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# Evaluation of different modules for management of fruit borer and pinworm in tomato

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**Abstract**
Investigation on 'Evaluation of different modules for the management of fruit borer and pinworm in tomato' was carried out on the farmer's field, A/P Tardal, Tal- Hatkanangale, Dist -Kolhapur, Maharashtra, India. Among different modules, module $M^2$ [Dipping of seedlings in Thiamethoxam 25 WG @ 1 gm/l 3 hrs before transplanting + Erection of yellow sticky traps (2 traps @ 100 $m^2$) after appearance of pests + Spraying of Chlorantraniliprole 18.5 SC @ 0.5 ml/l + Spraying of *Bacillus thuringiensis kurstaki* @ 1.25 ml/l at 15 days after first spray] performed best for management of fruit borer and pinworm in tomato crop.

**Keywords:** Tomato, modules, pinworm, fruit borer, chlorantraniliprole

## 1. Introduction

Tomato, scientifically identified as *Solanum lycopersicum* L., holds a notable status among vegetables globally, ranking only behind potato and onion in terms of importance. In India, the productivity of tomatoes significantly falls short of its production potential when compared to more developed countries. Throughout the cropping period, tomatoes are vulnerable to various pests, including pathogens, weeds, nematodes, insects, and other arthropods. In India, around 16 pests are identified as affecting tomatoes from germination to harvesting, leading to diminished yields and compromised quality. The presence of insect pests at different stages of the crop substantially impacts the production and fruit quality of tomatoes (Chavan *et al*., 2021) [4].

The production and yield of the crop encounter notable hurdles attributed to the presence of the fruit borer, *Helicoverpa armigera* (Hubner). This prominent pest specifically targets the economically valuable component of the plant – the fruits, rendering them unfit for human consumption and resulting in significant crop losses ranging from 85% to 93.7%. The impact on the fruits manifests in surface deformities and rotting, further exacerbated by secondary bacterial infections (Selvanarayanan, 2000) [10].

*Tuta absoluta* (Meyrick) is a recently introduced pest in India, causing widespread issues in both open field tomato cultivation and protected crops. A female *T. absoluta* can individually lay up to 260 eggs on tender leaves during its lifespan. Plants experience damage from direct larval feeding on leaves, stems, buds, calyces, and young or ripe fruit. Furthermore, secondary pathogens invade through wounds inflicted by the pinworm. The overall impact results in damage ranging from 60.08% to 82.31% on tomatoes (Anonymous, 2023) [1]. Given the significance of the damage caused by these pests to tomato crops and the current management practices in place, the present study aims to evaluate the effectiveness of different methods against the tomato fruit borer and pinworm on tomatoes.

## 2. Materials and Methods

An experiment was conducted during *Summer*, 2023 on the farmer's field, A/P Tardal, Tal-Hatkanangale, Dist-Kolhapur, Maharashtra, India.The experiment was laid out in Randomized Block Design (RCBD). There were nine modules with three replications. Tomato cultivar Ansal seedlings, were transplanted in the main field with a plot size of 4.0 X 3.0 m and spacing of about 65 × 45 cm on 31st January 2023.

Irrigation was provided through drip immediately after transplanting. Seedling root dip was imposed while transplanting and the other treatments were imposed according to the schedule. Module details given in table 1.

