Development of biorational management for tomato leaf miner, *Tuta absoluta*

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ABSTRACT: The experiment was carried out in farmers’ fields of Chaklarhat, Tunirhat, Panchagarh and Research Field of Horticulture Research Center, Bari, Gazipur from October 2017 to June 2018 to find an effective and suitable management approach against tomato leaf miner, *Tuta absoluta*. There was a total of ten treatments, viz., Treatment 1 = Application of *Metarhizium anisopliae* (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water, Treatment 2 = Foliar spray of azadirachtin (Bio-Neem plus 1EC @ 1mL/L of water), Treatment 3 = Foliar spray of *Bacillus thuringiensis* (Biocure) @ 2g/L of water, Treatment 4 = Mass trapping through installation of delta sex pheromone trap, Treatment 5 = Spraying of spinosad (Tracer 45WSC) @ 0.5mL/L of water, Treatment 6 = Spraying with chlorantraniliprole (Coragen 20SC) @ 0.5mL/L of water, Treatment 7 = Hand picking and destruction of infested leaf and fruit, Treatment 8 = Foliar spray of *B. thuringiensis* (Biocure) @ 2g/L of water + mass trapping through installation of delta sex pheromone trap + application of *M. anisopliae* biopesticide in soi @ 5g/L of water, Treatment 9 = Foliar spray of azadirachtin (Bio-Neem plus 1EC @ 1mL/L of water) + mass trapping through installation of delta sex pheromone trap + Application of *M. anisopliae* (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water and Treatment 10 = untreated control were evaluated against *T. absoluta* following RCB design with three replications. Results revealed that foliar spray of azadirachtin (Bio-Neem plus 1EC @ 1mL/L of water) + mass trapping through installation of delta sex pheromone trap + application of *M. anisopliae* (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water performed best in reducing *T. absoluta* infestation, increase of marketable yield and highest marginal benefit cost ratio.

KEY WORDS: Biopesticides, management, neem, pheromone traps, *Tuta absoluta*

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INTRODUCTION

Tomato is a popular vegetable in Bangladesh and it can be grown year-round. However, the South American tomato leaf miner, *Tuta absoluta* (Lepidoptera: Gelichiidae) is a devastating pest of tomato and is very difficult to control. It is known to cause 80 to 100 % crop loss in tomato (Desneux et al., 2010). The infestation of *T. absoluta* has also been reported on potato, eggplant and some solanaceous weeds (Urbaneja et al., 2013). This pest can complete 10-12 generations a year. Each female can lay 250-300 eggs in its lifetime. In 2006, it was identified in Spain and after that in a decade it has spread to most of Europe, Africa, West, Central and South Asia (Sridhar et al., 2014; Venkataramanan et al., 2017). In 2016, *T. absoluta* got introduced to Bangladesh (Hossain et al., 2016). This experiment was conducted to identify a non-chemical pesticide approach to manage *T. absoluta* in Bangladesh.

MATERIALS AND METHODS

Study sites

Studies were carried out at farmers’ field (26.2019°N and 88.3745°E) of Panchagarh and research field of Bangladesh Agricultural Research Institute, Gazipur (23.5937°N and 90.2432°E) district, Bangladesh. These two sites represent the commercial production areas as well as different climatic zones for tomato production in Bangladesh.

Plot layout and data collection

Studies were conducted following a Randomized Complete Block design with 10 treatments and 3 replications per location in two consecutive tomato growing seasons from October 2017 to June 2018. BARI tomato-17 and Indian Hybrid tomato variety 501 were used as test crops for winter and summer season, respectively. The treatments were:

1 = application of *Metarhizium anisopliae* (Lycomax, Russel
IPM) biopesticide in soil @ 5g/L of water; Treatment 2 = Foliar spray of azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water); Treatment 3 = Foliar spray of Bacillus thuringiensis (Biocure) @ 2g/L of water; Treatment 4 = Mass trapping through installation of delta sex pheromone trap; Treatment 5 = Spraying of spinosad (Tracer 45WSC) @ 0.5ml/L of water; Treatment 6 = Spraying with chlorantraniprole (Coragen 20SC) @ 0.5ml/L of water; Treatment 7 = Hand picking and destruction of infested leaf and fruit; Treatment 8 = Foliar spray of B. thuringiensis (Biocure) @ 2g/L of water + mass trapping through installation of delta sex pheromone trap + application of M. anisopliae (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water; Treatment 10 = control. Foliar sprays were applied by knap-sack sprayer. Data on number of healthy and infested plants; leaf and fruit infestation by leaf miner from the whole plot was recorded weekly. On the other hand, per cent plant infestation, leaf infestation per plant and fruit damage (visual estimation) by leaf miner was calculated.

