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Bithika Phukan
Jr. Scientist, Regional, Agricultural Research Station, Karimganj 788710, Assam, India

Sahidur Rahman
Professor, Department of Entomology, Assam Agricultural University, Jorhat 785013, Assam, India

Kapil Kumar Bhuyan
Department of Tea Husbandry and Technology, Assam Agricultural University, Jorhat 785 013, Assam, India

Correspondence
Bithika Phukan
Jr. Scientist, Regional Agricultural Research Station, Karimganj 788710, Assam, India

Effects of botanicals and acaricides on management of *Tetranychus urticae* (Koch) in tomato

Bithika Phukan, Sahidur Rahman and Kapil Kumar Bhuyan

Abstract
An investigation on "Effects of botanicals and acaricides on management of *Tetranychus urticae* (koch) in Tomato" was carried out under polyhouse and experimental garden of Department of Entomology, Assam Agricultural University (AAU), Jorhat during 2012 and 2013. Evaluation of acaricides *viz*., profenofos 50EC (250g a.i./ha) and spiromesifen 240 SL (80g a.i./ha) and botanicals *viz*., bionol (10ml/l), pestoneem (3ml/l and 5ml/l) and eliminix (0.2%,0.3% and 0.4%) were found effective. Spiromesifen 240 SL gave the maximum reduction of 100% in the 7th day after first and second spraying during 2012 and 2013 and was at par with profenofos 50 EC (250g ai/ha) and eliminix (0.4%). However, eliminix (0.2%) was found to be the less effective treatment which resulted only in 50.99 and 43.73 after 7th day of treatment during 2012 and 2013 respectively. All the other treatments were at par in reduction of mites. Economics of the treatment showed that Spiromesifen 240 SL gave the maximum benefit: cost ratio of 1.13 in 2012 and 1.62 in 2013 respectively.

Keywords: *Tetranychus urticae*, management, tomato

1. Introduction
Mites are the most diverse representatives of ancient lineage in phylum Arthropoda, subphylum Chelicereta, class Arachnida and subclass Acari [12]. Their body plan is strikingly different to that of other arthropods in not having a separate head, instead an anterior region, the cephalothorax that combines the functions of sensing, feeding and locomotion [12]. Also a pair of pincer like mouthparts are present called as chelicerae. A remarkable diversity in acarine morphology is reflected in the variety of ecological and behavioural patterns that mites have adopted [4]. Thus the mites can inhabit either in soil, litter, water or plants.
Tomato is an important vegetable crop in India and is considered to have originated in Peru and South America [3]. It is known as protective food both for its nutritive value and wide spread cultivation. It is one of the most important vegetable crops cultivated for its fleshy fruits and is considered as important commercial and dietary vegetable crop [3]. As the tomato is widely adaptable and versatile, it is grown throughout the world either in outdoors or indoors. In India, total production of tomato is about 17,874'000 MT from an area of 884 '000 ha and the largest producer state is Karnataka with a production of 1916.6 '000 MT from an area of 57.80'000ha [3]. In Assam, tomato is grown in an area of 17.29' 000ha, production is 402.49'000 MT [3].
The crop has great production potential but there are some limiting factors which are responsible for its low productivity and arthropod pest is one of them [2]. Spider mites are assuming the status of serious pest on many crops of which tomato suffers heavily due to spider mite attack [2]. Under protected condition as well as field grown tomato, two spotted spider mite, *Tetranychus urticae* Koch, appears as serious pest causing remarkable damage to the crop mostly at late flowering or fruiting stage [1].
Tetranychids are important group of phytophagous mites attacking most of the plants [12]. The two spotted spider mite, *Tetranychus urticae* Koch is responsible for significant yield losses in many horticultural, ornamental and agricultural crops [13]. It is also a major concern in vegetables causing heavy damage leading to 7-48% yield losses [11].
Under outbreak conditions, as the chemical control is considered as the first line of defence, it is imperative to evaluate different acaricides and botanicals which are ecosafe, economic and very much effective at low application rate [11]. So, keeping in view the above facts, the present investigation "Effects of botanicals and acaricides on management of *Tetranychus urticae* (koch) in Tomato" was carried out.

2. Materials and Methods
The experiment was carried out under polyhouse and experimental garden of Department of Entomology, Assam Agricultural University (AAU), Jorhat during 2012 and 2013.

