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Evaluation of Synthetics and Eco-friendly Products against *Tetranychus urticae* Koch on Cucumber

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Tetranychus urticae Koch, is known as a two-spotted spider mite and the most obtrusive polyphagous non-insect pest that causes havoc on horticultural crops. Cucumber cultivation is threatened by a variety of pest infestations, among which two-spotted spider mites cause the most damage to the crop. The efficiency of six different chemical acaricides against *T. urticae* in cucumber grown in polyhouse was examined. The results of the acaricide evaluation trial revealed that, the cumulative mean mite population recorded was the least 3.82 nos/ 2 cm^2 leaf with 76.81 percent reduction in mite population observed in plot sprayed with spiromesifen 240 SC @ 0.8 ml/lit followed by fenazaquin 10 EC @1.5 ml/lit. with 73.35 percent reduction in mite population (4.39 nos/2 cm^2). However, the control plot recorded maximum mite population of 16.48 nos/2 cm^2. The results of the eco-friendly management trial revealed that, the cumulative mean mite population was recorded was the least 5.24 nos/ 2 cm^2 leaf with 69.97 percent reduction in mite population was observed in plot sprayed with spiromesifen 240 SC @ 0.8 ml/lit followed by fenazaquin 10 EC @1.5 ml/lit. (6.09 nos/2 cm^2) with 65.13 per cent reduction, azadirachtin 10000 ppm @ 2 ml/ lit. with 66.82 percent reduction in mite population (6.14 nos/2 cm^2).

Keywords: Cucumber; Tetranychus urticae; acaricides; eco-friendly products.

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1. INTRODUCTION

Tetranychus urticae, Koch, a species of highly polyphagous two-spotted spider mite, has recently established itself as a significant pest on almost all vegetable crops [1].The two-spotted spider mite commonly attacks cucurbit crops in farmers' fields, along with other insect pests including beetles, leaf miners, and fruit flies. It was shown to be a serious pest of at least 150 commercially significant agricultural and ornamental species, feeding on more than 900 host plants [2]. *T. uticae* has an egg, larvae, protonymph, deutonymph, and adult stages in its life cycle [3,4]. A period of inactivity occurs at each instar, during which the mite attaches itself and moults to the next stage [5]. The growth and development of *T. urticae* are either directly or indirectly favored by the higher temperature. *T. urticae* can increase its population in warm weather conditions, and it was also continuing to do so in protected areas due to regulated environmental conditions [6] and frequent, indiscriminate pesticide use, which led to the development of resistance in mites to chemical pesticides sprayed [7]. Two-spotted spider mite, *T. urticae* Koch is a significant pest in horticultural, orchard, and field crops, including apple [8] cotton [9], grape [10], bean [10] strawberry [11], and burning bush [12]. While Park and Lee (2002) assessed *T. urticae*infested cucumber leaf photosynthetic rate and chlorophyll content reductions, Hussey and Parr (1963) devised a visual measure for *T. urticae* on cucumber leaf damage [13].

The ability of *T. urticae* to develop acaricide resistance quickly, as well as their high reproductive potential and short life cycle (allowing multiple generations in a growing season), when combined with the frequent applications of acaricides typically needed to keep mite populations below economic thresholds, has been reported by many researchers as a major problem in the control of *T. urticae* in India and around the world [1]. In this context, evaluation of eco-friendly products against *T. urticae* Koch was done on cucumber.

2. MATERIALS AND METHODS

2.1 Evaluation of Acaricides against Two Spotted Spider Mites

The field experiment was carried out at Annur, Coimbatore District in cucumber grown under polyhouse with lucifer hybrid to evaluate the efficacy of acaricides.The treatment details includespropargite 57 EC @ 2 ml/lit., fenazaquin 10 EC @1.5 ml/lit, fenpyroximate 5 SC @ 0.8 ml/lit, hexythiazox 5.45 EC @0.8 ml/lit, spiromesifen 240 SC @ 0.8 ml/lit, abamectin 1.8 EC @0.8 ml/lit and control. Two rounds of spray applications were given at fortnightly interval. The experiment was conducted in RBD with three replications. The population of active mites were assessed in the top, middle and bottom leaves (2 cm^2) of ten randomly selected plants before spraying andon 3, 7, 10 and 14 days after each spraying. Fruit yield was recorded at each picking and expressed as t/ha.

