Eco-friendly Management of Brinjal Mite (*Tetranychus urticae* Koch) by Some Biorational Approaches

ABSTRACT

Aims: In order to assess the efficacy of several biorational techniques against brinjal mite, *Tetranychus urticae* Koch.

Study design: The study used a single component Randomized Complete Block Design (RCBD) with three replications.

Place and Duration of Study: The experiment was conducted in the central farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from October 2021 to February 2022.

Methodology: The experiment consisted of seven treatments and was laid in a single factor Randomized Complete Block Design (RCBD) with three replications. Treatments viz. T_1= Spinomax (0.4ml/L of water); T_2= Neem Oil (5ml/L of water); T_3= Biomax (1.2ml/L of water); T_4= Ripcord (1ml/L of water); T_5= *Trichoderma* sp. (200mg/L of water); T_6= Mehogany Leaf Extract (200mg/L of water); T_7= Absolute (Control).

Results: Data on different parameters were collected for assessing results for this experiment. In case of experiment with different biorational control tactics, treatments showed varied response for mite pests. *Trichoderma* sp. (T_5) showed best result which was then followed by Neem oil (T_2) against mite pests infesting brinjal field. The results showed that in case of total number of fruit set, %healthy fruit was higher with the treatment of *Trichoderma* sp.

Conclusion: In most cases, except control treatment, ripcord showed the worst results against mite pests. So, *Trichoderma* sp. @200mg/L of water may be used for the eco-friendly management of brinjal mite.

Keywords: *Biorational approach, Tetranychus urticae, Trichoderma spp., Botanicals and Biopesticides*

1. INTRODUCTION

Bangladesh has one of the world's densest populations (1125 people per square kilometer) with a phenomenal growth rate of 1.37 percent. Despite the fact that Bangladesh is on track to become a middle-income country by 2021, agriculture remains the country's largest employer by far, employing 40.6 percent of the population [1]. The development and stability of Bangladesh's national economy have been significantly attributed to agriculture [2]. Bangladesh grows a wide range of vegetables. It is a key part of crop agriculture in Bangladesh, contributing $718 million (3.2%) to the country's agricultural GDP in 2018 [3]. Vegetables are the most often consumed group of plants because they are a key source of micronutrients. Brinjals, tomatoes, cauliflower, bitter gourd, ridge gourd, beans, carrots, spinach, and other major vegetables are grown in Bangladesh.

The plant known as the brinjal (*Solanum melongena* L.) also goes by the names aubergine, eggplant, melongene, garden egg, and guinea squash in British English [4]. In Bangladesh, it is the second-most significant vegetable crop in terms of acreage, productivity, and consumption, behind potatoes. It spans roughly 49,105 acres of the country's total vegetable area, generating 1.8 million tons per year [1]. Brinjal production is 55-60 t ha^{-1} [5]. The farmer is attracted to brinjal cultivation because of the better yield and longer fruiting and harvesting season [6]. Yield has been seriously harmed by the attack of different insect pests, which has lowered its fruit yield and quality. The shoot and fruit borer, *Leucinodes orbonalis* Guenee; the jassid, *Amrasca biguttula*; the whitefly, *Bemisia tabaci* Gennadius; and the aphid, *Aphis gossypii*, all attack the brinjal crop. Aphids and pests other than insects, such mites, especially the two-spotted spider mite *Tetranychus urticae Koch*, are the main obstacles to the productivity of brinjal [7,8]. Next to the shoot and fruit borer, the red spider mite, *T. urticae*, offers a considerable hazard to the cultivation of brinjal. The yield was reduced by up to 12.18 percent to 32.1 percent as a result of mite infestation [9]. *T. urticae* was found to cause a 16.16 percent yield reduction in brinjal [10].

