Research Article

Bio-Efficacy of Some Acaricides for Controlling Red Spider Mite *Tetranychus urticae* Koch. (Acari: Tetranychidae) on Brinjal *Solanum melongena* L.

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Abstract | A field trial was conducted to test the bio-efficacy of five commercial acaricidal formulations*viz.*, azocyclotine 25% WP (Gallop), fenpyroximate 5% SC (Unique-M), diafenthiuron 500 SC (Trophy), hexythiazon 10% WP (Nissorun) and abamectin 1.8% EC (Commando) against brinjal mites, *Tetranychus urticae*, on brinjal crop under field conditions. Brinjal vegetable was raised under standard agronomic practices. Field recommended dose of these acaricides were used knapsack sprayer. Results showed a significant mite reductionby allacaricides as compared to control. Among the tested acaricides, hexythiazon 10% WP (Nissorun) gave the highest reduction of mites (*i.e.,* 41.42, 55.56 and 37.90%) after 3, 5, and 7 days of first spray, respectively. Similarly, after second spray, hexythiazon 10% WP (Nissorun) again gave maximum reduction (*i.e.,* 41.65, 39.33 and 16.40%) of *T. urticae* at 3, 5 and 7 days, respectively.

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Introduction

Solanum melongena L., sometimes known as brinjal, aubergine or eggplant, is a significant vegetable crop that is a member of the Solanaceae family. It is a well-liked summer vegetable that is produced around the world in tropical and subtropical climates. Although it is a perennial crop, it is planted every year for commercial purposes. Calories, fat, water, fiber, protein, and carbs are all present in the fruit. It is an excellent source of vitamins and minerals. Customers in Pakistan always favor the form, size, and fruit colour of the several brinjal kinds that are cultivated there.

In Pakistan, the agricultural output of brinjal is acceptable. It is produced 88,148 tonnes over an area of and 9,044 acres in Pakistan. However, this yield of 40% is extremely low when compared to those of China, India, and Bangladesh, among other nations. The brinjal was attacked by several insect pests at various phases of growth, which resulted in a sustained loss of yields. The variety, season, and other factors all affect how much harm these bugs produce (Siscaro *et al*., 2019) few important insects pest of brinjal are brinjal fruit and shoot borer *Leucinodesorbonalis* (Pyraustidae: Lepidoptera), stem borer *Euzopheraperti*cella (Phycitidae: Lepidoptera) , red spider mites *Tetranychusurticae* (Acari: Tetranychidae) and many sucking pests like jassid *Amrascabigutullabigutulla* (Cicadellidae: Hemiptera), aphids *Myzuspersicae* (Aphididae: Homoptera) and white fly *Bemisia tabaci* (Aleyrodidae: Homoptera). Among these pests, red spider mites *T. urticae* is a most serious dangerous pest during summer months producing yield losses up to 32%.

The overuse of conventional formulated chemicals, which causes an imbalance in the natural regulating factors, is the major reason of this. The widespread use of hazardous pesticides, particularly pyrethroid acaricides, by vegetable producers is thought to be the main source of the red spider mite infestation in our homeland (Ghosh and Chakraborty, 2014) and some biopesticides (Ali *et al*., 2016). An insect population may be given a reproductive opportunity that allows for a fast rise in population as a result of changes in climate, habitat, or community organization. It is usual practice to cultivate crops in monocultures and to house cattle in contemporary raising facilities, which frequently causes mite outbreaks. Furthermore, this pest can grow and spread more easily in warm, dry climates (Ghosh and Hasan, 2021).

Mites have been stated as one of the most harmful pests of consumable fruits and vegetable crops (Ghosh and Chakraborty, 2014; Taher *et al*., 2019). The spread of this pest in several vegetables in Pakistan in recent years has caused severe issues for the producers. Red spider mite infection is typically first seen by a chlorotic, stippled look on the leaves, however this may not be as noticeable on plants with thick leaves. The chlorophyll that gives the leaves their green colour is removed by the mites as they feed on the underside of the leaves. Plant leaves that have been heavily affected get entirely pale, dry up, and drop off. The plants can suffer severe defoliation in large numbers. As plants weaken and photosynthetic activity is seriously hindered, yield may be greatly reduced (Fischer *et al*., 2019).

