Impact of integrated pest management modules on natural enemies of whiteflies, *Bemisia tabaci* (Genn.) in bitter gourd ecosystem

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Abstract: The impact of eight IPM modules on whitefly *Bemisia tabaci* and its natural enemies were recorded during kharif 2016 and 2017, rabi-summer 2016-17 and 2017-18. There was a significant difference among the modules in the number of natural enemies per plant. In general, it was found that during rabi-summer the population of *B. tabaci* was higher than the kharif season on bitter gourd. When modules were compared for the population of *B. tabaci*, module 1 to 4 (sowing maize as a barrier crop, removal of infested leaves and residues from the appearance of pests, erection of solar light trap with yellow pan @ 5 traps/ha for trapping, tying yellow sticky trap to attract whiteflies, spraying neem oil @ 1% and pongam oil @1%) and module 6 (spraying of *Metarhizium anisopliae* (2 x 10⁸), *Beauveria bassiana* (2 x 10⁸), Neem oil 1% and Pongam oil 1%) which do not include frequent insecticidal applications recorded higher number of coccinellids, syrphids, hymenopterans and spiders than the IPM modules where frequent applications of chemical insecticides were included as a treatment.

Keywords: IPM modules, natural enemies, whiteflies

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INTRODUCTION

Whitefly, *Bemisia tabaci* Genn. (Hemiptera: Aleyrodidae) is a devastating pest of vegetables, fruits, fibre, plantation crops and ornamental crops in tropical and subtropical regions of the world (Oliveira et al., 2001). Numerous species of natural enemies are recorded on *B. tabaci* (Gerling et al., 2001; Li et al., 2011; Torres et al., 2014). The natural enemies of *B. tabaci* occur in diversified agro -ecosystems all around the world, different species predators and parasitoids feed and parasitise on *B. tabaci* (Nordlund and Legaspi, 1996; Gerling et al., 2001; Palaniswami et al., 2001). Several studies have been conducted on the importance of the beneficial fauna attacking *B. tabaci* in agricultural systems (Asimwwe et al., 2007; Atuncha et al., 2013). In India studies conducted in Andhra Pradesh, Tamil Nadu and Maharashtra states have also added important information on natural enemies of *B. tabaci* (Natarajan, 1990; Kapadia and Puri, 1991; Rao et al., 1989). In the present study experiments were conducted to assess the impact of eight integrated pest management (IPM) modules on whitefly *Bemisia tabaci* and its natural enemies in bitter gourd ecosystem during kharif 2016 and 2017, rabi-summer 2016-17 and 2017-18.

MATERIALS AND METHODS

Except plant protection measures, IPM module included eco-friendly and bio-rational strategies with farmers practice of chemical insecticide sprays (Table 1). Seeds were sown during kharif – 2016, 2017 and rabi-summer 2016-17 and 2017-18. In all the modules including farmers practice and control, bitter gourd seeds were treated with imidacloprid 17.8 SL before sowing in order to manage the early sucking pests and sprayed imidacloprid 17.8 SL @ 0.35ml/l on the seedlings three hours before transplanting. The pest management interventions were executed when the pest population crossed economic threshold level.

Observations were recorded at 10 days intervals on three leaves each from top middle and bottom of the 5 randomly selected plants in each replication. Similarly, natural enemy population per plant was also recorded on 5 randomly selected plants in each replication and for parasitoids, under surface of the leaves were examined for parasitism with magnifier hand lens (10X), the parasitised whiteflies turned black. The bitter gourd fruit yield was recorded from each module and the data were presented as in kg/ha and benefit cost ratio of each treatment was worked out. Data regarding whitefly damage and viral
disease infestations were recorded from 10th day after planting and continued up to 110 days. All the data set were subjected to pooled analysis of variance (ANOVA) after appropriate transformations according to Gomez and Gomez (1984).

**RESULTS AND DISCUSSION**

The impact of eight IPM modules on natural enemies were recorded for two seasons, **kharif** 2017 and **rabi-summer** 2017-18. Four observations were recorded at 30, 50, 70 and 80 days after planting (DAP). There was a significant difference among the modules in the number of natural enemies per plant on an average. Prominent natural enemies viz. coccinellids (*Coccinella septempunctata* (L.) and *Menochilus sexmaculatus* (Fab.)), syrphid (*Eristalis quinquestriatus*), hymenopteran *Encarsia guadeloupae* (Viggiani) and spiders *Phytoseiulus* sp, *Amblyseius* spp. were recorded during the study (Table 2).