The most diverse members of the phylum Arthropoda are mites, which are members of the subphylum Chelicerata and subclass Acari. Acari are the only arachnid species that eats plants. Common agricultural pests known as plant feeding mites damage a variety of crops, including fruits, vegetables, forage crops, ornamentals, and others. There are five families of the over 7,000 phytophagous mite species that have been discovered worldwide: Eriophyidae, Tarsonemidae, Tetranychidae, Tenuipalpidae, and Tuckerillidae [11]. The Tetranychidae family, popularly known as spider mites, is a huge family with approximately 1,200 species distributed across 70 genera [12]. *Tetranychus urticae* Koch (Acari: Tetranychidae), a two-spotted spider mite that affects over 1000 plant species from over 140 plant families, is one of the most devastating polyphagous pest species [13,14]. Koch originally characterized it in 1836, and it is assumed to have originated in temperate areas [15]. It feeds mostly on the midrib and plant veins, resulting in 50 to 100 percent yield reductions [16]. Mites are controlled with a variety of systemic chemical pesticides, including synthetic pesticides, although the mite has shown rapid pesticide resistance [17]. Due of the mite's quick growth and development, high fecundity, and haplo-diploid sex determination, pesticide resistance has quickly evolved [17]. Pesticide residues in vegetables are causing a decline in vegetable exports due to importing countries' major concerns [18]. Furthermore, the usage of synthetic chemicals has caused major environmental issues and posed a threat to human life [19,20]. Alternative techniques, such as the use of various bio-control agents, essential plant oils, and bio-pesticides, should be investigated for their acaricidal activity against mites in order to reduce the usage of chemical acaricides and develop integrated management tactics.

Plant-based pesticides are environmentally friendly and non-toxic to humans, fish, and other wildlife. Many essential oils extracted from plants had insecticidal and acaricidal activities against a variety of soft-bodied arthropod pests [21]. They have a variety of useful qualities, including repellence, antifeedant activity, growth regulation, and toxicity to a variety of insect and mite pests [22]. Today's vegetable growers in Bangladesh and other nations utilize a variety of synthetic chemical pesticides, including organophosphates, carbamates, pyrethroids, and nicotinoids [23]. Bangladeshi farmers rely heavily on the use of hazardous pesticides, with dangerous pesticides accounting for up to 25% of the cost of agriculture [24].

In Bangladesh, reports on the effectiveness of several chemical pesticides [25] and predators [26] to suppress mites are available. However, evidence on the effectiveness of entomopathogens, plant oils, and bio-pesticides against mite’s populations were scarce. As a result, the current study was designed to make an eco-friendly management using *Trichoderma* spp., bio-pesticide, plant oils, plant extracts, insecticide against mite’s populations in brinjal.

2. MATERIALS AND METHODS

2.1. Geographical location and climate

The current research was carried out between October 2019 and February 2020. The experiments were carried out at Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh. The site is located in latitude 23077'N and longitude 90033'E, with an elevation of 8.2 meters above sea level. The experimental site was located in a subtropical environment, and its climatic circumstances were characterized by significant sparse rainfall throughout the rabi season. The soil was from AEZ-28, "The Modhupur Tract." The test site was above flood level, flat, and equipped with an irrigation and drainage system.

2.2. Planting materials

The test crop in this experiment was BARI Begun 1. At the Bangladesh Agricultural Research Institute in Gazipur, Bangladesh, seeds were gathered.

Table 01. Treatments used in order to check efficacy of miticide with bio-pesticides in controlling mites.

Treatment No.	Name	Dose

T_1	Spinomax	0.4 ml/L of water at 15 days interval
T_2	Neem oil	5 ml/L of water at 15 days interval
T_3	Biomax	1.2 ml/L of water at 15 days interval
T_4	Ripcord	1 ml/L of water at 15 days interval
T_5	*Trichoderma* spp.	200 mg/L of water at 15 days interval
T_6	Mehogany Leaf extract	200 mg/L of water at 15 days interval
T_7	Control	Absolute

2.3. Experimental design

In order to minimize the impacts of soil heterogeneity, the experiment was set up using a single factor randomized complete block design (RCBD) with three replications. To reflect the three replications, the experimental area was divided into three blocks. Seven-unit plots were created within each block, and elevated bunds served as treatment markers. Thus, there were 7X3=21 plots in all. The unit plot was 3.6 by 1.6 meters. Two blocks and two plots were kept apart by 0.5 m and 0.5 m, respectively.