Our farmers frequently use the wrong acaricides to fight this insect, and occasionally they use conventional acaricides without having enough field control of this pest. The use of newer acaricides and the documentation of the population abundance and geographic spread of this pest in vegetables would provide our farmers with additional options for battling spider mites in vegetable farming. Realizing this approach, efforts were made in the present study to screen out new-chemistry acaricides for effective control of pests.

Materials and Methods

To assess the effectiveness and efficacy of few novel chemistry acaricides *viz*., azocyclotine 25% WP (Gallop), fenpyroximate 5% SC (Unique-M), diafenthiuron 500 SC (Trophy), hexythiazon 10% WP (Nissorun) and abamectin 1.8% EC (Commando) against the red spider mites' infestation. The research trial was conducted in the farmer's field under natural conditions during the year 2021. The experiment was laid out in a randomized complete block design (RCBD) with a total of six treatments together with five of them of promising standard acaricides and an untreated control having three replications of each treatment. Acaricides names, their formulation and doses used in the experiment are shown in Table 1.

Table 1: *Acaricides with their formulations and doses used against mite.*

Treatments	Common name	Formulation	Trade name	Dose (100 liter of water)
T_1	Azocyclotine	25% WP	Gallop	75 gm
T_2	Fenpyroximate	5% SC	Unique-M	200 ml
T_3	Hexythiazon	10% WP	Nissoran	200 gm
T_4	Abamectin	1.8% EC	Commando	300 ml
T_5	Diafenthiuron	500 SC	Trophy	200 ml

On a total area of 2023 m^2, the brinjal variety black beauty was transplanted in the field on ridges with row to row and plant to plant distances maintained at 70 and 25 cm, respectively. There were three blocks altogether, each with six rows of plants. When the population in the brinjal crop was over the

ETL threshold (8–10 per leaf), two sprays of each treatment were carried out at 15-days intervals. After calibration, a knapsack sprayer with a hollow cone nozzle was utilized for both the first and second spray. The amount of water to be utilized for each treatment was calibrated prior to the spray. Plots used as controls were left untreated. Throughout the entire cropping season, uniform whole-field agronomic practices were used.

Data was gathered prior to spraying as well as 3 days, 5 days, and 7 days following spraying from each block. Six plants from each block were chosen at random for this project. A magnifying lens was used to count the number of mites in the area. Three leaves were randomly chosen from each plant: one leaf from the top section, one leaf from the center, and one leaf from the lower portion. The Abbott formula (Abbott, 1925) was used to compute the percent mite reduction.

$$\text{Percent reduction of mites} = \frac{\text{Population before spray} - \text{Population after spray}}{\text{Population before spray}} \times 100$$

Identification

The mite specimens were put on microscope slides in a drop of Hoyer's media for identification (Singh and Raghuraman, 2011). Slides were dried for 4-5 days at 35–40 °C in a hot air oven. Specimens were examined using an Olympus SZX 41 (Digital microscopes) phase contrast microscope, and identification was accomplished by referring to established keys (Chant and McMurtry, 2007).

Results and Discussion

Reduction of Tetranychusurticae at different time intervals after 1st spray

Table 2 displays the findings of the field bio effectiveness tests conducted on several acaricides. After 3 days of 1st spray, all acaricides showed a highly significant difference among the treatments (F= 118.03; df=21; P<0.01). After 3 days of acaricides application, the highest percent reduction of *T. urticae* was observed in plots treated with hexythiazon (41.42%) followed by diafenthiuron (58.97%) and abamectin (62.35%). The least mite reduction which was statistically similar to each other were by fenpyroximate (77.60%) and azocyclotine (84.85%) exhibited. The highest mite population per leaf was observed in control plots (85.94 individuals) which were significantly higher than those of all other acaricides tested.

