Biointensive management of whiteflies (Bemisia tabaci Gennadius) infesting chilli (Capsicum annuum L.)

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DOI: https://doi.org/10.22271/j.ento.2020.v8.i6e.7883

Abstract
A field experiment was carried out to biointensive management of whiteflies (Bemisia tabaci Gennadius) infesting chilli (Capsicum annuum L.) during rabi season of 2018-19 at Central Experiment Station, Wakawali, Dist. Ratnagiri. During this experiment total six biopesticides tested viz., Metarrhizium anisopliae 2×10^8 cfu/ml @ 2.5ml/lit, Beauveria bassiana 2×10^8 cfu/ml @ 5ml/lit, Lecanillicium lecanii 2×10^8 cfu/ml @ 4ml/lit, Nomuraea rileyi 2×10^8 cfu/g @ 1g/lit, Bacillus thuringiensis 3.5% ES @ 2ml/lit, Pongamia oil 2% EC @ 10ml/lit, respectively. The results regarding overall mean of three sprays against whiteflies revealed that the treatment Lecanillicium lecanii 2×10^8 cfu/ml @ 4ml/lit was the best treatment which was recorded minimum (1.49) mean whitefly population per three leaves per plant and was at par with Beauveria bassiana 2×10^8 cfu/ml @ 5ml/lit (1.55).

Keywords: Biointensive management, whiteflies, chilli, biopesticides

Introduction
Chilli (Capsicum annuum L.), is one of the most important spice cum vegetable crop of India which belongs to family Solanaceae. Chilli is cultivated in almost all Indian states, although it is concentrated mainly in Southern states, Andhra Pradesh, Karnataka, Tamil Nadu and Orissa. In India, it is grown over an area 309 thousand ha, with a production of 3592 thousand MT during year 2017-18. In Maharashtra, it is grown over an area 30.59 thousand ha, with a production of 342.48 thousand MT during year 2017-18 (Anonymous, 2018) (18). The major limiting factor for low yield of chilli is the insect pests infestation in nursery and even after transplanting of chilli in field. Over 35 species of insects and mites have been reported as pests of pepper, which includes thrips, aphids, whiteflies, fruit borers, cutworms, plant bugs, mites and other minor pests (Sorensen, 2005) (12).

Among the insect pests harbouring chillies, the whitefly, Bemisia tabaci Genn. (Aleyrodidae: Hemiptera) has become a serious threat to crop production in recent years not only by causing direct feeding damage but also by vectoring and transmission of Begomoviruses and Criniviruses that cause serious problems (Morales, 2007) (7). Particularly, the epidemics of chilli leaf curl disease, caused by Chilli leaf curl virus and transmitted by B. tabaci is a serious challenge to yield of chillies in South India (Raj et al., 2005; Kumar et al., 2006; Senanayake et al., 2007; Chattopadhyay et al., 2008) (9, 5, 10, 3).

In chemical management, due to irrational use of chemical pesticides cause serious health hazards, environmental problems, persistence of toxic residues, disruption on balance of ecosystem. In case of biopesticides, they do not leave any harmful toxic residues, besides conserving natural enemies. It is difficult for insects to develop resistance to these biopesticides. As the chilli is served as vegetable, the management of whiteflies has to be on organic basis. Hence, the present investigation was undertaken to find out the effective biointensive management against whiteflies infesting chilli which can be suitably acceptable in pest management programme.
Materials and Methods
A field experiment was conducted during rabi season 2018–19 to study biointensive management of whiteflies infesting chilli (genotype- Jwala). The details of experiment are given in below

Cultural operations
The land was prepared as per the requirements of chilli crop and cleared by removing the residues of the previous crop. The experiment was laid out in Randomized Block Design (RBD). The half dose of urea fertilizer and full dose of phosphorous and potash was applied at the time of sowing and remaining half dose of urea was applied at 30 days after sowing. The experimental area was sown with good seed of chilli (genotype- Jwala) in each plot. The transplanting of seedlings was done forty days after sowing. The other agronomic operations viz., intercultural operations and weeding were done as per recommendation.