**Table 1:** Module details

| Modules | Module Details |
|---|---|
| M1 | Root treatment with Imidacloprid 17.8SL @ 0.25ml /l water for 30 minutes + Spraying of *Lecanicillium lecanii* @ 5 g/l at ETL of pests + Spraying of Spinosad 45% SC @ 0.5 ml/l at 15 days after first spray + Spraying of HaNPV @ 1 ml/l at 15 days after second spray |
| M2 | Dipping of seedlings in Thiamethoxam 25 WG @ 1 gm/l 3 hrs before transplanting + Erection of yellow sticky traps (2 traps @ 100 $m^2$) after appearance of pests + Spraying of Chlorantraniliprole 18.5 SC @ 0.5 ml/l + Spraying of *Bacillus thuringiensis* kurstaki @ 1.25 ml/l at 15 days after first spray |
| M3 | Planting of marigold as a trap crop + Foliar spray of NSE 5% at ETL of pests + Spraying of *Metarhizium anisopliae* @ 5 g/l at 15 days after first spray + Spraying of Spinosad 45% SC @ 0.5 ml/l at 15 days after second spray |
| M4 | Installation of pheromone trap @ 1 trap/350 $m^2$ + Spraying of *Metarhizium anisopliae* @ 5 g/l at ETL of pests + Spraying of entomopathogenic nematodes @ 10 g/l at 15 days after first spray + Spraying of Dimethoate 30 EC @ 2 ml/l at 15 days after second spray |
| M5 | Planting of beans as a trap crop + Release of *Trichogramma chilonis* adults @ 16000/ha + Spraying of Lambda cyhalothrin 5% EC @ 1.33 ml/l + Spraying of Flubendamide 39.35 SC @ 0.2 ml/l at 15 days after first spray |
| M6 | Spraying of *Beauveria bassiana* @ 5 g/l at ETL of pests + Spraying of Dimethoate 30 EC @ 2 ml/l at 15 days after first spray + Spraying of Lambda cyhalothrin 5% EC @ 1.5 ml/l at 15 days after second spray + Spraying of Tetraniliprole SC 200 @ 0.5 ml/l at 15 days after third spray |
| M7 | Foliar spray of *Lecanicillium lecanii* @ 5 g/l at ETL of pests + Foliar spray of NSE 5% @ 1 ml/ at 15 days after first spray + Spraying of Chlorantraniliprole 18.5 SC @ 0.4 ml/l at 15 days after second spray + Spraying of Tetraniliprole SC 200 @ 0.5 ml/l at 15 days after third spray |
| M8 | Spraying of *Metarhizium anisopliae* @ 5 g/l at ETL of pests + Spraying of Dimethoate 30 EC @ 2 ml/l at 15 days after first spray + Spraying of HaNPV @ 1 ml/l at 15 days after second spray + Spraying of Flubendamide 39.35 SC @ 0.2 ml/l 15 days after third spray |
| M9 | Untreated Control |

### 2.1 Incidence of tomato fruit borer and tomato pin worm

Total four sprayings were given. First spraying was given 20 DAT, second 30 DAT, third 45 DAT and last spraying was given at 60 DAT. The observations were recorded on five randomly selected plants from each plot at 30 DAT, 40 DAT, 55 DAT and 70 DAT after the imposition of treatments.

In case of tomato fruit borer, at each picking, the healthy and infested fruits were separated from entire plot of each treatment, their number and weight was recorded and percent fruit infestation was worked out.

$$\text{Per cent fruit damage} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits}} \text{ X } 100$$

For pinworm, the observation on pest count were recorded on five randomly selected plants in each treatment plot and total number of leaves and infested leaves were counted and the percentage of pinworm infestation was worked out. Precount was taken one day prior to first spray (Ramesh and Ukey, 2007) [9].

$$\text{Per cent mined leaves} = \frac{\text{Number of damaged leaves}}{\text{Total number of emerged leaves}} \text{ X } 100$$

### 2.2 Fruit yield and Cost economics

The matured tomato fruits of good marketing quality were selected for harvesting. Tomato fruits from each plot were picked and weighed separately. Three pickings were carried out at the time of harvesting. Total yield from each plot was calculated and computed on hectare basis. Cost effectiveness of each module was assessed based on net returns. Net returns of each treatment were worked out by deducting total cost of the treatment from the gross returns. Total cost of production includes both cultivation as well as plant protection cost. Further, gross returns, net returns and B: C ratio was calculated by using formulas as given below.

Gross returns = Marketable fruit yield × Market price

Net returns = Gross returns – Total cost

### 2.3 Statistical analysis of the experimental data

The data obtained from each module in the present investigation for various parameters such as per cent fruit borer infestation and per cent pinworm infestation per plant were subjected to ANOVA for a Randomized Block Design (RBD), with appropriate statistical transformation (arc sine), wherever necessary. After analysis, data was suitably interpreted by using the critical difference value calculated at 0.05 level of probability. The calculations were done at five per cent level of significance.

## 3. Results and Discussions

The results obtained during the course of investigations are presented under the following heads.

### 3.1 Effect of different modules on tomato fruit borer (*H. armigera*) infestation on number and weight basis and yield of tomato

The recording of fruit infestation percentages, both in terms of numerical count and weight, was conducted during each picking session. The averaged results are detailed in Table 2. The data presented in Table 2 clearly indicates that all modules exhibited significant superiority over the untreated control in terms of protection against tomato fruit borer infestation.