2.4. Land preparation and intercultural operation

On September 2019, the brinjal variety seeds were sowed in the seedbed. With the help of the farm department, the plot chosen for the experiment was opened in the first week of October 2019 and kept exposed to the sun for a week. After one week, the soil was harrowed, ploughed, and cross-ploughed numerous times, followed by laddering to guarantee good tilth. Each unit site's soil was amended with organic and inorganic manures. On October 15, 2019, seedlings were transplanted. When irrigation and drainage were required, they were provided. To keep the plots free of weeds so they could expand their growth and development, weeding was done.

2.5. Manuring and fertilizer application

Fertilizers N, P, K in the forms of urea, TSP, molybdate, and sulfate, S, Zn, and B in the forms of gypsum, zinc sulphate, and borax were supplied as recommended by the Bangladesh Agricultural Research Institute [27].

2.6. Data recording on efficacy of treatments against mite in brinjal

2.6.1. Data recording on plant height affected by mite infestation and treatments

The brinjal plant’s height was measured with a meter scale 3 times in the duration in the field. Plant’s heights were measured at 20 DAP, 40 DAP and 60 DAP. The data were counted on average.

2.6.2. Data recording on infested leaves affected by mite infestation and treatments

During the early morning hours, when the pest was least active, the number of mite nymphs and adults was counted on six leaves (each from two upper, middle, and lower leaves per plant). First, the mite population on the leaf's upper surface was counted. Next, the leaf was carefully rotated to count the population on the lower surface.

2.6.3. Data recording on infested fruits affected by mite infestation and treatments

On 2, 7 and 15 days after spraying, the pre and post treatment observations on live mite populations were compared. Each time fruit was harvested, the yield from each plot was recorded separately, and the overall yield was calculated on a per-hectare basis. The data were then transformed appropriately for a statistical analysis and significance test.

2.7. Statistical analysis

Data were gathered and assembled in a Microsoft Excel spreadsheet. Later, STATISTIX-10 software was used to perform an analysis of variance on the data. The f variance test was used to create an ANOVA, and mean value comparisons were carried out.

3. RESULTS AND DISCUSSION

The results and the subsequent discussion of the present study under heading and sub-heading conducted are depicted in this section.

3.1. Position of mite species

Mite is a minute pest of vegetables which suck the plant sap from the lower part of the leaves. It causes viral disease as secondary pest. Mite causes serious damage at brinjal.