In general, it was found that during **rabi-summer**, the population of *B. tabaci* on bitter gourd was higher compared to **kharif** season it. As a numerical response, the population of natural enemies was also higher compared to the **kharif** season (Table 3). When modules were compared for the *B. tabaci* population, modules 1 to 4 (sowing maize as a barrier crop, removal of infested leaves and residues from the appearance of pests, erection of solar light trap with yellow pan @ 5 traps/ha for trapping, tying yellow sticky trap to attract whiteflies) and module 6 (Spraying *M. anisopliae* (2x10⁹), *B. bassiana* (2x10⁸), Neem oil 1% and Pongam oil 1%) which
Table 2. Natural enemies recorded on whiteflies in bitter gourd ecosystem

| Coleopterans | Chrysopids and Syrphids | Hymenopterans | Spiders |
|--------------|-------------------------|---------------|---------|
| Coccinellidae: Lady bird beetle, *Coccinella septempunctata* (L.), *Menochilus sexmaculatus* (Fab.) | Chrysopidae: Green lacewing, *Chrysoperla zastrowi sillemi* (Esben-Peterson) | Parasitoid – *Encarsia guadeloupae* Viggiani | Predatory mites, *Phytoseiulus* sp, *Amblyseius* spp. |
| Staphilinidae: Rove beetle, *Paederus fuscipes* (Curtis) | Syrphidae: Syrphid fly, *Eristalis quinquestriatus* (Fab.) | | Phytoseiidae |

Table 3. Effect of IPM modules on natural enemies in bitter gourd ecosystem, *kharif* *

| Modules | No. of coccinellids / plant | No. of syrphids / plant | No. of hymenopterans / plant | No. of spiders / plant |
|---------|-----------------------------|-------------------------|-------------------------------|------------------------|
|         | 30 DAP | 50 DAP | 70 DAP | 90 DAP | Mean | 30 DAP | 50 DAP | 70 DAP | 90 DAP | Mean | 30 DAP | 50 DAP | 70 DAP | 90 DAP | Mean |
| M1      | 2.22   | 2.67   | 2.22   | 2.22   | 2.33  | 1.89   | 2.11   | 1.89   | 1.56   | 1.86  |
| M2      | 1.89   | 2.89   | 2.22   | 2.22   | 2.31  | 1.78   | 2.22   | 1.67   | 1.67   | 1.83  |
| M3      | 2.11   | 2.56   | 2.33   | 2.33   | 2.33  | 1.67   | 2.22   | 1.78   | 1.67   | 1.83  |
| M4      | 2.33   | 2.78   | 2.22   | 2.22   | 2.39  | 1.89   | 2.33   | 1.67   | 1.67   | 1.89  |
| M5      | 1.11   | 1.22   | 1.22   | 1.11   | 1.17  | 0.89   | 1.11   | 0.89   | 1.11   | 1.00  |
| M6      | 2.11   | 2.56   | 2.11   | 2.33   | 2.28  | 1.78   | 2.22   | 1.67   | 1.67   | 1.83  |
| M7      | 1.11   | 1.44   | 1.11   | 1.11   | 1.19  | 1.11   | 0.89   | 1.11   | 0.89   | 1.00  |
| M8      | 0.56   | 0.89   | 0.67   | 0.56   | 0.67  | 0.56   | 0.56   | 0.56   | 0.44   | 0.53  |
| M9      | 2.11   | 2.78   | 2.22   | 2.33   | 2.36  | 1.78   | 2.22   | 1.78   | 1.67   | 1.86  |

SEM (±) | 0.12 | 0.11 |
CD (P=0.05) | 0.37 | 0.34 |
CV (%) | 12.74 | 14.71 |

| Modules | No. of hymenopterans / plant | No. of spiders / plant |
|---------|-----------------------------|------------------------|
|         | 30 DAP | 50 DAP | 70 DAP | 90 DAP | Mean | 30 DAP | 50 DAP | 70 DAP | 90 DAP | Mean |
| M1      | 2.11   | 1.89   | 1.44   | 1.11   | 1.64  | 2.22   | 1.89   | 1.67   | 1.11   | 1.72  |
| M2      | 1.89   | 1.78   | 1.44   | 1.22   | 1.58  | 2.11   | 1.89   | 1.56   | 1.22   | 1.69  |
| M3      | 2.11   | 1.89   | 1.56   | 1.22   | 1.69  | 2.22   | 1.78   | 1.67   | 1.22   | 1.72  |
| M4      | 2.22   | 1.67   | 1.44   | 1.33   | 1.67  | 2.11   | 1.89   | 1.67   | 1.33   | 1.75  |
| M5      | 1.11   | 1.12   | 0.89   | 0.78   | 0.97  | 1.11   | 1.11   | 1.11   | 0.78   | 1.03  |
| M6      | 2.11   | 1.89   | 1.44   | 1.22   | 1.67  | 2.22   | 1.89   | 1.89   | 1.22   | 1.81  |
| M7      | 0.89   | 1.11   | 0.89   | 0.89   | 0.94  | 0.89   | 1.22   | 1.11   | 0.67   | 0.97  |
Table 4. Effect of IPM modules on natural enemies in bitter gourd ecosystem, *rabi-summer*