Module M2 recorded the lowest percentage fruit damage, i.e., 9.00 per cent in terms of the number of fruits and 8.05 per cent in terms of weight, compared to 31.00 per cent and 28.86 per cent on a numerical and weight basis in the untreated control Module M9, respectively. However, this module was also on par with Module M1, with observed infested fruits at 10.67 per cent and 9.25 per cent on a numerical and weight basis, respectively. The next most effective modules were M5, M8, and M6, with fruit infestation ranging from 10.76 per cent to 12.90 per cent on a numerical basis and 9.72 per cent to 11.55 per cent on a weight basis, respectively.

Module M2 proved to be excellent against tomato pests, recording the least damage from fruit borer (*H. armigera*) and yielding 398.08 q/ha of tomato fruits. Modules M6 and M3 were the next most effective modules in controlling fruit borer infestation in tomatoes, yielding 323.16 q/ha and 314.91 q/ha of tomatoes, respectively.

Module M2 recorded the highest percentage increase in yield over the control, i.e., 117.13 per cent, followed by M6 (76.27 per cent), M3 (71.77 per cent), and M8 (66.45 per cent). Module M5 recorded the lowest percentage increase in yield over the control, i.e., 48.27 per cent.

Module M2, consisting of chlorantraniliprole, was found superior to other modules, followed by M6 and M9. This trend was also observed in terms of yield. Chlorantraniliprole recorded the least fruit damage and higher fruit yield, as reported by Choudhary *et al*., (2021) [5], Pawar *et al*., (2008) [8] and Bandhavi *et al*., (2022) [3], which aligns with the present findings.

Chlorantraniliprole was highly effective against bollworms (Helicoverpa) and superior to all other treatments, as recommended by Hivare *et al*., (2019) and Jamir *et al*., (2022). Among the tested IPM modules, the lowest fruit damage (5.74 per cent) and the maximum tomato yield (22013 kg/ha) were obtained in Module M1, where the use of chlorantraniliprole was integrated with other control strategies, as reported by Usman *et al*., (2015) [11]. This finding is confirmatory with the present result.

**Table 2:** Effect of different modules on tomato fruit borer (*H. armigera*) infestation number and weight basis and yield of tomato

| **Module** | **Per cent Fruit borer infestation** | | **Yield (kg/plot)** | **Yield (q/ha)** | **Per cent yield increase over control** |
|---|---|---|---|---|---|
| | **Number Basis** | **Weight Basis** | | | |
| M1 | 10.67 (19.01)* | 9.25 (17.68) | 38.78 | 302.25 | 64.86 |
| M2 | 9.00 (17.44) | 8.05 (16.35) | 47.77 | 398.08 | 117.13 |
| M3 | 15.87 (23.45) | 14.86 (22.67) | 32.62 | 314.91 | 71.77 |
| M4 | 14.78 (22.61) | 13.43 (21.49) | 33.45 | 278.75 | 52.04 |
| M5 | 12.90 (21.02) | 11.55 (19.85) | 36.27 | 271.83 | 48.27 |
| M6 | 10.76 (19.13) | 9.72 (18.13) | 37.79 | 323.16 | 76.27 |
| M7 | 13.75 (21.54) | 12.71 (20.77) | 34.48 | 287.33 | 56.72 |
| M8 | 12.78 (20.94) | 11.21 (19.56) | 36.61 | 305.16 | 66.45 |
| Untreated Control | 31.00 (33.80) | 28.86 (32.46) | 22.00 | 183.33 | - |
| S.E.± | 1.125 | 1.065 | 1.898 | | |
| C.D. (5%) | 3.38 | 3.19 | 5.69 | | |
| C.V. | 8.82 | 8.78 | 9.01 | | |

DAT- Days after Transplanting, NS- Non-significant, *Figures in parentheses are arc sine transformed values.

### 3.2 Effect of different modules on tomato pinworm (*Tuta absoluta* Meyrick) of tomato

Information regarding the survival population of pinworms on tomatoes was collected one day before spraying and at 30, 40, 55 and 70 days after transplanting. The data is provided in Table 3 shows that, all modules demonstrated significant efficacy in reducing the pinworm population, particularly at the 30 days after transplanting (DAT). Module M2 was identified as the most effective, with a 10.80 per cent pinworm infestation which was at par with M1 (12.60 per cent) and M6 (16.00 per cent). The maximum survival population of pinworm infestation was observed in Module M5 (23.40 per cent), compared to the untreated control (37.33 per cent).