Table 2: *Comparative reduction (%) of Tetranychusurticae at different time intervals after 1st spray.*

Treatments	3 Days Mean±SE	5 Days Mean±SE	7 Days Mean±SE
T_1	84.85± 1.68 a	81.90± 1.19 a	66.56±0.66 a
T_2	77.60 ±1.65 a	55.52±0.89 c	32.21±1.62 cd
T_3	41.42 ± 0.67 c	55.56±0.90 c	37.90±0.63 c
T_4	62.35± 1.23 b	72.58 ±0.33 b	54.76 ±2.02 b
T_5	58.97±1.05 b	71.63 ±0.71 b	61.59 ± 1.03 ab
Control	85.94 ±1.71 a	84.20±1.12 a	60.96 ± 0.19 e
Tukey's HSD@ 5%	11.51	8.13	10.74
F-value	118.03	154.11	104.13

*Means sharing similar letters are not significantly different by Tukey's Test at P = 0.05 HSD = Highly Significant Difference Value * = Significant at P ≤ 0.05. ** = Significant at P ≤ 0.01.*

Similarly, highly significant difference was found among treatments for the control of mites after 5 days of spray in experiment (F= 154.11; df= 21; P<0.01). The acaricides, hexythiazon (55.56%) and fenpyroximate (55.52%) recorded maximum percentage of reduction which was statistically similar to each other followed by abamectin (72.58%) and diafenthiuron (71.63%) which were also statistically similar to each other (Table 2). Among the treatments, azocyclotine recorded the least mite reduction (*i.e.*, 81.90%). The mite population per leaf was also observed highest in control plots (84.20%) after 5 days which were significantly higher than those of all other tested acaricides.

After 7 days of spraying, the highest percentage of reduction was also observed in the plots treated with hexythiazon (37.90 %) and having lowest mite population was recorded followed by fenpyroximate (32.21%), abamectin (54.76%) and diafenthiuron (61.59%) was recorded of treated plots. The least percentage of reduction was recorded azocyclotine (66.56 %). The control treatments recorded highest mite population (60.96%). It was observed that all the tested acaricides gave more or less satisfactory percent reduction of mite population hexythiazon being recorded the highest percentage of reduction (Table 2).

Reduction of T. urticae at different time intervals after 2nd spray

The results of the field bio efficacy test of different acaricides are presented in the Table 3. The data from these results showed effectiveness of various acaricides for the control of mites after 3 days of 2nd spray revealed a highly significant difference among the treatments (F= 88.41; df= 21; P<0.01). After 3 days, the highest reduction of mites by the application of acaricides observed in plots which was treated with hexythiazon (41.65%) followed by diafenthiuron (45.87%), abamectin (56.56%) and fenpyroximate (66.50%). The least percent reduction was observed in plot treated with azocyclotine (72.30%). The highest mite population per leaf was observed in control plots (80.01%) which were significantly higher than those of all other acaricides tested.

Table 3: *Comparative reduction (%) of Tetranychus urticae at different time intervals after 2nd spray.*

Treatments	3 Days Mean±SE	5 Days Mean±SE	7 Days Mean±SE
T_1	72.30±1.96 a	70.21±1.31 a	74.29±1.01 a
T_2	66.50±1.01 ab	54.00±1.03 b	51.17± 0.95 b
T_3	41.65±1.69 f	39.33±0.34 d	16.40±0.69 de
T_4	56.56± 1.66 bcd	53.03.04±1.20 b	51.35±0.32 b
T_5	45.87±0.37 ef	53.40±0.66 b	34.82± 0.98 c
Control	80.01±1.55 g	78.99±0.68 e	80.03 ±1.01 e
Tukey's HSD@ 5%	12.42	8.71	9.02
F-Value	88.41	184.09	152.37

*Means sharing similar letters are not significantly different by Tukey's Test at P = 0.05 HSD = Highly Significant Difference Value * = Significant at P ≤ 0.05. ** = Significant at P ≤ 0.01.*

Similarly, highly significant difference (F=184.09; df=21; P<0.01) were found among treatments for the control of mites after 5 days of spray in experiment presented in Table 3. The acaricides hexythiazon (39.33%) recorded maximum percent reduction followed by abamectin (53.03%), diafenthiuron (53.40%) and fenpyroximate (54.00%) recorded percentage of reduction which was statistically similar to each other. The least percent reduction was recorded in Azocyclotine *i.e.*, (70.21%). The mite population per leaf was also observed highest in control plots (78.99%) after 5 days which were significantly higher than those of all other acaricides tested.