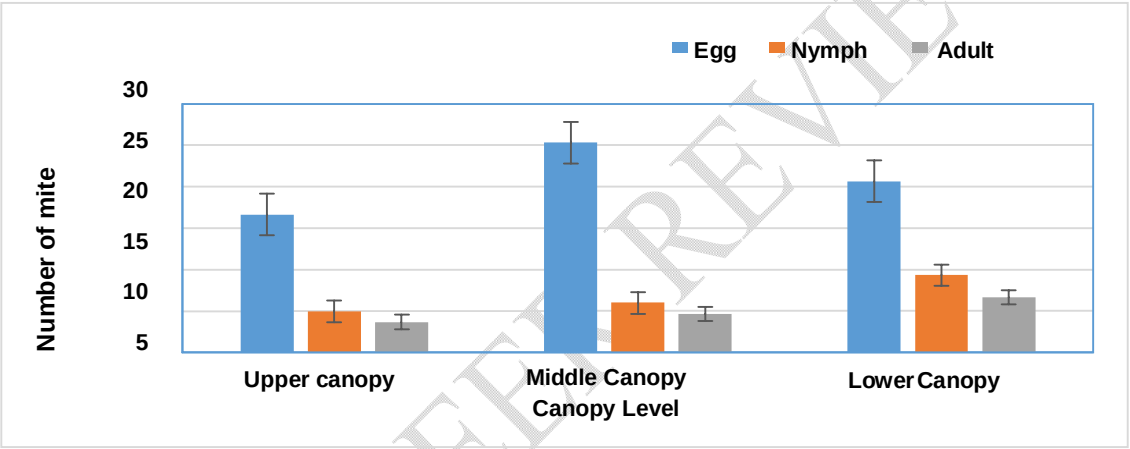

Figure 01. Population of mite species found in different canopy level of brinjal

From the figure 01, it is revealed that on an average all stages of mite population were found in brinjal field. In order to search a clear idea about mite habitat and distribution, three layers of brinjal canopy was thoroughly investigated. It was found that the highest number of eggs were present in middle canopy (25.33) followed by lower canopy (20.66) and upper canopy (16.66). In case of nymph population, highest number of nymphs were obtained from lower canopy (9.33) which was followed by middle canopy (6) and upper canopy (5). Similar trend was followed by adult mite population in brinjal field. It was seen that highest number of adult mites were found from lower canopy (6.66) followed by middle (4.66) and upper canopy (3.66) (Figure 01). Results are similar with the findings of Patil (2005). He showed that highest number of eggs, nymph and adult was found from middle canopy, bottom canopy and upper canopy respectively. A vertical slit on one side of the membrane allowed the larva to exit from the egg. With its legs, the larva expanded this aperture so that it could exit, leaving the eggshell on the leaf surface undamaged. After hatching, the eggshells were typically difficult to see. Natural mortality and predation caused the number of nymphs and adults to decline.

3.2. Effect of treatments on the brinjal leaf infestation of mite pests

It is evident that there was varied abundance and population density of mite in the brinjal field during the study period after the application of treatments. The plots were sprayed thrice at 15 days interval. The counting was made after each spray. From the table it is evident that the best control was obtained after the first spray followed by second and third spray. In case of the first spray, the lowest population was found from *Trichoderma* (11.33 per leaf) which is significantly different from any other treatments of the experiment. After *Trichoderma*, the lowest mite population was found from neem oil (12.66 per leaf) followed by Spinomax (14.0 per leaf), Biomax (14.33 per leaf), mehogany leaf extract (15.33 per leaf) and Ripcord (16 per leaf). Though numerically differed, there was no significant difference between T_3 and T_6, T_1 and T_3. However, the highest mite population (17.33 per leaf) was found from the absolute treatment (control) which was significantly different from other treatments

(Table 02).

In case of second spray, the lowest population was found from *Trichoderma* (12.33 per leaf) which was significantly similar with neem oil (13.0 per leaf). After *Trichoderma* and neem oil, the lowest mite population was found from followed by Biomax (15.0 per leaf), Spinomax (15.33 per leaf), mehogany leaf extract (16.0 per leaf) and Ripcord (17.33 per leaf) (Table 02). Though numerically differed, there was no significant difference between T_1, T_3 and T_6, T_4 and T_6, T_4 and T_7. However, the highest (18.0 per leaf) mite population was found from the absolute treatment (control) (Table 02).

In case of third spray, the lowest population was found from *Trichoderma* (14.0 per leaf) which was significantly and numerically similar with neem oil (14.0 per leaf). After *Trichoderma* and neem oil, the lowest mite population was found from followed by Biomax (16.67 per leaf), Spinomax (17.0 per leaf), Mehogany leaf extract (18.33 per leaf) and Ripcord (18.62 per leaf) (Table 02). Though numerically differed, there was no significant difference between T_1 and T_3 and T_1 and T_6, T_4 and T_7. However, the highest (19.67 per leaf) mite population was found from the absolute treatment (control). More or less similar result was found by Patel et al. [28]. In their study, plots treated with a 0.5 percent neem oil spray had a much lower mite population (2.63 mites/4 cm2 leaf) than the remainder of the bio-pesticidal treatments. Neem oil application (at a concentration of 3%) reduced the population of the mite *T. urticae* in a field trial with brinjal from 36.76 to 59.43%, according to Ramaraju [29]. Neem oil, at a concentration of 2%, was successful in killing *T. macfarlanei* on brinjal, according to Roopa [30]. According to Patil and Nandihalli [9], plots of aubergine that had been treated with neem oil had the fewest *T. macfarlanei* eggs and adults documented.