At 40 DAT, Module M2 remained significantly superior, recording a 12.13 per cent pinworm infestation. Treatments with Module M1 (12.27 per cent) and M6 (15.40 per cent) were at par with Module M2.

Observations at 55 DAT indicated that all modules exhibited significant superiority over the control in reducing the pinworm infestation. Module M2 (9.00 per cent) was identified as the best, at par with Module M1 (9.27 per cent) and M6 (13.73 per cent). However, Module M8 (15.20 per cent) and M7 (14.93 per cent) were least effective in reducing pinworm infestation.

At 70 DAT, Module M2 was identified as the best, recording a 9.13 per cent pinworm infestation. Module M1 (9.47 per cent) and M6 (12.00 per cent) were at par with Module M2. The maximum pinworm infestation was recorded in Module M3 (15.13 per cent) compared to the untreated control (36.33 per cent).

Considering the overall performance of all the modules, they were significantly superior to the untreated control in reducing the percentage pinworm infestation. Module M2 (10.26 per cent) was identified as the best, followed by Module M1 (10.90 per cent), M6 (14.28 per cent) and M4 (16.00 per cent). Module M5 (16.76 per cent) was found to be least effective.

Module M2 recorded the highest percentage reduction of pinworm infestation over the untreated control, i.e., 71.29 per cent, followed by M1 (69.52 per cent), M6 (60.06 per cent), M4 (55.26 per cent), M3 (54.24 per cent) and M8 (54.00 per cent).

The outcomes align with the research conducted by Jamshidnia *et al*., (2018) [7] suggesting that Bt and Spinosad are viable options for integration with other biological and cultural methods for comprehensive management of tomato pinworms. These findings are in accordance with results reported by Bajracharya *et al*., (2018) [2] who reported that chlorantraniliprole 18.5 SC at 0.3 ml/l at 12 days interval was a superior insecticide for the management of *T. absoluta* in field conditions.

**Table 3:** Effect of different modules on pinworm (Tuta absoluta Meyrick)

| Module | Percent leaf mines infestation/plant | | | | | | Per cent Reduction over control |
|---|---|---|---|---|---|---|---|
| | Precount | 30 DAT | 40 DAT | 55 DAT | 70 DAT | Mean | |
| M1 | 15.53 (23.21)* | 12.60 (20.42) | 12.27 (20.49) | 9.27 (17.59) | 9.47 (17.91) | 10.90 (19.27) | 69.52 |
| M2 | 15.20 (22.94) | 10.80 (19.12) | 12.13 (20.35) | 9.00 (17.40) | 9.13 (17.49) | 10.26 (18.68) | 71.29 |
| M3 | 15.40 (23.11) | 16.60 (21.08) | 19.33 (26.03) | 14.40 (22.22) | 15.13 (22.89) | 16.36 (23.86) | 54.24 |
| M4 | 15.47 (23.15) | 17.60 (24.79) | 18.07 (25.14) | 13.93 (21.88) | 14.40 (22.25) | 16.00 (23.57) | 55.26 |
| M5 | 15.73 (23.37) | 23.40 (28.93) | 17.73 (24.79) | 11.47 (19.77) | 14.47 (22.34) | 16.76 (24.17) | 53.12 |
| M6 | 15.07 (22.84) | 16.00 (23.56) | 15.40 (23.02) | 13.73 (21.74) | 12.00 (19.71) | 14.28 (22.20) | 60.06 |
| M7 | 15.60 (23.26) | 18.27 (25.12) | 19.13 (25.92) | 14.93 (22.68) | 14.60 (22.34) | 16.73 (24.14) | 53.21 |
| M8 | 15.67 (23.31) | 17.13 (24.34) | 18.53 (25.44) | 15.20 (22.81) | 14.93 (22.73) | 16.45 (23.92) | 54.00 |
| Untreated control | 15.80 (23.42) | 37.33 (37.62) | 35.07 (36.24) | 34.33 (35.86) | 36.33 (37.07) | 35.76 (36.73) | - |
| S.E.± | 0.199 | 1.567 | 1.567 | 1.326 | 1.403 | | |
| C.D. (%) | NS | 4.70 | 4.70 | 3.98 | 4.21 | | |
| C.V. | | 10.72 | 10.74 | 10.24 | 10.68 | | |

DAT= Days after Transplanting, N.S. – Non-significant, *Figures in parentheses are arc sine transformed values.

