Original Research Article

Evaluation of synthetics and eco-friendly products against *Tetranychus urticae* Koch on cucumber

UNDER PEER REVIEW

Abstract

Tetranychus urticae Koch, is known as a two-spotted spider mite and the most obtrusive polyphagous non-insect pest that is causing causes havoc on horticultural and agricultural crops. The cultivation of cucumber Cucumber cultivation is threatened by a variety of pest infestations, among which two-spotted two-spotted spider mites causing 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 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 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 ecofriendly eco-friendly management trial revealed that, the cumulative mean mite population recorded was the least 5.24 nos/ 2 cm^2 leaf with 69.97 per centpercent 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 per cent percent reduction in mite population (6.14 nos/2 cm^2).

Comment [H1]: Please, add one sentences and give implication from the research result on the end abstract

Key words Keywords: Cucumber, *Tetranychus urticae*, acaricides, ecofriendly eco-friendly products.

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 the conclusion of each instar, during which the

Formatted: Font: Italic

mite attaches itself and moults to the next stage [5]. The growth and development of *T. urticae* are either directly or indirectly favoured by the higher temperature. *T. urticae* has the ability tocan-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.etranychus 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].

Comment [H2]: Please, add purpose of the research

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 includes propargite 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 intervals. 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.

Formatted: Space After: 0.6 line

Comment [H3]: Please add data analysis after the end paragraph

UNDER PEER REVIEW

2.2. Evaluation of ecofriendly products

The field experiment was carried out at Annur, Coimbatore District in cucumber grown under polyhouse with lucifer hybrid to 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., *Nomurae 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.

Formatted: Space After: 0.6 line

Comment [H4]: Please add data analysis after the end paragraph

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). 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 Ccumulative 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)

UNDER PEER REVIEW

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 Ccumulative 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). However, a control plot recorded low fruit yield of 18.1 t/ha (Table 4).

UNDER PEER REVIEW

Table 1. Efficacy of acaricides against two spotted spider mite, *Tetranychus urticae* in cucumber (First round of application)

Comment [H5]: Please, read the guidelines about writing of table and follow it

Treatments	Mite population (no./ 2 cm^2)						% Reduction Over control
	Pre count	3 DAT	7 DAT	10 DAT	14DAT	Mean	
Propargite 57 EC @ 2 ml/lit	10.65	5.29 (2.41)	4.79 (2.30)	6.24 (2.60)	8.07 (2.93)	6.10	61.43
Fenazaquin 10 EC @1.5 ml/lit	11.12	4.68 (2.28)	4.15 (2.16)	5.20 (2.39)	6.33 (2.61)	5.09	67.81
Fenpyroximate 5 SC @ 0.8 ml/lit	11.98	5.07 (2.36)	4.89 (2.32)	5.89 (2.53)	6.91 (2.72)	5.69	64.01
Hexythiazox 5.45 EC @0.8 ml/lit	10.78	5.00 (2.34)	5.18 (2.38)	6.17 (2.58)	7.48 (2.82)	5.96	62.31
Spiromesifen 240 SC @ 0.8 ml/lit	12.42	4.18 (2.16)	3.93 (2.10)	4.76 (2.29)	6.18 (2.58)	4.76	69.89
Abamectin 1.8 EC @0.8 ml/lit	11.64	4.52 (2.24)	4.66 (2.27)	6.15 (2.58)	7.02 (2.74)	5.59	64.66
Control	12.44	13.90 (3.79)	15.25 (3.97)	16.19 (4.09)	17.89 (4.29)	15.81	0.01
SE (d)		0.30	0.22	0.19	0.25	0.04	
CD (p=0.05)		0.63	0.46	0.40	0.51	0.08	

DAT- Days after treatment; *Mean of three replications, Figures in parentheses are $\sqrt{x+0.5}$ transformed values

UNDER PEER REVIEW

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

Treatments	Mite population (no./ 2 cm^2)						Cumulative mean (no./ 2 cm^2)	% Reduction Over control	Yield (t/ha)
Propargite 57 EC @ 2 ml/lit	4.67 (2.27)	3.93 (2.10)	5.46 (2.44)	4.93 (2.28)	4.69	73.48	5.39	67.28	25.2
Fenazaquin 10 EC @1.5 ml/lit	3.61 (2.03)	3.26 (1.94)	4.22 (2.17)	3.81 (2.05)	3.70	79.09	4.39	73.35	27.3
Fenpyroximate 5 SC @ 0.8 ml/lit	4.15 (2.16)	3.44 (1.98)	4.79 (2.30)	4.36 (2.15)	4.13	76.65	4.91	70.22	25.7
Hexythiazox 5.45 EC @0.8 ml/lit	4.66 (2.27)	3.52 (2.00)	4.73 (2.29)	4.68 (2.19)	4.30	75.65	5.13	68.87	23.3
Spiromesifen 240 SC @ 0.8 ml/lit	3.12 (1.90)	2.34 (1.69)	3.18 (1.92)	3.14 (1.84)	2.88	83.69	3.82	76.81	26.8
Abamectin 1.8 EC @ 0.8 ml/lit	4.74 (2.29)	3.96 (2.11)	4.84 (2.31)	4.77 (2.24)	4.51	74.46	5.05	69.36	25.3
Control	17.99 (4.30)	16.42 (4.11)	17.02 (4.19)	17.67 (4.20)	17.15		16.48		19.8
SE (d)	0.21	0.26	0.19	0.25	0.03				
CD (p=0.05)	0.44	0.55	0.39	0.53	0.07				