2.1 Evaluation of acaricides and certain botanicals.
The experiment was conducted to assess the efficacy of the different acaricides and botanicals namely profenophos (50 EC), spiromesifen (240 SL), bionol, pestoneem and eliminix. The experiment was carried out in plastic plots in the polyhouse in completely randomized design with 9 treatments and 3 replications each.

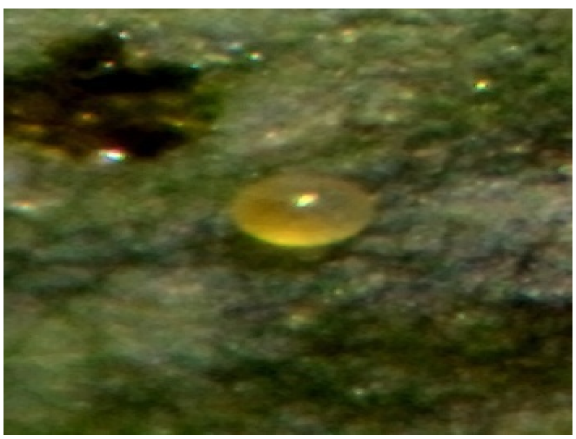
2.1.1 Layout of the experiment
Design	: CRD
Variety	: Tomato: Pusa ruby
Number of treatments	: 9
Number of replications	: 3
Number of pots	: 27

2.1.2 The treatments details are as follows
T_1: Profenofos 50 EC @ 250g a.i./ha
T_2: Spromesifen 240SL @ 80g a.i./ha
T_3: Bionol @ 1.0%
T_4: Pestoneem @ 0.3%
T_5: Pestoneem @ 0.5%
T_6: Eliminix @ 0.2%
T_7: Eliminix @ 0.3%
T_8: Eliminix @ 0.4%
T_9: Control (Untreated)

The dose of commercial acaricides are taken as g a.i./ha whereas for botanicals, per cent concentration of doses were considered to justify the experimental results with the previous works.

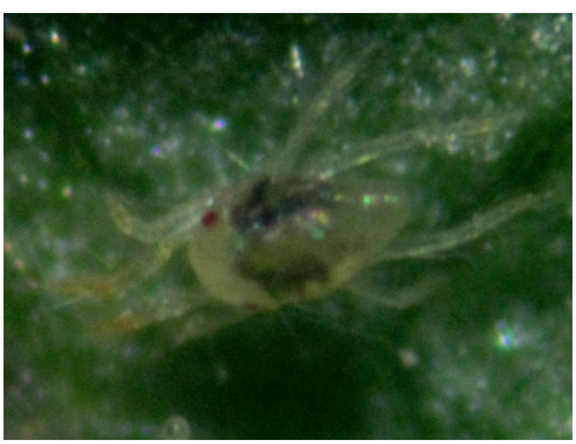
2.2 Application of treatments
All the treatments were applied on the potted plants with hand sprayer. Spraying was properly maintained so as to prevent drift of acaricidal spray to other pots. First spray was done at the first appearance of the symptoms with sufficient number of mites/leaf. The sprayer was washed thoroughly prior to the application of each treatment.

2.3 Sampling and method of observation
To evaluate the effect of foliar spray of various treatments on the population of mites, from each pot 3 randomly selected leaves from the upper, middle and lower canopy were plucked and held in separate polythene bags which were properly labelled and brought to the laboratory for counting mite population under a steriozoom binocular microscope at 4X magnification as shown in figure 1. The mite population was counted at one day before spraying and 1, 3 and 7 days after spraying (DAS). The data so obtained on mite count were summed up and converted to number of mite per leaf basis. Data so obtained were then statistically analyzed using fisher test so as to compare the effectiveness of acaricides against mite. The yield of ripe fruit of tomato/pot was estimated in kilograms.



a. Egg of *T.urticae*

b. First instar larvae of *T.urticae*



c. Adult male of *T. urticae* mite

d. Adult female of *T. urticae* mite

Fig 1: Different life stages of *Tetranychus urticae* (a-d)

2.4 Estimation of reduction or increase in two-spotted mite population

To estimate the reduction or increase in two-spotted mite population, data that were observed on 1, 3, 5 and 7 days after spraying were deducted from the pre-spraying count data and converted into percentage by the following formulae:

$$\text{Reduction}(-)/\text{increase}(+) = \frac{\text{Number of mites at pre spraying count - Number mites at 1, 3, 5, 7 DAS}}{\text{Number of mites at pre spraying count}}$$

2.5 Statistical Analysis

All the data were analyzed statistically. Significance of variance due to treatment effect was determined by calculating the respective ‘F’ values (Panse and Sukhatme, 1995).