| Modules | No. of coccinellids/plant | No. of syrphids/plant |
|---------|---------------------------|-----------------------|
|         | 30 DAP | 50 DAP | 70 DAP | 90 DAP | Mean | 30 DAP | 50 DAP | 70 DAP | 90 DAP | Mean |
| M1      | 2.44   | 3.33   | 3.44   | 4.33   | 3.39 | 2.67   | 2.56   | 2.44   | 2.56   | 2.56 |
| M2      | 2.33   | 3.44   | 2.89   | 4.44   | 3.28 | 2.78   | 2.44   | 2.56   | 2.56   | 2.58 |
| M3      | 2.22   | 3.44   | 3.67   | 4.22   | 3.39 | 2.89   | 2.56   | 2.33   | 2.67   | 2.61 |
| M4      | 2.33   | 3.33   | 3.11   | 4.56   | 3.33 | 2.78   | 2.56   | 2.56   | 2.44   | 2.58 |
| M5      | 1.22   | 1.33   | 1.33   | 1.44   | 1.33 | 1.11   | 1.11   | 0.89   | 1.33   | 1.11 |
| M6      | 2.33   | 3.22   | 3.56   | 4.44   | 3.39 | 2.89   | 2.89   | 2.67   | 2.56   | 2.75 |
| M7      | 1.23   | 1.89   | 1.44   | 1.33   | 1.48 | 1.33   | 0.89   | 1.11   | 1.33   | 1.17 |
| M8      | 0.67   | 0.89   | 0.78   | 0.89   | 0.81 | 0.67   | 0.67   | 0.56   | 0.56   | 0.61 |
| M9      | 2.44   | 3.44   | 3.67   | 4.56   | 3.53 | 2.78   | 2.56   | 2.78   | 2.67   | 2.69 |
| SEM (±) | 0.36   |         |         |         |     | 0.08   |         |         |         |     |
| CD (P=0.05) | 1.10   |         |         |         |     | 0.25   |         |         |         |     |
| CV      | 26.98  |         |         |         |     | 7.60   |         |         |         |     |

| Modules | No. of hymenopterans/plant | No. of spiders/plant |
|---------|---------------------------|----------------------|
|         | 30 DAP | 50 DAP | 70 DAP | 90 DAP | Mean | 30 DAP | 50 DAP | 70 DAP | 90 DAP | Mean |
| M1      | 2.56   | 2.89   | 3.11   | 3.11   | 2.92 | 2.78   | 3.89   | 4.11   | 4.78   | 3.89 |
| M2      | 2.44   | 2.78   | 2.78   | 2.89   | 2.72 | 2.56   | 3.33   | 4.22   | 4.89   | 3.75 |
| M3      | 2.33   | 3.11   | 2.89   | 3.11   | 2.86 | 2.56   | 3.44   | 3.78   | 4.89   | 3.67 |
| M4      | 2.44   | 2.89   | 3.11   | 3.11   | 2.89 | 2.44   | 3.78   | 4.33   | 4.78   | 3.83 |
| M5      | 1.22   | 1.22   | 1.44   | 1.78   | 1.42 | 1.11   | 1.44   | 1.44   | 1.67   | 1.42 |
| M6      | 2.33   | 3.11   | 3.11   | 3.33   | 2.97 | 2.67   | 3.67   | 4.44   | 4.78   | 3.89 |
| M7      | 0.89   | 1.33   | 1.78   | 1.89   | 1.47 | 0.89   | 1.33   | 1.44   | 1.67   | 1.33 |
| M8      | 0.67   | 0.89   | 0.78   | 0.56   | 0.72 | 0.56   | 0.89   | 0.78   | 0.67   | 0.72 |
| M9      | 2.56   | 3.11   | 3.15   | 3.22   | 3.01 | 2.78   | 3.89   | 4.54   | 4.89   | 4.03 |

*Note: Pooled data of *kharif* for two seasons 2016 and 2017*
do not include frequent insecticidal applications recorded higher number of coccinellids, syrphids, hymenopterans and spiders than the IPM modules where frequent application of chemical insecticides were included as a treatment (Table 4).

**Yield and benefit - cost ratio (BCR)**

The IPM modules were evaluated for two seasons, *i.e.* *kharif* 2016, 2017 and *rabi-summer* 2016 - 17 and 2017 - 18. During *kharif*, all the modules gave significantly higher yields than the control (5.77 t/ha). Module 10 and 6 gave the highest yield of 10.27 and 10.06 t/ha, followed by Module 5 (9.97 t/ha) and Module 7 and 4 (9.64 and 9.38t/ha), respectively. By considering the economics, Module 6 recorded higher BCR (2.70) and ranked first among all the IPM trials evaluated, followed by Module 4 (2.62). The control gave BCR of 1.77 only (Table 5). The BCR among all the trials, except control, all modules gave good results and were at-par with each other.