2.2 Data Analysis

The data recorded from the field study was analysed using IBM SPSS v.21 software.

2.3 Evaluation of Eco-friendly Products

The field experiment was carried out at Annur, Coimbatore District in cucumber grown under polyhouse with lucifer hybridto evaluate the efficacy of eco-friendly products (biopesticides, botanicals and synthetics). The treatment details includes Azadirachtin 10000 ppm @ 2 ml/lit., Neem oil @ 30 ml/lit., *Beauveria bassiana*@ 3 ml/lit., *Nomuraea anisopliae* @ 3 ml/lit., *Lecanicillium lecanii*@ 3 ml/lit., *Hirsutella thompsonii*@ 3 ml/lit., spiromesifen 240 SC @ 0.8 ml/lit,fenazaquin 10 EC @1.5 ml/lit and control. Two rounds of spray applications were given at fortnightly interval. The experiment was conducted in RBD with three replications. The population of nymphs and adults of mites were assessed on the top, middle and bottom leaves of ten randomly selected plants before spraying and on3, 7, 10 and 14 days after each spraying. Fruit yield was recorded at each picking and expressed as t/ha.

3. RESULTS

3.1 Evaluation of Acaricides against Two Spotted Spider Mites

The results revealed that, after the first round of spraying least mite population of 4.76 nos/ 2 cm^2 leaf with 69.89 per cent reduction was observed in plot sprayed with spiromesifen 240 SC @ 0.8 ml/lit followed by fenazaquin 10 EC @1.5 ml/lit. with 67.81 per cent reduction in mite population (5.09 nos/2 cm^2). However, the control plot recorded maximum mite population of 15.81 nos/2 cm^2

Table 1. Efficacy of acaricides against two spotted spider mite, *Tetranychusurticae* in cucumber (I round of application)

T. no	Treatments	Dose	Active stage of mites / 2 cm^2 - DAT						% reduction over control
			Pre count	3	7	10	14	Mean	
1	Propargite 57 EC	2 ml/lit	10.65	5.29 (2.41)[a]	4.79 (2.30)[a]	6.24 (2.60)[a]	8.07 (2.93)[a]	6.10	61.43
2	Fenazaquin 10 EC	1.5 ml/lit	11.12	4.68 (2.28)[a]	4.15 (2.16)[a]	5.20 (2.39)[a]	6.33 (2.61)[a]	5.09	67.81
3	Fenpyroximate 5 SC	0.8 ml/lit	11.98	5.07 (2.36)[a]	4.89 (2.32)[a]	5.89 (2.53)[a]	6.91 (2.72)[a]	5.69	64.01
4	Hexythiazox 5.45 EC	0.8 ml/lit	10.78	5.00 (2.34)[a]	5.18 (2.38)[a]	6.17 (2.58)[a]	7.48 (2.82)[a]	5.96	62.31
5	Spiromesifen 240 SC	0.8 ml/lit	12.42	4.18 (2.16)[a]	3.93 (2.10)[a]	4.76 (2.29)[a]	6.18 (2.58)[a]	4.76	69.89
6	Abamectin 1.8 EC	0.8 ml/lit	11.64	4.52 (2.24)[a]	4.66 (2.27)[a]	6.15 (2.58)[a]	7.02 (2.74)[a]	5.59	64.66
7	Control		12.44	13.90 (3.79)[b]	15.25 (3.97)[b]	16.19 (4.09)[b]	17.89 (4.29)[b]	15.81	0.01
SE (M)				0.21	0.15	0.13	0.17		
SE (d)				0.30	0.22	0.19	0.25		
CD (p=0.05)				0.63	0.46	0.40	0.51		

*DAT- Days after treatment; *Mean of three replications, Figures in parentheses are √ x+ 0.5 transformed values*

Table 2. Efficacy of acaricides against two spotted spider mite, *T. urticae* in cucumber (II round of application)