The monetary return from the yield was calculated on the basis of farm gate price during April-June, 2018. Parameters of economic analysis were computed according to following formulas:

Gross return = Yield × Sale price,
Net return for treatment = Adjusted return – Cost of treatment
Marginal Benefit Cost Ratio = Adjusted return due to treatment / Cost of treatment

Data analysis
The data recorded on different parameters were analyzed statistically by using MSTAT-c software for analysis of variance after transformation. ANOVA was made by F-variance test and the differences between treatment means were compared by LSD test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of different treatments on plant, leaf and fruit infestation

Effect of different treatments on percent plant, leaf and fruit infestation by Tuta absoluta at Panchagarh and Gazipur are presented in Table 1. The lowest plant (45.23%) and leaf (14.35%) infestation was recorded in T4 treatment (Application of Metarhizium anisopliae (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water + foliar spray of Bacillus thuringiensis (Biocure) @ 2g/L of water + hand picking and destruction of infested leaves and fruits).

Table 1. Effect of different treatments on percent plant and leaf infestation by Tuta absoluta at Panchagarh and Gazipur during 2017-18

| Treatment | Dosage | % plant infestation | % reduction over control | % leaf infestation | % reduction over control |
|-----------|--------|---------------------|-------------------------|-------------------|-------------------------|
|           |        | Panchagarh | Gazipur | Panchagarh | Gazipur | Panchagarh | Gazipur | Panchagarh | Gazipur |
| T1        | 5 kg/ha| 58.64 (49.96)b | 10.21 (18.61)c | 30.72 | 70.36 | 19.22 (4.38)c | 7.58 (2.75)c | 24.33 | 51.22 |
| T2        | 1.0ml/L| 60.20 (50.90)b | 8.64 (16.97)c | 28.88 | 74.92 | 17.69 (4.20)d | 7.26 (2.67)c | 30.35 | 53.28 |
| T3        | 2 g/L  | 58.99 (50.17)b | 7.23 (15.58)c | 30.30 | 79.01 | 16.97 (4.12)d | 5.93 (2.43)c | 33.19 | 61.84 |
| T4        | -      | 80.43 (63.74)a | 17.30 (24.59)b | 4.97 | 49.78 | 23.35 (4.83)b | 10.09 (3.18)b | 8.07 | 35.07 |
| T7        | 0.5ml/L| 46.63 (43.04)c | 9.86 (18.27)c | 44.91 | 71.38 | 15.07 (3.88)fg | 7.53 (2.74)c | 40.67 | 51.54 |
| T9        | 0.5ml/L| 49.14 (44.49)c | 10.99 (19.31)bc | 41.94 | 68.09 | 16.06 (4.00)ef | 7.20 (2.68)bc | 36.77 | 53.67 |
| T10       | -      | 81.28 (64.40)a | 23.07 (28.69)b | 3.97 | 33.03 | 23.43 (4.84)b | 14.52 (3.81)b | 7.76 | 6.56 |
| T12       | -      | 46.40 (42.91)c | 9.09 (17.54)c | 45.18 | 73.61 | 14.76 (3.84)fg | 6.41 (2.52)c | 41.89 | 58.75 |
| T14       | -      | 45.23 (42.24)c | 6.78 (15.09)c | 46.56 | 80.32 | 14.55 (3.81)g | 5.06 (2.25)c | 42.72 | 67.44 |
| T16       | -      | 84.64 (66.94)a | 34.45 (35.87)aj | - | - | 25.40 (5.03)ja | 15.54 (3.94)ja | - | - |