DAT- Days after treatment; *Mean of three replications, Figures in parentheses are $\sqrt{x+0.5}$ transformed values

Comment [H6]: Please, read the guidelines about writing of table and follow it

UNDER PEER REVIEW

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

Treatments	Mite population (no./ 2 cm^2) * - DAT						% Reduction over control
	Pre count	3	7	10	14	Mean	
Azadirachtin 10000 ppm @ 2 ml/lit.	14.72	7.37 (2.81)	6.87 (2.71)	6.69 (2.68)	7.02 (2.74)	6.99	57.42
Neem oil @30 ml/lit.	13.65	8.40 (2.98)	8.38 (2.98)	8.65 (3.03)	9.26 (3.12)	8.67	47.15
B.bassiana@ 3 ml/lit	12.68	9.51 (3.10)	9.10 (3.16)	9.24 (3.12)	9.97 (3.24)	9.45	42.39
M. anisopliae @ 3 ml/lit	13.64	9.85 (3.22)	9.38 (3.14)	9.75 (3.20)	10.39 (3.30)	9.84	40.02
V. lecanii@ 3 ml/lit	12.06	10.54 (3.32)	10.25 (3.28)	10.05 (3.25)	11.10 (3.41)	10.48	36.11
H. thompsonii@ 3 ml/lit	14.33	9.91 (3.23)	9.23 (3.12)	10.19 (3.27)	11.01 (3.39)	10.09	38.53
Spiromesifen 240 SC @ 0.8 ml/lit	12.67	5.57 (2.46)	5.38 (2.42)	5.73 (2.50)	6.20 (2.59)	5.72	65.15
Fenazaquin 10 EC @1.5 ml/lit	13.25	6.05 (2.56)	6.26 (2.60)	6.78 (2.70)	7.30 (2.79)	6.60	59.79
Control	12.88	14.32 (3.85)	16.29 (4.10)	17.15 (4.20)	17.89 (4.29)	16.41	
SE (d)	0.22	0.25	0.26	0.23	0.35		
CD (P= 0.05)	0.45	0.50	0.54	0.48	0.50		

DAT- Days after treatment; * $\overline{\text{Mean}}$ of three replications; Figures in parentheses are $\sqrt{x+0.5}$ transformed values

Comment [H7]: Please, read the guidelines about writing of table and follow it

Comment [H8]: Please, read the guidelines about writing of table and follow it

UNDER PEER REVIEW

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

Treatments	Mite population ((no./ 2 cm^2) * - DAT					% Reduction over control	Cumulative mean	% redn.over control	Yield (t/ha)
	3	7	10	14	Mean				
Azadirachtin 10000 ppm @ 2 ml/lit.	6.22 (2.59)	5.75 (2.50)	5.98 (2.55)	6.61 (2.67)	6.14	66.82	6.81	60.98	22.2
Neem oil @30 ml/lit.	8.48 (3.00)	8.89 (3.06)	8.68 (3.03)	9.37 (3.14)	8.86	52.13	8.76	49.80	20.8
B. bassiana@ 3 ml/lit	10.09 (3.25)	9.93 (3.23)	10.01 (3.24)	11.49 (3.46)	10.38	43.90	10.85	37.84	21.9
M. anisopliae @ 3 ml/lit	10.49 (3.31)	9.86 (3.22)	10.17 (3.27)	12.09 (3.55)	10.65	42.41	11.94	31.64	21.8
V. lecanii@ 3 ml/lit	11.17 (3.42)	10.77 (3.36)	10.97 (3.39)	12.74 (3.64)	11.42	38.30	12.64	27.62	20.8
H. thompsonii@ 3 ml/lit	11.48 (3.46)	10.37 (3.30)	10.92 (3.38)	11.96 (3.53)	11.18	39.56	11.45	34.44	23.3
Spiromesifen 240 SC @ 0.8 ml/lit	4.89 (2.32)	4.47 (2.23)	4.68 (2.28)	5.03 (2.35)	4.77	74.23	5.24	69.97	25.1
Fenazaquin 10 EC @1.5 ml/lit	5.56 (2.46)	5.19 (2.39)	5.38 (2.42)	6.18 (2.58)	5.58	69.86	6.09	65.13	24.2
Control	17.18 (4.21)	18.23 (4.33)	17.71 (4.27)	20.89 (4.62)	18.50		17.46	-	18.10
SE (d)	0.19	0.23	0.19	0.23	0.04	-	-	-	
CD (P= 0.05)	0.40	0.47	0.38	0.46	0.08				

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

Comment [H9]: Please, read the guidelines about writing of table and follow it

UNDER PEER REVIEW

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* done on cucumber in poly house 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 thatabamectin 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 *M. 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 (2014) 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. lecani*i @ 0.30 percent liquid formulation, followed by *L. lecanii* @ 0.30 percent Wettable Powder formulation.