Table 1: Experimental details

| Location                  | Central Experiment Station, Wakawali, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri |
|---------------------------|--------------------------------------------------------------------------------------------------|
| Period of study           | November 2018 to April 2019                                                                     |
| Genotype                  | Jwala                                                                                           |
| Spacing                   | 60 cm x 60 cm                                                                                    |
| Size of treatment plot    | 6.6 m x 1.2m                                                                                    |
| Total plot size           | 166.32 m²                                                                                        |
| Date of transplanting     | 22nd November, 2018                                                                             |
| Method of planting        | On raised beds                                                                                   |
| Design                    | Randomized Block Design (RBD)                                                                    |
| Number of replication     | Three                                                                                            |
| Number of treatment       | Seven                                                                                           |

Table 2: Treatment details

| Tr. no. | Treatments                             | Conc. (%) | Dose       |
|---------|----------------------------------------|-----------|------------|
| T<sub>1</sub> | *Metarrhizium anisopliae* 2×10<sup>8</sup> cfu/ml | 0.25  | 2.5ml/lit |
| T<sub>2</sub> | *Bacillus thuringiensis* 3.5% ES @ 2ml/lit | 0.2  | 2ml/lit   |
| T<sub>3</sub> | *Nomuraea rileyi* 2×10<sup>8</sup> cfu/ml | 0.1  | 1g/lit    |
| T<sub>4</sub> | *Beauveria bassiana* 2×10<sup>6</sup> cfu/ml | 0.5  | 5ml/lit   |
| T<sub>5</sub> | *Lecanicillium lecanii* 2×10<sup>6</sup> cfu/ml | 0.4  | 4ml/lit   |
| T<sub>6</sub> | *Pongamia oil 2% EC* | 1   | 10ml/lit  |
| T<sub>7</sub> | Untreated control                      | -        | -         |

Spraying
The quantity of spray suspension required for each treatment was calibrated by spraying water over three plots in the experiment prior to the application of biopesticides. Spray suspension of desired strength of each biopesticide was prepared against whiteflies in the field.

The biopesticides were sprayed thrice. First spray of each biopesticide was applied when incidence was noticed, while remaining two sprays were given at an interval of 7 days with manually operated knapsack sprayer. The observations were recorded in each treatment on randomly selected five plants.

Method of recording observations
Observations on the number of whiteflies were recorded on five randomly selected plants per plot. Number of whitefly was recorded from the three leaves top, middle and bottom of the plant. The pre treatment observations were recorded a day before application of biopesticides and subsequently post treatment observation were recorded at second, third and seventh day after each spray was recorded in the early morning hours.

Results and Discussion
Efficacy of biopesticides against whiteflies (*B. tabaci Gennadius*) infesting chilli
The data pertaining to the efficacy of different biopesticides against whiteflies infesting chilli at 2<sup>nd</sup>, 3<sup>rd</sup> and 7<sup>th</sup> days after spray are presented in Table 3.

First spray
The data on mean population of whiteflies prior to biopesticides application ranged from 2.76 to 2.87 per three leaves per plant. There is no significant difference among the different treatments since uniform distribution of whiteflies in different treatments.

The observations recorded on second day after first spraying of biopesticides ranges from 2.39 to 3.01 per three leaves per plant. The treatment *Lecanicillium lecanii* 2×10<sup>5</sup> cfu/ml @ 4ml/lit was found to be most effective treatment which recorded 2.39 mean population of whiteflies per three leaves per plant and was at par with the treatments *Beauveria bassiana* 2×10<sup>4</sup> cfu/ml @ 5ml/lit (2.43) and *Metarrhizium anisopliae* 2×10<sup>5</sup> cfu/ml @ 2.5ml/lit (2.48). The treatment *Pongamia oil 2% EC* @ 10ml/lit recorded (2.75) mean population of whiteflies per three leaves per plant and was at par with treatments *Nomuraea rileyi* 2×10<sup>6</sup> cfu/g @ 1g/lit (2.81) and *Bacillus thuringiensis* 3.5% ES @ 2ml/lit recorded (2.84). The maximum (3.01) whiteflies population was found in untreated control.

At the third day after first spraying of biopesticides population of whiteflies per three leaves per plant ranges from 2.34 to 3.04. The treatment *Lecanicillium lecanii* 2×10<sup>5</sup> cfu/ml @ 4ml/lit was found to be most effective treatment which recorded 2.34 mean population of whiteflies per three leaves per plant and was at par with the treatment *Beauveria bassiana* 2×10<sup>4</sup> cfu/ml @ 5ml/lit (2.42). The treatment *Metarrhizium anisopliae* 2×10<sup>5</sup> cfu/ml @ 2.5ml/lit recorded (2.53) mean population of whiteflies per three leaves per plant and was at par with the treatment *Pongamia oil 2% EC* @ 1g/lit (2.79) and *Nomuraea rileyi* 2×10<sup>6</sup> cfu/g @ 1g/lit recorded (2.79) mean population of whiteflies per three leaves per plant and was at par with *Bacillus thuringiensis* 3.5% ES @ 2ml/lit (2.81). The maximum (3.04) whiteflies population was found in untreated control.