T. no	Treatments	Dose	Active stage of mites / 2 cm^2 - DAT						Cumulative mean / 2 cm^2	% redn Over control	Yield (t/ha)
			3	7	10	14	Mean	% redn			
1	Propargite 57 EC	2 ml/lit	4.67 (2.27)[a]	3.93 (2.10)[a]	5.46 (2.44)[a]	4.93 (2.28)[a]	4.69	73.48	5.39	67.28	25.2[b]
2	Fenazaquin 10 EC	1.5 ml/lit	3.61 (2.03)[a]	3.26 (1.94)[a]	4.22 (2.17)[a]	3.81 (2.05)[a]	3.70	79.09	4.39	73.35	27.3[c]
3	Fenpyroximate 5 SC	0.8 ml/lit	4.15 (2.16)[a]	3.44 (1.98)[a]	4.79 (2.30)[a]	4.36 (2.15)[a]	4.13	76.65	4.91	70.22	25.7[b]
4	Hexythiazox 5.45 EC	0.8 ml/lit	4.66 (2.27)[a]	3.52 (2.00)[a]	4.73 (2.29)[a]	4.68 (2.19)[a]	4.30	75.65	5.13	68.87	23.3[a]
5	Spiromesifen 240 SC	0.8 ml/lit	3.12 (1.90)[a]	2.34 (1.69)[a]	3.18 (1.92)[a]	3.14 (1.84)[a]	2.88	83.69	3.82	76.81	26.8[c]
6	Abamectin 1.8 EC	0.8 ml/lit	4.74 (2.29)	3.96 (2.11)[a]	4.84 (2.31)[a]	4.77 (2.24)[a]	4.51	74.46	5.05	69.36	25.3[b]
7	Control		17.99 (4.30)[b]	16.42 (4.11)[b]	17.02 (4.19)[b]	17.67(4.20)[b]	17.15		16.48		19.8
SE (m)			0.15	0.18	0.13	0.17					0.36
SE (d)			0.21	0.26	0.19	0.25					0.51
CD (p=0.05)			0.44	0.55	0.39	0.53					1.06

*DAT- Days after treatment; *Mean of three replications, Figures in parentheses are √ x+ 0.5 transformed values*

Table 3. Efficacy of biopesticide, acaropathogenic fungi and acaricides against two spotted spider mite, *T. urticae* in cucumber (I round of application)

T. no	Treatments	Dose	Active stage of mites (no./ 2 cm^2)* - DAT						% redn. Over control
			Pre count	3	7	10	14	Mean	
1	Azadirachtin 10000 ppm	2 ml/lit.	14.72	7.37 (2.81)^a	6.87 (2.71)^a	6.69 (2.68)^a	7.02 (2.74)^a	6.99	57.42
2	Neem oil	30 ml/lit.	13.65	8.40 (2.98)^b	8.38 (2.98)^b	8.65 (3.03)^b	9.26 (3.12)^b	8.67	47.15
3	*B.bassiana*	3ml/lit (1x10^8 spores/ ml)	12.68	9.51 (3.10)^b	9.10 (3.16)^b	9.24 (3.12)^b	9.97 (3.24)^b	9.45	42.39
4	*N. anisopliae*	3ml/lit (1x10^8 spores/ ml)	13.64	9.85 (3.22)^b	9.38 (3.14)^b	9.75 (3.20)^b	10.39 (3.30)^b	9.84	40.02
5	*L. lecanii*	3ml/lit (1x10^8 spores/ ml)	12.06	10.54 (3.32)^b	10.25 (3.28)^b	10.05 (3.25)^b	11.10 (3.41)^b	10.48	36.11
6	*H. thompsonii*	3ml/lit (1x10^8 spores/ ml)	14.33	9.91 (3.23)^b	9.23 (3.12)^b	10.19 (3.27)^b	11.01 (3.39)^b	10.09	38.53
7	Spiromesifen 240 SC @ 0.8	0.8 ml/lit	12.67	5.57 (2.46)^a	5.38 (2.42)^a	5.73 (2.50)^a	6.20 (2.59)^a	5.72	65.15
8	Fenazaquin 10 EC	1,5ml/lit	13.25	6.05 (2.56)^a	6.26 (2.60)^a	6.78 (2.70)^a	7.30 (2.79)^a	6.60	59.79
9	Control		12.88	14.32 (3.85)^c	16.29 (4.10)	17.15 (4.20)	17.89 (4.29)	16.41	-
SE (m)			NS	0.16	0.18	0.16	0.16	-	-
SE (d)				0.25	0.26	0.23	0.35	-	-
CD (P= 0.05)				0.50	0.54	0.48	0.50	-	-