Table 02. Effect of treatments on the brinjal leaf infestation of mite pests

Treatment	No. of Mites (Nymph and adult/ Leaf)		
	First Spray	Second Spray	Third Spray
Spinomax (T_1)	14.00 d	15.33 ab	17.00 ab
Neem oil (T_2)	12.66 e	13.00 b	14.00 b
Biomax (T_3)	14.33 cd	15.00 ab	16.67 ab
Ripcord (T_4)	16.00 b	17.33 a	18.67 a
Trichoderma (T_5)	11.33 f	12.33 b	14.00 b
Mehogany Leaf extract (T_6)	15.33 bc	16.00 ab	18.33 a
Control (T_7)	17.33 a	18.00 ab	19.67 ab
CV (%)	**4.62**	**15.26**	**14.20**
Standard Error	**0.38**	**1.32**	**1.33**

[At a 0.05 level of probability, means in a column that share a letter are statistically identical]

3.3. Effect of treatments on the total number of brinjal fruit

The study's treatments varied statistically from one another. It has been seen that maximum number (17.33) of brinjal fruits was found from *Trichoderma* (T_5) which was statistically significant from any other treatments of the study (Table 03). After *Trichoderma*, the maximum number (15.667) of fruit was obtained from neem oil (T_2) followed by Biomax (T_3) from which we obtained 14 fruits per plant, Spinomax (T_1) from which we obtained 15.33 fruits per plant, Ripcord (T_4) from which we obtained 12.33 fruits per plant and Mehogany Leaf extract (T_6) from which we obtained 11.67 fruits per plant. However, Control (T_7) obtained the fewest (10.33) brinjal fruits, which was substantially different from any other treatments. (Table 03). Furthermore, there were no statistical variations between T_4 and T_6, T_4 and T_1, T_1 and T_3. *Trichoderma* found to be effective against mite pests.

Table 03. Effect of treatments on the total number of brinjal fruit

Treatment	Total Number of fruits per plant	Increase Over Control (%)
Spinomax (T_1)	13.333 cd	30%
Neem oil (T_2)	15.667 b	51.69%

Biomax (T_3)	14.00 c	35.52%
Ripcord (T_4)	12.33 de	19.36%
Trichoderma (T_5)	17.33 a	67.76%
Mehogany Leaf extract (T_6)	11.67 e	12.97%
Control (T_7)	10.33 f	-
CV (%)	**4.22**	-
Standard Error	**0.32**	-

[At a 0.05 level of probability, means in a column that share a letter are statistically identical]

3.4. Effect of treatments on the number of healthy and infested brinjal fruit

From the table 04, it is evident that there was significant variation between the different treatments. The highest number of healthy fruits (14.67 fruits per plant) were obtained from *Trichoderma* (T_5) which was statistically different from any other treatments and *Trichoderma* (T_5) shows 193.4% increase in healthy fruit yield compared to control. The number of healthy brinjal fruits (12.33 fruits per plant) then followed by Neem oil (T_2) which was also statistically different from other treatments and showed 146.6% increase in healthy fruit yield compared to control (Table 04). Though there was no statistically significant variation between Spinomax (T_1) and Biomax (T_3) but numerically better yield was obtained from Biomax (9.66 fruits per plant) which showed 113.4% higher result than control where Spinomax (10.67 fruits per plant) showed 93.4% increase over control. Similarly, there was no statistical variation between Ripcord (T_4) and Mehogany Leaf extract (T_6) rather numerically differed from each other. Ripcord (8.33 fruits per plant) showed 66.6% increase over control treatment whereas Mehogany Leaf extract (7.33 fruits per plant) showed 46.06% increase over control treatment. However, the lowest healthy fruit yield (5.0 fruits per plant) was obtained from the absolute treatment where no insecticide was applied (Table 04).

On the other hand, there was also significant variation between the obtained infested bitter gourd fruits from different treatments. The lowest number of infested fruits (2.67 fruits per plant) were obtained from *Trichoderma* (T_5) which showed 49.91% decrease over control. Further, the number of infested fruits was observed in following order, Neem oil (T_2), Biomax (T_3), Spinomax (T_1), Ripcord (T_4), Mehogany Leaf extract (T_6) and untreated. No statistical variations found among the T_2, T_3 and T_5 as well as T_1, T_2, T_3 and T_4. Numerically, Neem oil and Biomax showed 37.52% decrease over untreated field followed by Spinomax, Ripcord, Mehogany Leaf extract which experienced 31.14%, 24.95% and 18.67% decrease in infested fruit number over control. However, the highest infested bitter gourd fruits (5.33 fruits per plant) were obtained from control which was statistically different from all other treatments of the current experiment.