The data recorded at seventh day after first spray revealed that the population of whiteflies per three leaves per plant ranges from 2.32 to 3.20. The treatment *Lecanicillium lecanii* 2×10<sup>5</sup> cfu/ml @ 4ml/lit was found to be most effective treatment which recorded 2.32 mean population of whiteflies per three leaves per plant and was at par with the treatments *Beauveria bassiana* 2×10<sup>5</sup> cfu/ml @ 5ml/lit (2.40) and *Metarrhizium anisopliae* 2×10<sup>5</sup> cfu/ml @ 2.5ml/lit (2.51). The treatment
Second spray

The results on effect of second spray are presented in Table 3. The observations recorded on second day after second spraying of biopesticides ranges from 1.98 to 3.38 per three leaves per plant. The treatment *Lecanicillium lecanii* 2×10⁸ cfu/ml @ 4ml/lit was found to be most effective treatment which recorded 1.98 mean population of whiteflies per three leaves per plant and was at par with the treatment *Nomurea rileyi* 2×10⁸ cfu/g @ 1g/lit (2.76) and *Bacillus thuringiensis* 3.5% ES @ 2ml/lit (2.78). The maximum (3.20) whiteflies population was found in untreated control.

At the third day after second spraying of biopesticides population of whiteflies per three leaves per plant ranges from 1.54 to 3.45. The treatment *Lecanicillium lecanii* 2×10⁸ cfu/ml @ 4ml/lit was found to be most effective treatment which recorded 1.54 mean population of whiteflies per three leaves per plant and was at par with the treatment *Beauveria bassiana* 2×10⁸ cfu/ml @ 5ml/lit (2.11). The treatment *Metarrhizium anisopliae* 2×10⁸ cfu/ml @ 2.5ml/lit recorded (2.38) mean population of whiteflies per three leaves per plant and was at par with Ponagmia oil 2% EC @ 10ml/lit (2.45) and *Nomurea rileyi* 2×10⁸ cfu/g @ 1g/lit (2.60). The treatment *Bacillus thuringiensis* 3.5% ES @ 2ml/lit recorded (2.70) mean population of whiteflies per three leaves per plant. The maximum (3.38) whiteflies population was found in untreated control.

The data recorded at seventh day after second spray revealed that the whiteflies population per three leaves per plant ranges from 0.33 to 2.95. The treatment *Lecanicillium lecanii* 2×10⁸ cfu/ml @ 4ml/lit was found to be most effective treatment which recorded 0.33 mean population of whiteflies per three leaves per plant and was at par with the treatment *Beauveria bassiana* 2×10⁸ cfu/ml @ 5ml/lit (0.84). The treatment *Metarrhizium anisopliae* 2×10⁸ cfu/ml @ 2.5ml/lit recorded (1.94) mean population of whiteflies per three leaves per plant and was at par with Ponagmia oil 2% EC @ 10ml/lit (2.04). The treatment *Nomurea rileyi* 2×10⁸ cfu/g @ 1g/lit recorded (2.29) and *Bacillus thuringiensis* 3.5% ES @ 2ml/lit (2.44) mean population of whiteflies per three leaves per plant. The maximum (3.45) whiteflies population was found in untreated control.

Third spray

The results on effect of third spray are presented in Table 3. The observations recorded on second day after third spraying of biopesticides ranges from 0.75 to 3.38 per three leaves per plant. The treatment *Lecanicillium lecanii* 2×10⁸ cfu/ml @ 4ml/lit was found to be most effective treatment which recorded 0.75 mean population of whiteflies per three leaves per plant and was at par with the treatment *Beauveria bassiana* 2×10⁸ cfu/ml @ 5ml/lit (0.76). The treatment *Metarrhizium anisopliae* 2×10⁸ cfu/ml @ 2.5ml/lit recorded (1.13) mean population of whiteflies per three leaves per plant and was at par with the treatment Ponagmia oil 2% EC @ 10ml/lit (1.16). The treatments *Nomurea rileyi* 2×10⁸ cfu/g @ 1g/lit recorded (1.48) and *Bacillus thuringiensis* 3.5% ES @ 2ml/lit (1.76) mean population of whiteflies per three leaves per plant. The maximum (3.38) whiteflies population was found in untreated control.