The Standard Error (SE) of difference of mean was calculated by using the following formula:

$$\text{SEd}\pm = \sqrt{\frac{2 \times \text{Error mean square}}{\text{Number of replications}}}$$

To find out the significance of mean difference amongst the treatments critical difference (CD) was calculated by multiplying the standard error of difference of means with appropriate table value of ‘t’ at 5 per cent level of probability (Panse and Sukhatme, 1995).

CD = SED ± x ‘t’ (at 5%) for error degree of freedom.

2.6 Benefit: cost ratio

The benefit cost ratio was worked out by deducting the value of the yield over control and dividing it by the total cost of the expenditure over control as shown below:

$$\text{Benefit: Cost ratio} = \frac{\text{Yield in treatment \quad yield in control}}{\text{Cost of treatment}}$$

3. Results

3.1 Evaluation of certain acaricides and botanicals against *T. urticae* attacking tomato

Potted trials were conducted during 2012 and 2013 to evaluate the efficacy of acaricides *viz*., profenofos 50EC (250g a.i./ha) and spiromesifen 240 SL (80g a.i./ha) and botanicals *viz*., bionol (1.0%), pestoneem (0.3% and0.5%) and eliminix (0.2%,0.3% and 0.4%). Pre-treatment count of the mite population was made one day before spraying and post treatment counts were made at one, three, five and seven days after the spraying of treatments.

3.1.1 Population count of two spotted spider mite, *T. urticae* in tomato one day before spraying of treatment, 2012

Mite count was taken from each potted tomato plants, one day before treatment. The data are present in table 1. The highest mean no of mites recorded was 9.0 mites per leaf and the lowest was 7.0 mites per leaf.

3.1.2 Efficacy of certain acaricides and botanicals on the *T. urticae* population in tomato at different days after spraying, 2012

The efficacy of the different acaricides and botanicals were tested against two spotted spider mite, *T. urticae* during 2012 as shown in Fig 2. Results presented in Table 1 showed the effect of various acaricidal and botanical treatments in controlling mites. Data recorded at one day after spraying revealed that spiromesifen 240 SL (80g a.i./ha) gave the best result reducing 44.96 per cent mite population. This was followed by profenofos 50EC (250g a.i./ha) which was also at par with eliminix (0.4%) which resulted 33.96 and 30.63 percent reduction of mite population respectively, after 1 day of spraying. Lowest reduction in the mite population was recorded in eliminix (0.2%) and pestoneem (0.5%) that resulted in 14.48 percent reduction of mites and was at par with, pestoneem (0.3%), eliminix (0.3%) and bionol (1.0%) which resulted in 18.22, 18.24 and18.78 mite reductions, respectively.

The data recorded at three days after spraying presented in Table 1, revealed that all the treatments significantly reduced the *T. urticae* population per leaf as compared to control. Spiromesifen 240 SL (80g a.i./ha) maintained its superiority by recording 73.04 per cent reduction in mite population. The next best treatment was profenofos 50 EC (250g a.i./ha) which resulted in 61.26 per cent reduction followed by eliminix(0.4%) that recorded a reduction of 47.61 per cent population. Eliminix (0.2%) gave the lowest reduction of mites which was at par with eliminix (0.3%), pestoneem (0.5%), pestoneem (0.3%) and bionol (1.0%) resulting a population reduction of 23.41, 29.44, 24.20, 32.75 and 36.50 per cent, respectively.

After five days of treatments, significant difference among the treatments was noticed in reduction of mite population as shown in Table 1. Spiromesifen 240 SL (80g a.i./ha) stood significantly superior recording the highest of 88.03 per cent reduction of mite population which was at par with profenofos 50EC (250g a.i./ha) that recorded 78.25 per cent of mites while eliminix (0.4%) recorded a reduction of 60.47 per cent of mite population. The lowest efficacy was given by eliminix (0.2%) that recorded 38.69 per cent reduction of mite population.

The perusal of data recorded at 7 days after spraying revealed that spiromesifen 240 SL (80g a.i./ha) maintained its superiority over other treatments in reduction of mite population by 100 per cent which was also at par with profenofos 50EC (250g a.i./ha) and eliminix (0.4%) resulting in 91.90 and 77.45 per cent reduction, respectively. Eliminix (0.2%) and pestoneem (0.3%) recorded the lowest reduction of 50.98 per cent mite population as shown in Fig 3.