### 3.3 Effect of different modules on Incremental Cost Benefit Ratio (ICBR) of tomato

The additional yield, additional returns and incremental cost-benefit ratio (ICBR) of various modules were computed and are outlined in Table 4.

#### 3.3.1 Additional returns of different modules

Information regarding additional returns over the control, as presented in Table 4, reveals that the highest additional income of Rs. 322,125 per hectare was achieved with module M2. Following closely, module M6 exhibited the next highest additional income at Rs. 209,745 per hectare. Conversely, modules M3 (Rs. 19,370), M8 (Rs. 182,745), M1 (Rs. 178,380), and M7 (Rs. 156,000) per hectare reported comparatively lower additional returns over the control. The lowest additional income, Rs. 132,750 per hectare, was recorded in module M5.

**3.3.2 Incremental Cost Benefit Ratio (ICBR):** The highest Incremental Cost-Benefit Ratio (ICBR) of 1:99.17 was observed in module M6. Following M6, the next modules in descending order are M2, M5, M8, M7, and M3, with ICBRs of 1:72.46, 1:62.47, 1:52.21, 1:24.06, and 1:22.14, respectively. Modules M1 (1:18.25) and M4 (1:16.04) recorded relatively lower ICBR values, suggesting that these modules are more expensive compared to others.

In this research, all modules demonstrated superiority over the untreated control in terms of tomato fruit yield. Module M2 achieved the highest yield, closely followed by M6, which also exhibited better performance in terms of ICBR. This discovery is consistent with the outcomes reported by Usman *et al*., (2015) [11] wherein the effectiveness of IPM modules in decreasing fruit damage caused by *H. armigera* was documented. Module M6, integrating chlorantraniliprole with other control strategies, showed the lowest fruit damage (5.74 per cent) and the maximum tomato yield (22,013 kg/ha) with a cost-benefit ratio of 1:6.4. The conclusion drawn from this study supports the present results and is consistent with the overall findings.