There were statistical significant differences in the population of natural enemies among the different modules. The IPM modules, where the number of natural enemies was higher, recorded the lower *Bemisia tabaci* infestation and consequently had higher yields. This is a reflection of the action of natural enemies on whitefly population and in turn on the bitter gourd crop yields. The results are in-line with Nisha Lekshmi (2013) who reported the activity of coccinellids was at peak in summer compared to *kharif*. There were statistical significant differences in the population of natural enemies among the different bio-rational modules (Kedar et al., 2014). Sardana et al., (2006) reported significantly higher populations of coccinellids, followed by 10.39, 10.24 and 10.09 t/ha in modules 8, 5 and 7 respectively. As per the economics, the module 6 recorded higher BCR (2.82), followed by module 44 (2.76) and module 7 (2.67). Control plot gave cost-benefit ratio of 1.83. Overall, based on BCR values obtained from the different modules tested, it was observed that were significantly superior and were at-par with each other except the control.

### Table 5. Effect of IPM modules on bitter gourd yield

| Module No. | Kharif Yield (in tons/ha) | Rabi-summer Yield (in tons/ha) | Mean Yield (in tons/ha) | Kharif BCR | Rabi-summer BCR | Mean BCR |
|------------|-----------------|-----------------|----------------------|-----------|----------------|---------|
| 1          | 8.08e           | 7.96e           | 8.02c                | 2.34      | 2.30           | 2.32    |
| 2          | 9.06d           | 8.78d           | 8.92c                | 2.55      | 2.47           | 2.51    |
| 3          | 9.78c           | 9.60c           | 9.69b                | 2.55      | 2.50           | 2.53    |
| 4          | 9.86bc          | 9.38c           | 9.62b                | 2.76      | 2.62           | 2.69    |
| 5          | 10.24           | 9.97b           | 10.10ab              | 2.52      | 2.45           | 2.49    |
| 6          | 10.50a          | 10.06a          | 10.28a               | 2.82      | 2.70           | 2.76    |
| 7          | 10.09ab         | 9.64c           | 9.86ab               | 2.67      | 2.56           | 2.61    |
| 8          | 10.39a          | 10.27a          | 10.33a               | 2.61      | 2.58           | 2.60    |
| 9          | 5.97f           | 5.77f           | 5.87e                | 1.83      | 1.77           | 1.80    |
| SEM (±)    | 0.15            | 0.12            | 0.14                 | -         | -              | -       |
| CV (%)     | 0.42            | 0.38            | 0.39                 | -         | -              | -       |
| CD@5%      | 2.85            | 2.37            | 2.52                 | -         | -              | -       |

*Note: Pooled data of *rabi-summer* for two seasons 2016-17 and 2017-18

During *rabi-summer* 2017-18, the same set of IPM modules were evaluated. Same trend was observed in all the modules and it gave significantly higher yields than the control (5.97 t/ha). Module 6 gave the highest yield of 10.50 t/ha and statistical significant differences in the population of natural enemies among the different bio-rational modules (Kedar et al., 2014). Sardana et al., (2006) reported significantly higher populations of coccinellids,
predatory spiders and *Chrysoperla* in IPM field of bitter gourd plant. Rao *et al.* (1989) on mungbean and urdbean and Gurlaz and Sangha (2016) on chilli, reported that the *B. tabaci* was predated by coccinellids, *Verania vineta*, *Menochilus sexmaculata*, *Chrysoperla zasthrowi sillemi* and the phytoseiids, *Amblyseius* sp. Three coccinellid predators namely, *B. suturealis*, *S. parcesetosum* and *C. sexmaculata* were observed on whiteflies. Whiteflies are known to be attracted to the yellow range of the natural light. The yellow colour can attract more whiteflies. Chu *et al.* (2000) could prove that the most attractive colours in a wavelength range between 490 to 600 nm for *Bemisia argentifollii* were yellow-green, yellow, and spring green respectively. Mutwiwa and Tantau (2005) also reported that the greenhouse whitefly, *Trialeuodes vaporariorum*, were attracted to lamps of the yellow colour.

Hence the present research findings indicate that module 6 (Spraying of *M. anisopliae* (2 x 10⁸), *B. bassiana* (2 x 10⁸), neem oil 1% and pongam oil 1%) which do not include frequent insecticidal applications recorded higher number of coccinellids, syrphids, hymenopterans and spiders than the IPM modules where frequent applications of chemical insecticides were included as a treatment. Module 6 also gave the highest yield and BCR in all cases.

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