Fig 2: Healthy mite and egg of *T. urticae* before spraying

Fig 3: Affected adult and egg of *T. urticae* due to treatments after spraying

3.1.3 Population count of two spotted spider mite, *T. urticae* in tomato one day before spraying of treatment, 2013

From each potted tomato plants, the mites were counted one day before treatment. Data are present in Table 2 showed that the highest mean no of mites recorded was 60.0 mites per leaf and the lowest was 46.0 mites per leaf.

3.1.4 Efficacy of certain acaricides and botanicals on the *T. urticae* population in tomato after different days after spraying, 2013

The results presented in Table 2 revealed that after one day of spraying of the treatment, spiromesifen 240 SL (80g a.i./ha) gave a maximum reduction of 80.83 per cent of mite population. It was followed by profenofos 50EC (250g a.i./ha) and pestoneem (0.5%) that recorded a reduction of 60.39 per cent and 49.50 per cent respectively which was at par with elminix (0.4%) that reduced a population of 36.34 per cent. However, eliminix (0.2%) resulted the lowest reduction of mite population with of 19.17 per cent.

After three days of treatment, spiromesifen 240 SL (80g a.i./ha) gave the highest reduction of mite population of 90.16 per cent as presented in table 2 and was at par with profenofos 50EC (250g a.i./ha) and pestoneem (0.5%) which recorded 76.74 and 60.63 per cent reduction of mite population, respectively; while the lowest result was given by the eliminix (0.2%) which was at par with eliminix (0.3%) and pestoneem (0.3%) that recorded reduction of 32.23, 35.09 and 35.94 per cent, respectively.

Data recorded after five days of spraying exhibited similar result of efficacy of the treatments as shown in Table 2. Spiromesifen 240 SL (80g a.i./ha) resulted in maximum reduction of mite population with 96.16 per cent and was at par with profenofos 50EC (250g a.i./ha), pestoneem (0.5%) and elminix (0.4%) that gave a reduction of 86.34, 75.87 and 67.43 per cent respectively while eliminix (0.2%) gave the lowest reduction percent of 40.30 and was at par with eliminix (0.3%) pestoneem (0.3%), bionol (1.0%) and pestoneem (0.3%) that recorded 46.24, 47.38, 49.81 per cent, respectively.

Likewise, after seven days of treatment, similar results were observed where spiromesifen 240 SL (80g a.i./ha) gave the highest reduction of the mite population which was 100 per cent and was at par with profenofos 50EC (250g a.i./ha), pestoneem (0.5%) and elminix (0.4%) that recorded 93.92, 82.50 and 70.27 per cent respectively. Eliminix (0.2%) was the least effective treatment with a reduction of 43.73 per cent of mite population and was also at par with eliminix (0.3%) pestoneem (0.3%), bionol (1.0%) and eliminix (0.3%) that recorded 51.40, 53.76, 55.16 per cent respectively, (Table 2).

3.6 Benefit: cost ratio

The yield of the tomato crop obtained during 2012 and 2013 from different treated potted plants along with their benefit: cost ratio is presented in Table 3 and 4, respectively. The results revealed that maximum yield/pot were obtained from treatment spiromesifen 240 SL (80g a.i./ha) which is about 2.33kg during 2012 and 2.93kg during 2013. The minimum yield was obtained from the control pot i.e.11 kg and 1.16kg during 2012 and 2013 respectively. The highest benefit-cost ratio was also found in the treatment spiromesifen 240 SL (80g a.i./ha), i.e.1.13 and 1.62 during 2012 and 2013, respectively. On the basis of benefit-cost ratio, performance of the treatments were found in the decreasing order of spiromesifen 240 SL (80g a.i./ha) > profenofos 50EC (250g a.i./ha) > eliminix (0.4%) > bionol (1.0%)> pestoneem (0.5%) > eliminix (0.2%) > pestoneem (0.3%) > eliminix (0.3%).

Table 1: Population reduction of two spotted mite, *T. urticae* due to spraying of acaricides and botanicals spray during 2012.