Table 04. Effect of treatments on the number of healthy and infested brinjal fruit

Treatment	Number of healthy fruits	Increase Over Control (%)	Number of infested fruits	Decrease Over Control (%)

	per plant		per plant	
Spinomax (T_1)	9.67 c	93.4%	3.67 bc	31.14%
Neem oil (T_2)	12.33 b	146.6%	3.33 cd	37.52%
Biomax (T_3)	10.67 c	113.4%	3.33 cd	37.52%
Ripcord (T_4)	8.33 d	66.6%	4.00 bc	24.95%
Trichoderma (T_5)	14.67 a	193.4%	2.67 d	49.91%
Mehogany Leaf extract (T_6)	7.33 d	46.6%	4.33 b	18.67%
Control (T_7)	5.00 e	-	5.33 a	-
CV (%)	**7.10**	-	**14.42**	-
Standard Error	**0.39**	-	**0.31**	-

[At a 0.05 level of probability, means in a column that share a letter are statistically identical]

3.5. Effect of treatments on the yield of brinjal

The highest yield (37.833 t/ha) was obtained from T_5 (*Trichoderma*) which was statistically significant from any other treatments of the present study and obtained 22.03% more yield than control treatment. The yield was then followed by Neem oil (T_2) and Biomax (T_3) which observed 36.33 and 35.33 t/ha respectively and no significant variation was observed between these two treatments (Table 05). The lowest yield (31.0 t/ha) comes from the absolute treatment which was statistically similar with the result obtained from Mehogany Leaf extract (T_6). Mehogany Leaf extract showed only 3% increase in yield over control. Overall, the *Trichoderma* (T_5) showed the best effect in every cases. This may be attributed to holistic approach of eco-friendly management tactics.

Table 05. Effect of treatments on the yield of brinjal

Treatment	Yield (t/ha)	Increase Over Control (%)
Spinomax (T_1)	34.00 c	9.67%
Neem oil (T_2)	36.33 b	17.19%
Biomax (T_3)	35.33 b	13.96%
Ripcord (T_4)	32.57 d	5.06%
Trichoderma (T_5)	37.83 a	22.03%
Mehogany Leaf extract (T_6)	31.93 de	3%
Control (T_7)	31.00 e	-
CV (%)	**2.07**	-
Standard Error	**0.41**	-

[At a 0.05 level of probability, means in a column that share a letter are statistically identical]

The ability of *Trichoderma*-based products to manage phytopathogenic fungus has contributed to their exceptional success. Some Trichoderma strains are distinctive for their prolonged use in horticulture because they exhibit a strong bio stimulant effect. They colonize plant roots in the natural environment with no obvious negative effects and are harmless for humans, livestock, and crop plants. Conidia-containing formulations, whether solid or liquid, can be employed to create adequate numbers of viable inoculant during the product's development and field use. Trichoderma releases auxins, short peptides, volatiles, and other active metabolites into the rhizosphere, which promote root branching and nutrient uptake capability, boosting plant growth and productivity. This communication occurs on multiple levels with the root and shoot systems. Recent proteomic and genetic data reveal that *Trichoderma* activates transcription factors, DNA processing proteins, and mitogen activated protein kinase 6, which are attractive targets for the development of more effective treatments.

4. CONCLUSION

The efficiency of various biorational approaches was evaluated in the field against the brinjal mite,

Tetranychus urticae, which infested brinjal. The treatment containing *Trichoderma* sp. @200 mg/L of water was shown to be superior to the other treatments in terms of lowering the brinjal mite population, however it was followed by neem oil @5 ml/L of water at 15 days interval. The treatment with Ripcord @1 ml/L of water was the least successful in reducing the mite population in brinjal, where the pest population was substantially higher. Thus, among the several biorational approaches tested, *Trichoderma* sp. @200 mg/L of water and neem oil @5 ml/L of water at 15 days interval were found to be effective against *T. urticae*, the brinjal mite.

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