At the third day after third spraying of biopesticides population of whiteflies per three leaves per plant ranges from 0.60 to 3.20. The treatment *Lecanicillium lecanii* 2×10⁸ cfu/ml @ 4ml/lit was found to be most effective treatment which recorded 0.60 mean population of whiteflies per three leaves per plant and was at par with the treatment *Beauveria bassiana* 2×10⁸ cfu/ml @ 5ml/lit (0.67). The treatment *Metarrhizium anisopliae* 2×10⁸ cfu/ml @ 2.5ml/lit recorded (1.13) mean population of whiteflies per three leaves per plant and was at par with the treatment Ponagmia oil 2% EC @ 10ml/lit (1.20). The treatment *Nomurea rileyi* 2×10⁸ cfu/g @ 1g/lit recorded (1.40) and treatment *Bacillus thuringiensis* 3.5% ES @ 2ml/lit recorded (1.60) mean population of whiteflies per three leaves per plant. The maximum (3.20) whiteflies population was found in untreated control.

The data recorded at seventh day after third spray revealed that the whiteflies population per three leaves per plant ranges from 0.33 to 2.95. The treatment *Lecanicillium lecanii* 2×10⁸ cfu/ml @ 4ml/lit was found to be most effective treatment which recorded 0.33 mean population of whiteflies per three leaves per plant and was at par with the treatment *Beauveria bassiana* 2×10⁸ cfu/ml @ 5ml/lit (0.38). The treatment *Metarrhizium anisopliae* 2×10⁸ cfu/ml @ 2.5ml/lit recorded (0.84) mean population of whiteflies per three leaves per plant and was at par with treatment Ponagmia oil 2% EC @ 10ml/lit (0.91). The treatment *Nomurea rileyi* 2×10⁸ cfu/g @ 1g/lit recorded (1.12) mean population of whiteflies per three leaves per plant and was at par with the treatment *Bacillus thuringiensis* 3.5% ES @ 2ml/lit (1.20). The maximum (2.95) whiteflies population was found in untreated control.

The data on mean population of whitefly per three leaves per plant after three sprays revealed that the treatment *Lecanicillium lecanii* 2×10⁸ cfu/ml @ 4ml/lit was the best treatment which was recorded minimum (1.49) mean pest population per three leaves per plant and was at par with *Beauveria bassiana* 2×10⁸ cfu/ml @ 5ml/lit (1.55). The treatment *Metarrhizium anisopliae* 2×10⁸ cfu/ml @ 2.5ml/lit recorded (1.60) mean population of whiteflies per three leaves per plant and was at par with the treatment Ponagmia oil 2% EC @ 10ml/lit (1.64). The treatment *Nomurea rileyi* 2×10⁸ cfu/g @ 1g/lit recorded (1.90) mean population of whiteflies per three leaves per plant and was at par with the treatment *Bacillus thuringiensis* 3.5% ES @ 2ml/lit (2.08). The maximum (3.53) whiteflies population was found in untreated control.

The present findings are in conformity with the results of Karkar (2012) [6]. He evaluated the efficacy of various microbial insecticides against the population of whitefly in brinjal and reported that the population of whitefly were effectively suppressed in the treatment of *M. anisopliae* and *V. lecanii* (2×10⁸ cfu/g) @ 4 ml/lit. Whereas, *B. bassiana* and *N. rileyi* were proved inferior against whiteflies infesting brinjal.

Sharma *et al.* (2015) [8] evaluated the efficacy of bio-
pesticides in tomato to control tobacco whitefly *B. tabaci* and reported that the treatments *M. anisopliae* @ 5 g/lit (92.67%), *B. bassiana* @ 2 g/lit (91.90%), *M. anisopliae* @ 2 g/lit (91.50%), *V. lecanii* @ 2 g/lit (90.84%) were highly effective following *B. bassiana* @ 5 ml/lit (87.53%) and *M. anisopliae* @ 5 ml/lit (85.8%) in reducing the population of whitefly over control after third spray.

Abdel-Raheem and Al-Keridis (2017) [1] studied the virulence of three entomopathogenic fungi against whitefly, *B. tabaci* infesting tomato crop and reported that three concentrations 1×10⁶, 1×10⁷ and 1×10⁸ spores/ml of *M. anisopliae*, *B. bassiana* and *V. lecanii* were used against tomato whitefly under field condition. Among these 3rd concentration (1×10⁸) was the best concentration against whitefly after the third application in *V. lecanii*, *B. bassiana* and *M. anisopliae*. The percent of reduction was ranged between 52 and 100 per cent in all concentrations. The treatment *V. lecanii* was more virulence than *B. bassiana* and *M. anisopliae* against *B. tabaci*.