Treatment	Dose	Mean number of mites per leaf (Pre-treatment)	Percent reduction of mites per leaf at different days after spraying (post-treatment)			
			1DAS	3DAS	5DAS	7DAS
T_1: Profenophos 50 EC	250 g a.i./ha	7.66	33.96 (35.61)	61.26 (51.47)	78.25 (62.17)	91.90 (73.46)
T_2: Spiromerifen 240 SL	80 g a.i./ha	8.66	44.96 (42.07)	73.04 (58.69)	88.03 (69.73)	100 (90)
T_3: Bionol	1.0%	7.33	18.78 (25.62)	36.50 (37.17)	44.97 (42.07)	58.99 (50.13)
T_4: Pestoneem	0.3%	9	18.22 (25.25)	32.75 (34.88)	44.24 (41.67)	50.98 (45.52)
T_5: Pestoneem	0.5%	7	14.48 (22.30)	24.20 (29.47)	42.06 (40.40)	57.93 (49.54)
T_6: Eliminix	0.2%	7	14.48 (22.30)	23.41 (28.93)	38.69 (38.47)	50.99 (45.52)
T_7: Eliminix	0.3%	9	18.24 (25.25)	29.44 (32.83)	48.14 (43.91)	58.51 (49.89)
T_8: Eliminix	0.4%	7.66	30.63 (33.58)	47.61 (43.04)	60.47 (51.00)	77.45 (61.62)
T_9: Control	Water spray	7	+19.16 (25.92)	+32.22 (34.57)	+41.85 (40.28)	+47.61 (43.04)
S.Ed(±)		NS	4.59	4.21	6.15	7.48
CD(0.05)		NS	9.63	8.84	12.92	15.72

DAS: Days after spray

Figures in the parenthesis are angular transformed values

+ Represents the percent increase and other values represent percent reduction in population

Table 2: Population reduction of two spotted mite, *T. urticae* due to spraying of acaricides and botanicals spray during 2013.

Treatment	Dose	Mean number of mites per leaf (Pre-treatment)	Percent reduction of mites per leaf at different days after spraying (post-treatment)			
			1DAS	3DAS	5DAS	7DAS
T_1: Profenophos 50 EC	250 g a.i./ha	56.66	60.39 (50.94)	76.74 (61.14)	86.34 (68.28)	93.92 (75.70)
T_2: Spiromerifen 240SL	80 g a.i./ha	56.66	80.83 (64.01)	90.16 (71.66)	96.16 (78.61)	100 (90)
T_2: Bionol	1.0%	47.66	28.72 (32.39)	43.38 (41.15)	47.38 (43.45)	55.16 (47.93)
T_4: Pestoneem	0.3%	55	21.22 (27.42)	35.94 (36.81)	49.81 (44.89)	53.76 (47.12)
T_5: Pestoneem	0.5%	46	49.50 (44.71)	60.63 (51.12)	75.87 (60.53)	82.50 (65.27)
T_6: Eliminix	0.2%	53.66	19.17 (25.92)	32.23 (34.57)	40.3 (39.41)	43.73 (41.38)
T_7: Eliminix	0.3%	52	28.21 (31.08)	35.09 (36.37)	46.24 (42.82)	51.40 (45.80)
T_8: Eliminix	0.4%	60	36.34 (37.05)	57.52 (49.31)	67.43 (55.18)	70.27 (56.91)
T_9: Control	Water spray	56.66	+2.5(9.1)	+6.41 (14.65)	+11.5 (19.82)	+15.33 (23.03)
S.Ed(±)		NS	8.29	8.49	6.88	7.28
CD(0.05)		NS	17.42	17.84	14.46	15.30

DAS: Days after spray
Figures in the parenthesis are angular transformed values
+ Represents the percent increase and other values represent percent reduction in population

Table 3: Economics of the treatment due to effect of different treatments, 2012.

Treatment	Dose	Yield/pot (kg)	Benefit : cost ratio
T_1: Profenophos 50 EC	250g a.i./ha	2.06	0.94
T_2: Spiromesifen 240SL	80g a.i./ha	2.33	1.13
T_3: Bionol	1.0%	1.66	0.48
T_4: Pestoneem	0.3%	1.33	0.22
T_5: Pestoneem	0.5%	1.4	0.27
T_6: Eliminix	0.2%	1.33	0.23
T_7: Eliminix	0.3%	1.26	0.16
T_8: Eliminix	0.4%	2.03	0.91
T_9: Control	Water spray	1.1	-

Table 4: Economics of the treatment due to effect of different treatments, 2013.

