shearer (1991) reported that fenpropathrin was highly repellent pyrethroid acaricide, primarily caused runoff and resulted in little direct mortality of *Panonychus ulmi* (Koch).

Control of *Tetranychus urticae* on vegetable crop like brinjal has been difficult due to its fast developmental rate, high reproductive potential, and also might be due to development of resistance to major groups of insecticides such as organochlorines, organophasphates, carbamates and synthetic pyrethroids. Hence there is a need to evaluate newer chemical with different mode of action and susceptibity of pest stages help to manage this mite pest from the point of view of their ecofriendly features like lower persistence, lower application dosage etc., relative toxicity studies will give the basic dosage value for fixing up of field doses for better management of *T. urticae*. The abamectin was most ovicidal with the lowest LC_{50} values of 2.63 ppm followed by fenpyroximate (4.59 ppm), hexythiazox (4.82 ppm) and fenazaquin (8.86 ppm). Buprofezin and hexythiazox having

growth regulating activity these are effective against eggs and nymphal stages of *T. urticae*. For adult females of *T. urticae,* abamectin and fenpyroximate were found more toxic (0.01 and 1.91 ppm, respectively), while Horticultural Mineral Oil was least toxic with the highest LC_{50} value of 424.10 ppm.

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