*DAT- Days after treatment; * Mean of three replications; Figures in parentheses are √ x+ 0.5 transformed values*

Table 4. Efficacy of biopesticide, acaropathogenic fungi and acaricides against two spotted spider mite, *T. urticae* in cucumber (II round of application)

T. no	Treatments	Dose	Active stage of mites (no./ 2 cm^2)* - DAT					% redn over control	Cumulative mean	% redn. over control	Yield (t/ha)
			3	7	10	14	Mean				
1	Azadirachtin 10000 ppm	2 ml/lit.	6.22 (2.59)^a	5.75 (2.50)^a	5.98 (2.55)^a	6.61 (2.67)^a	6.14	66.82	6.81	60.98	22.2^b
2	Neem oil	30 ml/lit.	8.48 (3.00)^b	8.89 (3.06)^b	8.68 (3.03)^b	9.37 (3.14)^b	8.86	52.13	8.76	49.80	20.8^b
3	*B.bassiana*	3ml/lit (1x10^8 spores/ ml)	10.09 (3.25)^b	9.93 (3.23)^b	10.01 (3.24)^b	11.49 (3.46)^b	10.38	43.90	10.85	37.84	21.9^b
4	*N. anisopliae*	3ml/lit (1x10^8 spores/ ml)	10.49 (3.31)^b	9.86 (3.22)^b	10.17 (3.27)^b	12.09 (3.55)^b	10.65	42.41	11.94	31.64	21.8^b
5	*L. lecanii*	3ml/lit (1x10^8 spores/ ml)	11.17 (3.42)^c	10.77 (3.36)^b	10.97 (3.39)^b	12.74 (3.64)^c	11.42	38.30	12.64	27.62	20.8^b
6	*H. thompsonii*	3ml/lit (1x10^8 spores/ ml)	11.48 (3.46)^c	10.37 (3.30)^b	10.92 (3.38)^b	11.96 (3.53)^b	11.18	39.56	11.45	34.44	23.3^b
7	Spiromesifen 240 SC	0.8 ml/lit	4.89 (2.32)^a	4.47 (2.23)^a	4.68 (2.28)^a	5.03 (2.35)^a	4.77	74.23	5.24	69.97	25.1^c
8	Fenazaquin 10 EC	1,5ml/lit	5.56 (2.46)^a	5.19 (2.39)^a	5.38 (2.42)^a	6.18 (2.58)^a	5.58	69.86	6.09	65.13	24.2^c
9	Control		17.18 (4.21)^c	18.23 (4.33)^c	17.71 (4.27)^c	20.89 (4.62)^d	18.50	-	17.46	-	18.10^a
SE (m)			0.13	0.15	0.12	0.15					0.85
SE (d)			0.19	0.23	0.19	0.23		-	-	-	1.27
CD (P- 0.05)			0.40	0.47	0.38	0.46					2.58

*DAT- Days after treatment; *Mean of three replications; Figures in parentheses are √ x+ 0.5 transformed values*

(Table 1). After second spraying least mite population of 2.88 nos/2 cm^2 leaf with 83.69 per cent reduction was observed in plot sprayed with spiromesifen 240 SC @ 0.8 ml/lit followed by fenazaquin 10 EC @1.5 ml/lit. with 79.09 per cent reduction in mite population (3.70 nos/2 cm^2). However, the control plot recorded maximum mite population of 17.15 nos/2 cm^2 (Table 2). The cumulative mean of first and second spray revealed that, least mite population of 3.82 nos/2 cm^2 leaf with 76.81 per cent reduction was observed in plot sprayed with spiromesifen 240 SC @ 0.8 ml/lit followed by fenazaquin 10 EC @1.5 ml/lit. with 73.35 per cent reduction in mite population (4.39 nos/2 cm^2). However, control plot recorded maximum mite population of 16.48 nos/2 cm^2 (Table 2). Fruit yield was high 27.3 t/ ha in the plot received fenazaquin 10 EC @1.5 ml/lit followed by spiromesifen 240 SC @ 0.8 ml/lit (26.8 t/ha) followed by fenpyroximate 5 SC @ 0.8 ml/lit (25.7 t/ha). However, control plot recorded the fruit yield of 19.8 t/ha (Table 2).