Treatment	Dose	Yield/pot (kg)	Benefit : cost ratio
T_1: Profenophos 50 EC	250 g a.i./ha	2.56	1.32
T_2: Spiromesifen 240SL	80 g a.i./ha	2.93	1.62
T_2: Bionol	1.0%	1.73	0.48
T_4: Pestoneem	0.3%	1.46	0.28
T_5: Pestoneem	0.5%	1.5	0.30
T_6: Eliminix	0.2%	1.5	0.33
T_7: Eliminix	0.3%	1.33	0.16
T_8: Eliminix	0.4%	2.33	1.14
T_9: Control	Water spray	1.16	-

4. Discussion

During the present investigation, two spotted spider mite, *Tetranychus urticae* Koch was found to be the mite species attacking tomato crop. *T. urticae* was the major mite species in tomato crop [8].

It was evident from the present investigation that all the acaricides *viz*., profenofos 50EC (250g a.i./ha) and spiromesifen 240 SL (80g a.i./ha) and botanicals *viz*., bionol (1.0%), pestoneem (0.3% and 0.5%) and eliminix (0.2%, 0.3% and 0.4%) were found effective in controlling the *T. urticae* population in tomato. During 2012, spiromesifen 240 SL (80g a.i./ha) was found to be the most effective treatment in reducing the mite population upto 44.96, 73.04, 88.03 and 100 percent at 1, 3, 5 and 7 days after spraying respectively and was at par with profenofos 50 EC (250g a.i./ha) and eliminix (0.4%). While eliminix (0.2%) was found to be the less effective treatment which resulted only 14.48, 23.41, 38.69 and 50.99 percent of reduction of mite population after 1,3,5 and 7 days after spraying, respectively. In 2013, a similar results were obtained where spiromesifen 240 SL (80g a.i./ha) found to be superior among the treatments by reducing the mite population to 80.83, 90.16, 96.16 and 100 percent after 1, 3, 5 and 7 days after spraying, respectively and was at par with profenofos 50 EC (250g a.i./ha) and eliminix (0.4%). On the other hand, eliminix (0.2%) was found to be the less effective treatment which resulted only in 19.17, 32.23, 40.30 and 43.73 per cent reduction of mite population after 1, 3, 5 and 7 days after spraying, respectively and was at par with eliminix (0.3%) pestoneem (0.3%) and bionol (1.0%). The reduction of mite population by spiromesifen treatment was due to its ability to suppress the larvae and reduce the fecundity of the female adults thereby reducing the mite population. The findings were similar with that of [10] where he observed that the larvae of *T. urticae* population were more affected by the two highest concentrations of spiromesifen (2.78 and 5.57mg/ l). The experiment was also conducted on acaricidal activities of spiromesifen, spirodiclofen and spirotetramat against female adults of *T. urticae* and found that the highest susceptibility of the mite population to these compounds was observed for spirodiclofen (3.1 mg a.i./l) followed by spiromesifen (26.39mg a.i./l) [9]. Also it was reported by Nauen *et al*. (2005) that the fecundity of the two spotted spider mite *T. urticae* female was greatly reduced after the treatment of spiromesifen on bean leaves in a concentration ranging from 0.064 to 40mg/l. Azadirachtin @ 1% was also found effective against *T. urticae* population that gave a population reduction of 70.16% [5].

The highest mean yield of 2.33 kg/pot and 2.93 kg/pot was obtained from spiromesifen 240 SL pots during 2012 and 2013, respectively. Benefit cost ratio was worked out and spiromesifen 240 SL registered the highest benefit cost ratio of 1.13 and 1.62 over control during 2012 and 2013, respectively. The difference in the benefit: cost ratio with other treatments was almost same due to less variation of yield among the potted plants.

5. Conclusion

From the present investigation, it can be concluded that due to application of different chemicals, the mite pest has developed resistance against certain acaricides. Therefore, evaluation of newer acaricides and botanicals are essential from time to time. Among the acaricides and botanicals evaluated against *T. urticae* population, spiromesifen 240 SL (80g a.i./ha) was the best treatment which was also at par with profenofos 50EC (250g a.i./ha), eliminix (0.4%). Therefore, from the present investigation, it can be concluded that organic formulation can be used as an alternative to chemical acaricides and eliminix (0.4%) and pestoneem (0.5%) can be applied as an organic treatment against the mite pest, *T. urticae*.

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