After 7 days of spraying, the highest mite reduction was also observed in the plots treated with hexythiazon (16.40%) and having lowest mite population was recorded followed by fenpyroximate (51.17%), abamectin (51.35%) and diafenthiuron (34.82%) was recorded of treated plots (Table 3). The least mite reduction was recorded in treatment where, azocyclotine (74.29%) were used. The control treatments recorded the highest mite population (80.03%). It was observed that all the tested acaricides gave more or less satisfactory percent reduction of mite population but acaricide hexythiazon was recorded as the most effective with the highest mite reduction.

Bio-efficacy of acaricides against *T. urticae* on brinjal during first and second spray showed that all the tested acaricides were found significantly effective in reducing the population of *T. urticae*. After 1st spray, acaricides abamectin, diafenthiuron, fenpyroximate and hexythiazox including azocyclotine were significantly at par in controlling the population of *T. urticae* (Table 2). Hexythiazon showed the highest reduction to *T. urticae* post 3, 5, and 7-days spray after 1st and 2nd spray (Tables 2 and 3). The findings of the present study are consistent with some previous studies Demaeght, Osborne *et al.* (2014) and Jan *et al.* (2021) who reported that Nissoran (hexythiazon 10%WP) was quite effective in controlling mites population in brinjal. Likewise, Reddy *et al.* (2014) and Ravali *et al.* (2017) reported hexythiazox, was highly superior against mites and gave 97-100% controlling greenhouse results as well as in field for *T. urticae* is agreed to our results.

In the present findings, fenpyroximate, abamectin, azocyclotine and diafenthiuron was almost equally effective against the mites. These results agree with findings of (Kumar and Wyman, 2009) who reported that acaricides having excellent acaricidal activity to mite in brinjal vegetable. All the acaricides were found effective in reducing mite population. Among them Abamectin, Azocyclotine and Fenpyroximate, were comparatively the least effective acaricides against *T. urticae* due to slow killer and development of resistance to some extent against mites. Many previous works by the researchers such as Choi *et al.* (2015) and Sangamithra *et al.* (2021) who have reported the incidence of resistance in mites in different parts of the world by fenpyroximate and azocyclotine.

Conclusions and Recommendations

Findings revealed that all acaricides azocyclotine, fenpyroximate, diafenthiuron and abamectin against brinjal mite, *T. urticae* were effective ones. Acaricide hexythiazon gave comparative better control among for both sprays at 3, 5 and 7 days. Therefore, to get the highest control of *T. urticae*, acaricides such as hexythiazon can be used in these days for effective control of this pest under field conditions.

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Novelty Statement

In Punjab province, the preferred acaricides were put to the test to reduce yield losses brought on by this pest's attack on aubergine and brinjal. The current study's conclusions and suggestions will serve as a foundation for choosing acaricides to increase brinjal production and as guidance for future research.

Author's Contribution

Muhammad Hasnain: Principal author did research and wrote the 1st draft of the manuscript.
Muhammad Hussnain Babar and Ghulam Sarwar: Helped in data collection.
Muhammad Kashif Nadeem: Reviewed literature and acaricides arrangement
Sajid Nadeem and Muhammad Shahid: Helped in data analysis and review draft.
Muhammad Akram and Ali Raza: Helped in performing quantitative data analysis.
Mussurrat Hussainand Qaisar Abbas: Provided practical assistance and helped in the writing
Each author assisted equally in analysis, revising, feedback, and endorsing the manuscript.

Conflict of interest
The authors have declared no conflict of interest.

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