Level of significance: ** **
CV% | 5.37 | 8.56 | 3.05 | 5.71 |

[Treatments]: Treatment1 = Application of Metarhizium anisopliae (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water; Treatment2 = Foliar spray of Azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water); Treatment3 = Foliar spray of Bacillus thuringiensis (Biocure) @ 2g/L of water; Treatment4 = Mass trapping through installation of Delta sex pheromone trap; Treatment5 = Spraying of spinosad (Tracer 45WSC) @ 0.5ml/L of water; Treatment6 = Spraying with chlorantraniprole (Coragen 20SC) @ 0.5ml/L of water; Treatment7 = Hand picking and destruction of infested leaves and fruits; Treatment8 = Foliar spray of Bacillus thuringiensis (Biocure) @ 0.5ml/L of water + Mass trapping through installation of Delta sex pheromone trap + Application of M. anisopliae (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water + foliar spray of Bacillus thuringiensis (Biocure) @ 2g/L of water + Hand picking and destruction of infested leaves and fruits; Treatment9 = Foliar spray of M. anisopliae biopesticide in soil @ 5g/L of water + Mass trapping through installation of Delta sex pheromone trap + Application of M. anisopliae (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water + foliar spray of Bacillus thuringiensis (Biocure) @ 2g/L of water + Application of M. anisopliae biopesticide in soil @ 5g/L of water; Treatment10 = untreated control]
of azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + mass trapping through installation of delta sex pheromone trap followed by T1 treatment (foliar spray of Bacillus thuringiensis (Biocure) @ 2g/L of water + mass trapping through installation of delta sex pheromone trap + application of M. anisopliae (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water) at Panchagarh. Per cent reduction of infestation over control were also exhibited the same trend. At Gazipur, the lowest plant (6.78%) and leaf (5.06%) infestation were recorded in T9 treatment (application of M. anisopliae (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water + foliar spray of azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + mass trapping through installation of delta sex pheromone trap + application of M. anisopliae (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water). Both of them were statistically at par with each other. Accordingly, per cent reduction of infestation over control were also exhibited the same trend. On the contrary maximum infestation was recorded in untreated control plot both at Panchagarh and Gazipur.

Effect of different treatments on per cent fruit infestation by T. absoluta at Panchagarh and Gazipur during 2017-18 is presented in Table 2. At Panchagarh, the treatment T1 had the lowest fruit infestation (10.92%) followed by T4 treatment (11.00%). Maximum fruit infestation (19.97%) was recorded in control plot. Accordingly, maximum reduction of fruit infestation over control was also found in Treatment T4 (45.32%) followed by T8 treatment (44.92%). The similar trend was also found at Gazipur.

**Effect of different treatments on marketable yield**

The results indicated that T9 treatment (application of M. anisopliae (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water + foliar spray of azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water + mass trapping through installation of delta sex pheromone trap) provided the highest marketable yield (51.07ton/ha) followed by T8 treatment (foliar spray of B. thuringiensis (Biocure) @ 2g/L of water + mass trapping through installation of delta sex pheromone trap + application of M. anisopliae (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water) (49.41ton/ha) at Panchagarh (Table 3). Accordingly 39.65% and 35.11% marketable yield were increased in T9 treatment and T8 treatment respectively over untreated control.

But in case of Gazipur, T8 treatment (application of M. anisopliae (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water + foliar spray of azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + mass trapping through installation of delta sex pheromone trap) provided the highest marketable yield (64.20 ton/ha) followed by T9 (foliar spray of B. thuringiensis (Biocure) @ 2g/L of water + mass trapping through installation of delta sex pheromone trap + application of M. anisopliae (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water) (62.21ton/ha). Accordingly, the same trend was found in increased marketable yield over control treatment.

| Treatment | Dosage | % fruit infestation | % reduction over control |
|-----------|--------|---------------------|--------------------------|
|           |        | Panchagarh | Gazipur | Panchagarh | Gazipur |
| T1        | 5kg/ha | 13.23 (3.64)abcd | 1.67 (1.29)c | 33.75 | 49.24 |
| T2        | 1.0ml/L | 13.37 (3.66)abcd | 1.66 (1.23)c | 33.05 | 49.54 |
| T3        | 2 g/L | 12.80 (3.58)abcd | 1.77 (1.33)c | 35.90 | 46.20 |
| T4        | - | 18.29 (4.28)ab | 2.02 (1.41)bc | 8.41 | 38.60 |
| T5        | 0.5ml/L | 11.44 (3.38)c | 1.44 (1.11)c | 42.71 | 56.23 |
| T6        | 0.5ml/L | 16.98 (4.05)abc | 1.32 (1.14)c | 14.97 | 59.88 |
| T7        | - | 16.42 (4.05)abc | 2.71 (1.64)ab | 17.78 | 17.63 |
| T8        | - | 11.00 (3.36)c | 1.63 (1.27)c | 44.92 | 50.45 |
| T9        | - | 10.92 (3.30)d | 1.27 (1.12)c | 45.73 | 61.39 |
| T10       | - | 19.97 (4.47)a | 3.29 (1.81)a | - | - |
| Level of significance | ** | ** |
| CV% | 17.00 | 9.16 |