Comment [H10]: Please add some references of the last 5 years

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 aspollute the environment. Hence, azadirachtin @ 10000 ppm can be used as an alternative to the chemical acaricides against two spotted spider mites.

6. References

Comment [H11]:

Comment [H12]: Please add more updated references (last 5 years)

UNDER PEER REVIEW

1. Reddy, D.S. and M.P. Latha, *Efficacy of certain new acaricides against two spotted spider mite, Tetranychus urticae Koch. on ridge gourd.* Pest Management in Horticultural Ecosystems, 2013. **19**(2): p. 199-202.
2. Van Leeuwen, T., et al., *Acaricide resistance mechanisms in the two-spotted spider mite Tetranychus urticae and other important Acari: a review.* Insect biochemistry and molecular biology, 2010. **40**(8): p. 563-572.
3. Cagle, L.R., *Life history of the two-spotted spider mite.* 1949.
4. Dosse, G., *The greenhouse spider mite.* Tetranychus urticae Koch forma dianthica and its control—Pflanzenschutz-Nachrichten Bayer, 1952. **5**: p. 239-267.
5. BOUDEREAUX, H., *Biological aspects of some phytophagous mites.* Annual Review of Entomology, 1963. **8**: p. 137-154.
6. Whalon, M.E., D. Mota-Sanchez, and R.M. Hollingworth, *Global pesticide resistance in arthropods*. 2008: Cabi.
7. Dekeyser, M.A., *Acaricide mode of action.* Pest Management Science: Formerly Pesticide Science, 2005. **61**(2): p. 103-110.
8. Croft, B., S. Hoyt, and P. Westigard, *Spider mite management on pome fruits, revisited: organotin and acaricide resistance management.* Journal of economic entomology, 1987. **80**(2): p. 304-311.
9. Wilde, G. and J. Morgan, *Chinch bug on sorghum: chemical control, economic injury levels, plant resistance.* Journal of Economic Entomology, 1978. **71**(6): p. 908-910.
10. Hluchý, M. and Z. Pospíšil, *Damage and economic injury levels of eriophyid and tetranychid mites on grapes in Czechoslovakia.* Experimental & applied acarology, 1992. **14**(2): p. 95-106.
11. Raworth, D., *An economic threshold function for the twospotted spider mite, Tetranychus urticae (Acari: Tetranychidae), on strawberries.* The Canadian Entomologist, 1986. **118**(1): p. 9-16.
12. Sadof, C.S. and C.M. Alexander, *Limitations of cost-benefit-based aesthetic injury levels for managing twospotted spider mites (Acari: Tetranychidae).* Journal of economic entomology, 1993. **86**(5): p. 1516-1521.
13. Park, Y.-L. and J.-H. Lee, *Impact of twospotted spider mite (Acari: Tetranychidae) on growth and productivity of glasshouse cucumbers.* Journal of Economic Entomology, 2005. **98**(2): p. 457-463.
14. Al-Antary, T.M., et al., *Residual effect of six acaricides on the two spotted spider mite (Tetranychus urticae Koch) females on cucumber under plastic houses conditions in three upper lands regions in Jordan.* Advances in Environmental Biology, 2012: p. 2992-2998.
15. Bharadwaj, S. and S. Sharma. *Response of two spotted mite, Tetranychus urticae Koch.(Fam: Tetranychidae) to new acaricides in apple orchards of Himachal Pradesh.* in *Abstract of International Symposium-cum-workshop in Acarology*. 2010.
16. Nugroho, I. and Y. bin Ibrahim, *Efficacy of laboratory prepared wettable powder formulation of entomopathogenous fungi Beauveria bassiana, Metarhizium anisopliae and Paecilomyces fumosoroseus against the Polyphagotarsonemus latus (Bank)(Acari: Tarsonemidae)(broad mite) on Capsicum annum (chilli).* Journal of Bioscience, 2007. **18**(1): p. 1-11.
17. Ullah, M.S. and U.T. Lim, *Laboratory bioassay of Beauveria bassiana against Tetranychus urticae (Acari: Tetranychidae) on leaf discs and potted bean plants.* Experimental and Applied Acarology, 2015. **65**(3): p. 307-318.

UNDER PEER REVIEW