3.2 Evaluation of Eco-friendly Products

The results revealed that, after first round of spraying least mite population of 5.72 nos/ 2 cm^2 leaf with 65.15 per cent reduction was observed in plot sprayed with spiromesifen 240 SC @ 0.8 ml/lit followed by fenazaquin 10 EC @1.5 ml/lit with 59.79 per cent reduction in mite population (6.60 nos/2 cm^2), azadirachtin 10000 ppm @ 2 ml/ lit. (7.49 nos/2 cm^2). However, control plot recorded maximum mite population of 16.41 nos/2 cm^2 (Table 3). After second spraying least mite population of 4.77 nos/2 cm^2 leaf with 74.23 percent reduction was observed in plot sprayed with spiromesifen 240 SC @ 0.8 ml/lit followed by fenazaquin 10 EC @ 1.5 ml/lit with 69.86 percent reduction in mite population (5.58 nos/2cm^2), azadirachtin 10000 ppm @ 2 ml/ lit. (6.14 nos/2 cm^2). However, the control plot recorded maximum mite population of 18.50 nos/2 cm^2 (Table 4). The cumulative mean of first and second spray revealed that, least mite population of 5.24 nos/2 cm^2 leaf with 69.97 per cent reduction was observed in plot sprayed with spiromesifen 240 SC @ 0.8 ml/lit followed by fenazaquin 10 EC @ 1.5 ml/lit with 65.13 per cent reduction in mite population (6.09 nos/2cm^2), azadirachtin 10000 ppm @ 2 ml/ lit. (6.81 nos/2 cm^2). However, a control plot recorded maximum mite population of 17.46 nos/2 cm^2 (Table4). The control plot recorded low fruit yield of 18.1 t/ha (Table 4).

4. DISCUSSION

The production of vegetables under protected cultivation become popular and adopted to grow in major parts of world. The optimization of weather parameters provided a favorable environmental condition for the growth of plants as well as for various insect and non-insect pests. The evaluation of six synthetic acaricides sprayed against *T.urticae* on cucumber in polyhouse revealed that among all sprayed chemicals spiromesifen recorded an excellent reduction (76.81 %) in mite population over control. The similar were reported by the Al-Antary (2012), who observed that spiromesifen proved to be effective in control of mites under controlled environment with an extended period of control as it has long residual action [14].Bharadwaj (2010) recorded that abamectin at 0.01 percent, hexythiazox at 0.0025 percent, propargite at 0.05 percent, and fenazaquin at 0.001 percent recorded excellent reductions on mite populations, while fenpyroximate at 96.10 percent and hexythiazox at 55.73-100 percent recorded the highest reductions due to longer residual action [15].

Among various tested bio-pesticides, azadirachtin resulted the highest reduction of two-spotted spider mite in cucumber under protected cultivation. This was followed by the neem oil (49.50 %), *B. bassiana (*37.84 %), *H. thompsonii* (34.44 %), and N*. anisopliae* (31.64 %). Whereas *L. lecanii* (27.2) recorded the least reduction compared to the other tested biocontrol agents. According to Ihsan and Ibrahim (2007), phytophagous mites of Capsicum were successfully eradicated by the application of Wettable Powder (WP) formulation of *B. bassiana* @ 1×10^{10} conidia in ml/lit [16]. Ullah and Lim [17] also shown that *T. urticae* population on potted bean plants was reduced by 94 percent after two sprays of *B. bassiana* @ 1×10^{8} spores/ml[17]. The maximum control on mite population was achieved with *L. lecanii* @ 0.30 percent liquid formulation, followed by *L. lecanii* @ 0.30 percent Wettable Powder formulation. Besides, Najafabadi et al. [18] reported that cucumber cultivars *viz.*, Samer star and Davos are resistant to *T. urticae*.

5. CONCLUSION

The efficacy of different acaricides and bio-pesticides has been studied against two spotted spider mites in cucumber under protected cultivation. The experiment was designed for

both chemicals and bio-pesticides in the account of testing the efficiency in mite population reduction. As the vegetable is marketed immediately upon harvesting, spraying of chemicals may cause residue problems as well as pollute the environment. Hence, azadirachtin @ 10000 ppm can be used as an alternative to the chemical acaricides against two spotted spider mites.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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