Prithiva et al. (2017) [8] evaluated the efficacy of different formulations of *B. bassiana* against *B. tabaci* on tomato and reported that among the different formulations tested viz., crude, talc and oil formulations, *B. bassiana* (Bb 112) oil formulation was most effective against whitefly on tomato with 45.86% reduction in population over control followed by t alc (29.62%) and crude formulations (21.63%).

Harshita et al. (2019) [9] studied the management of whitefly, *B. tabaci* infesting tomato ecosystem and they reported that the treatment *B. bassiana* @ 5 ml/lit was recorded 5.17 whitefly/ leaf followed by *B. thuringiensis* var. krustaki @ 2 ml/lit (6.06 whitefly/leaf), respectively.

### Table 3: Efficacy of different biopesticides against whitefly (*Bemisia tabaci* Gennadius) infesting chilli

| Treatment | Pre count | Mean population of whitefly per 3 leaves per plant | |
|-----------|-----------|-----------------------------------------------------|--|
|           | I spray   | II spray | III spray | 2 DAS | 3 DAS | 7 DAS | 2 DAS | 3 DAS | 7 DAS | 2 DAS | 3 DAS | 7 DAS | Overall mean |
|-----------|-----------|----------|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------------|
| T₁        | 2.76 (1.94) | 2.48 (1.86) | 2.53 (1.88) | 2.51 (1.87) | 2.38 (1.84) | 1.94 (1.71) | 1.60 (1.61) | 1.13 (1.46) | 1.13 (1.46) | 0.84 (1.36) | 1.84 (1.67) | |
| T₂        | 2.80 (1.95) | 2.43 (1.85) | 2.42 (1.85) | 2.40 (1.84) | 2.11 (1.76) | 1.55 (1.60) | 1.22 (1.49) | 0.76 (1.33) | 0.67 (1.29) | 0.38 (1.17) | 1.55 (1.58) | |
| T₃        | 2.82 (1.95) | 2.39 (1.84) | 2.34 (1.83) | 2.32 (1.82) | 1.98 (1.73) | 1.54 (1.59) | 1.16 (1.47) | 0.75 (1.32) | 0.60 (1.27) | 0.33 (1.15) | 1.49 (1.56) | |
| T₄        | 2.86 (1.96) | 2.81 (1.95) | 2.79 (1.95) | 2.76 (1.94) | 2.60 (1.90) | 2.29 (1.81) | 1.90 (1.70) | 1.48 (1.57) | 1.40 (1.55) | 1.12 (1.46) | 2.13 (1.76) | |
| T₅        | 2.87 (1.97) | 2.84 (1.96) | 2.83 (1.96) | 2.78 (1.95) | 2.70 (1.92) | 2.44 (1.85) | 2.08 (1.75) | 1.76 (1.66) | 1.60 (1.61) | 1.20 (1.48) | 2.25 (1.79) | |
| T₆        | 2.86 (1.96) | 2.75 (1.94) | 2.62 (1.90) | 2.56 (1.89) | 2.45 (1.86) | 2.04 (1.74) | 1.64 (1.62) | 1.16 (1.47) | 1.20 (1.48) | 0.91 (1.38) | 1.93 (1.70) | |
| T₇        | 2.87 (1.97) | 3.01 (2.00) | 3.04 (2.01) | 3.20 (2.05) | 3.38 (2.09) | 3.45 (2.11) | 3.53 (2.13) | 3.38 (2.09) | 3.20 (2.05) | 2.95 (1.99) | 3.24 (2.06) | |
| SE (±x)   | 0.01       | 0.01     | 0.01       | 0.02     | 0.02     | 0.02     | 0.02     | 0.02     | 0.02     | 0.02     | 0.02     | |
| CD at 50% | NS         | NS       | NS         | 0.03     | 0.03     | 0.06     | 0.06     | 0.03     | 0.06     | 0.03     | 0.06     | 0.05     |

*Figures in parentheses are \(\bar{X} \pm 3 S\) values

DAS- Days after Spraying

### Conclusion

From the present study, it can be concluded that the treatment *Lecanicillium lecanii* 2×10⁸ cfu/ml @ 4 ml/lit was the best treatment for effective management of whiteflies infesting chilli which was recorded minimum (1.49) mean whitefly population per three leaves per plant and was at par with * Beauveria bassiana* 2×10⁸ cfu/ml @ 5 ml/lit (1.55).

### Acknowledgements

The researchers would like to express their gratitude to the Department of Agricultural Entomology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli for the support of labour cost, experimental land and research facility support.

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