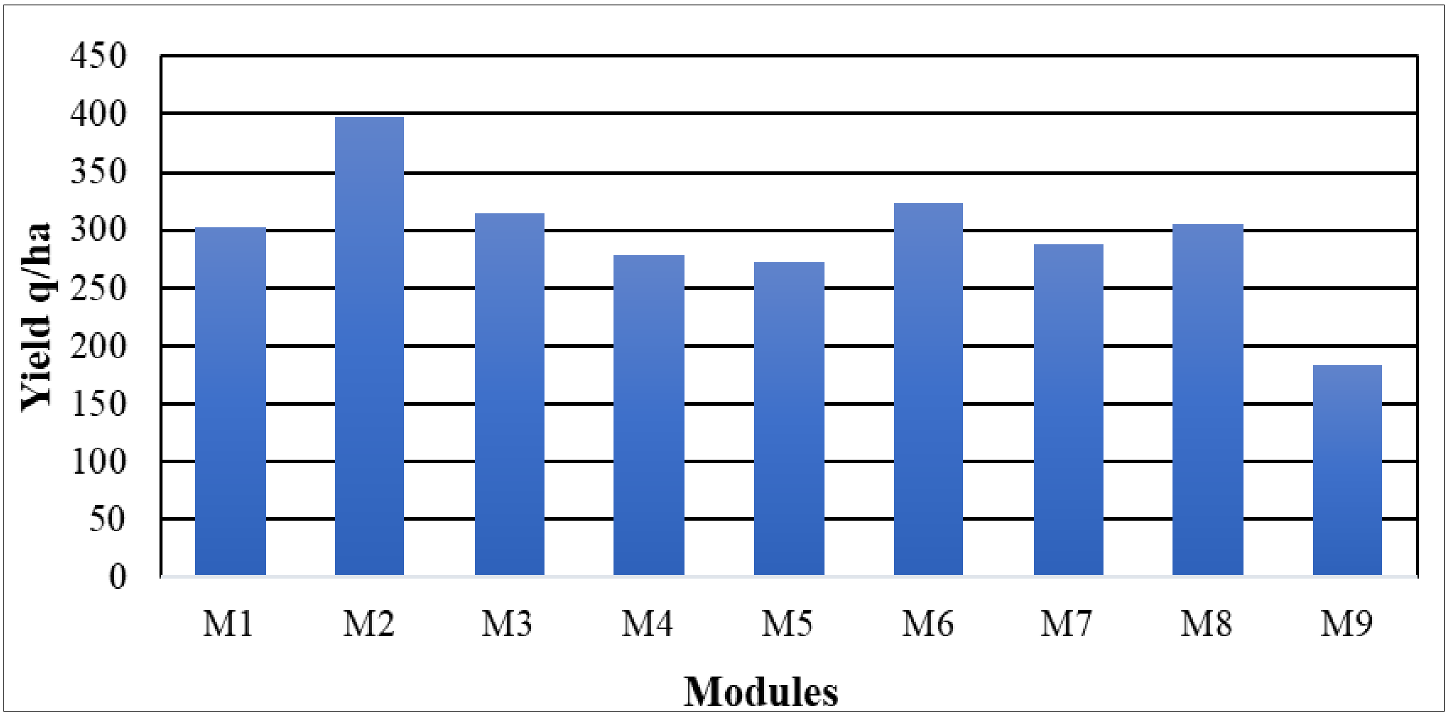


**Fig 1:** Graphical representation of economics of different modules

**Table 4:** Benefit Cost ratio of different IPM modules

| Module | Tomato yield q/ha | Additio nl yield over control (qt/ha) | Addition al income over control (Rs/ha) | Cost of cultivatio n except cost of insecticides (Rs/ha) | Cost of insecticid es (Rs/ha) | Total cost of cultivatio n (Rs/ha) | Gross monitor y return (Rs/ha) | Net returns (Rs/ha) | B:C rati o | ICBR |
|---|---|---|---|---|---|---|---|---|---|---|
| M1 | 302.25 | 118.92 | 178380 | 98870 | 9769 | 108639 | 453375 | 344736 | 4.17 | 1:18.25 |
| M2 | 398.08 | 214.75 | 322125 | 98870 | 4445 | 103315 | 597120 | 493805 | 5.77 | 1:72.46 |
| M3 | 314.91 | 131.58 | 197370 | 98870 | 8911 | 107781 | 472365 | 364584 | 4.38 | 1:22.14 |
| M4 | 278.75 | 95.42 | 143130 | 98870 | 8920 | 107790 | 418125 | 310335 | 3.87 | 1:16.04 |
| M5 | 271.83 | 88.50 | 132750 | 98870 | 2125 | 100995 | 407754 | 306750 | 4.03 | 1:62.47 |
| M6 | 323.16 | 139.83 | 209745 | 98870 | 2115 | 100985 | 484740 | 383755 | 4.80 | 1:99.17 |
| M7 | 287.33 | 104.00 | 156000 | 98870 | 6482 | 105352 | 430995 | 325643 | 4.09 | 1:24.06 |
| M8 | 305.16 | 121.83 | 182745 | 98870 | 3500 | 102370 | 457740 | 355370 | 4.47 | 1:52.21 |
| M9 | 183.33 | - | - | 98870 | - | 98870 | 274995 | 176125 | 2.78 | - |

Cost of tomato = Rs. 1500/- per quintal

## 4. Conclusion

The module M2 (9.00 per cent on number basis & 8.05 per cent on weight basis) showed lowest per cent infested fruits on number & weight basis followed by module M1(10.67 per cent on number basis & 9.25 per cent on weight basis) and M6 (10.76 per cent on number basis & 9.72 per cent on weight basis).

The module M2 (10.26 per cent) was found most superior in reducing pinworm infestation at 30, 40, 55 and 70 days after transplanting. The next best modules were M1 (10.90 per cent) and M6 (14.28 per cent).

The M2 (398.08) recorded highest tomato fruit yield followed by M6 (323.16) and M3 (314.91). The module M2 (1:5.77) showed maximum B:C ratio followed by module M6 (1:4.80) while regarding ICBR ratio, module M6 (1:99.17) showed maximum followed by module M2 (1:72.46) for the pests of tomato.

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