(Treatments: Same as indicated under Table 1)
Benefit cost analysis

Benefit cost analysis of different treatments for managing *T. absoluta* is presented in Tables 4a and b at Panchagarh and Gazipur, respectively. At Panchagarh, the Marginal Benefit Cost Ratio (MBCR) was the highest (10.91) in $T_9$ treatment (application of *M. anisopliae* (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water + foliar spray of azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + mass trapping through installation of delta sex pheromone trap) treated plots followed by that of $T_8$ treatment (foliar spray of *B. thuringiensis* (Biocure) @ 2g/L of water + mass trapping through installation of delta sex pheromone trap + application of *M. anisopliae* (Lycomax, Russel IPM) biopesticide in soil 5g/L of water) (6.95) treated plots.

At Gazipur, the Marginal Benefit Cost Ratio (MBCR) was the highest (7.09) in $T_9$ (foliar spray of *B. thuringiensis* (Biocure) @ 2g/L of water + mass trapping through installation of delta sex pheromone trap + application of *M. anisopliae* (Lycomax, Russel IPM) biopesticide in soil 5g/L of water) treated plots.
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Table 4b. Benefit/cost analysis of different treatments against tomato leaf miner, *Tuta absoluta* at Gazipur

| Treatment | Cost of Treatment (Tk/ha) | M. yield (ton/ha) | Gross return from produce (Tk/ha) | Net return (NR) from Treatment (Tk/ha) | Adjusted net return (Tk/ha) | MBCR |
|-----------|--------------------------|------------------|----------------------------------|---------------------------------------|-----------------------------|------|
| 1         |                          |                  | 4                                | 5(4-2)                                | 6                           | 7 (6/2) |
| T₁        | 5900.00                  | 40.39            | 403900                           | 398000                                | 22400                       | 3.80 |
| T₂        | 12050.00                 | 46.47            | 464700                           | 452650                                | 77050                       | 6.39 |
| T₃        | 22000.00                 | 42.88            | 428800                           | 406800                                | 31200                       | 1.42 |
| T₄        | 12500.00                 | 42.13            | 421300                           | 408800                                | 33200                       | 2.66 |
| T₅        | 9500.00                  | 43.10            | 431000                           | 421500                                | 45900                       | 4.83 |
| T₆        | 26375.00                 | 51.36            | 513600                           | 487225                                | 111625                      | 4.23 |
| T₇        | 9000.00                  | 40.28            | 402800                           | 393800                                | 18200                       | 2.02 |
| T₈        | 40400.00                 | 64.20            | 642000                           | 601600                                | 226000                      | 5.59 |
| T₉        | 30450.00                 | 62.21            | 622100                           | 591650                                | 216050                      | 7.09 |
| T₁₀       | -                        | 37.56            | 375600                           | 375600                                | -                           | -    |

Cost of *Metarrhizium anisopliae* (Lycomax, Russel IPM) biopesticide: 5000 Tk/kg; Cost of Bioneem plus: @ Tk 2800.00/L; Cost of *Bacillus thuringiensis* (Biocure): @ Tk 3500.00/kg; Cost of *Tuta* Lure + trap: @ 300Tk/Lure; Cost of Spinosad: @4000Tk/L; Cost of Coragen: @17500Tk/L; Cost of hand picking: Two labourers/ha @ Tk 450.00/day; Cost of spray: Two Cost labourers/spray/ha @ Tk 450.00/day; Spray volume required: 500L /ha; Farm gate price of Tomato: Tk 25.00/ kg (During May, 2018);

**Treatments:** Same as indicated under Table 1

*anisopliae* (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water) treated plots followed by that of T₂ treatment (application of *M. anisopliae* biopesticide in soil @ 5g/L of water + foliar spray of azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + mass trapping through installation of delta sex pheromone trap) (5.59) treated plots.

The T₄ (application of *M. anisopliae* (Lycomax, Russel IPM) biopesticide in soil @ 5g/L of water + foliar spray of azadirachtin (Bio-Neem plus 1EC @ 1ml/L of water) + mass trapping through installation of delta sex pheromone trap) proved to be effective considering reduction of *T. absoluta* infestation, increase of marketable yield and marginal benefit cost ratio. So, considering the result of two consecutive seasons at two locations, T₄ treatment package may be recommended for controlling tomato leaf miner, *T. absoluta*.

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