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

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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, *Lecanicillium 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 *Lecanicillium 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) [2].

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 eco-system. 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 × 60 cm
Size of treatment plot	:	6.6 m × 1.2m
Total plot size	:	166.32 m^2
Date of transplanting	:	22^{th} 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_1	*Metarrhizium anisopliae* 2×10^8 cfu/ml	0.25	2.5ml/lit
T_2	*Beauveria bassiana* 2×10^8 cfu/ml	0.5	5ml/lit
T_3	*Lecanicillium lecanii* 2×10^8 cfu/ml	0.4	4ml/lit
T_4	*Nomuraea rileyi* 2×10^8 cfu/g	0.1	1g/lit
T_5	*Bacillus thuringiensis* 3.5% ES	0.2	2ml/lit
T_6	Pongamia oil 2% EC	1	10ml/lit
T_7	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^{nd}, 3^{rd} and 7^{th} 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* 2×10^8 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* 2×10^8 cfu/ml @ 5ml/lit (2.43) and *Metarrhizium anisopliae* 2×10^8 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 *Nomurea rileyi* 2×10^8 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* 2×10^8 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* 2×10^8 cfu/ml @ 5ml/lit (2.42). The treatment *Metarrhizium anisopliae* 2×10^8 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 @ 10ml/lit (2.62). The treatment *Nomurea rileyi* 2×10^8 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 (2.83). 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* 2×10^8 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* 2×10^8 cfu/ml @5ml/lit (2.40) and *Metarrhizium anisopliae* 2×10^8 cfu/ml @ 2.5ml/lit (2.51). The treatment

Pongamia oil 2% EC @10ml/lit recorded (2.56) mean population of whiteflies per three leaves per plant and was at par with the treatment *Nomurea rileyi* 2×10^8 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.

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* 2×10^8 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 *Beauveria bassiana* 2×10^8 cfu/ml @ 5ml/lit (2.11). The treatment *Metarrhizium anisopliae* 2×10^8 cfu/ml @ 2.5ml/lit recorded (2.38) mean population of whiteflies per three leaves per plant and was at par with Pongamia oil 2% EC @ 10ml/lit (2.45) and *Nomurea rileyi* 2×10^8 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.

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* 2×10^8 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* 2×10^8 cfu/ml @ 5ml/lit (1.55*).* The treatment *Metarrhizium anisopliae* 2×10^8 cfu/ml @ 2.5ml/lit recorded (1.94) mean population of whiteflies per three leaves per plant and was at par with Pongamia oil 2% EC @ 10ml/lit (2.04). The treatment *Nomurea rileyi* 2×10^8 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.

The data recorded at seventh day after second spray revealed that the whiteflies population per three leaves per plant ranges from 1.16 to 3.53. The treatment *Lecanicillium lecanii* 2×10^8 cfu/ml @ 4ml/lit was found to be most effective treatment which recorded 1.16 mean population of whiteflies per three leaves per plant and was at par with the treatment *Beauveria bassiana* 2×10^8 cfu/ml @ 5ml/lit (1.22). The treatment *Metarrhizium anisopliae* 2×10^8 cfu/ml @ 2.5ml/lit recorded (1.60) mean population of whiteflies per three leaves per plant and was at par with the treatment Pongamia oil 2% EC @ 10ml/lit (1.64). The treatment *Nomurea rileyi* 2×10^8 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.

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* 2×10^8 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* 2×10^8 cfu/ml @ 5ml/lit (0.76). The treatment *Metarrhizium anisopliae* 2×10^8 cfu/ml @ 2.5ml/lit recorded (1.13) mean population of whiteflies per three leaves per plant and was at par with the treatment Pongamia oil 2% EC @ 10ml/lit (1.16). The treatments *Nomurea rileyi* 2×10^8 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* 2×10^8 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* 2×10^8 cfu/ml @ 5ml/lit (0.67). The treatment *Metarrhizium anisopliae* 2×10^8 cfu/ml @ 2.5ml/lit recorded (1.13) mean population of whiteflies per three leaves per plant and was at par with the treatment Pongamia oil 2% EC @ 10ml/lit (1.20). The treatment *Nomurea rileyi* 2×10^8 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* 2×10^8 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* 2×10^8 cfu/ml @ 5ml/lit (0.38). The treatment *Metarrhizium anisopliae* 2×10^8 cfu/ml @ 2.5ml/lit recorded (0.84) mean population of whiteflies per three leaves per plant and was at par with treatment Pongamia oil 2% EC @ 10ml/lit (0.91). The treatment *Nomurea rileyi* 2×10^8 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 recorded (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* 2×10^8 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* 2×10^8 cfu/ml @ 5ml/lit (1.55). The treatment *Metarrhizium anisopliae* 2×10^8 cfu/ml @ 2.5ml/lit recorded (1.84) mean population of whiteflies per three leaves per plant and was at par with Pongamia oil 2% EC @ 10ml/lit (1.93). The treatment *Nomurea rileyi* 2×10^8 cfu/g @ 1g/lit recorded (2.13) mean population of whiteflies per three leaves per plant and was at par with treatment *Bacillus thuringiensis* 3.5% ES @2ml/lit (2.25). All the above treatments were found to be significantly superior over untreated control which recorded highest pest population (3.24 per three leaves per plant).

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 x 10^8 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 biopesticides in tomato to control tobacco whitefly *B. tabaci* and reported that the treatments *M. anisopliae* @ 5g/lit (92.67%), *B. bassiana* @ 2g/lit (91.90%), *M. anisopliae* @ 2 g/lit (91.50%), *V. lecanii* @ 2g/lit (90.84%) were highly effective following *B. bassiana* @ 5ml/lit (87.53%) and *M. anisopliae* @ 5ml/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 1×10^7, 1×10^8 and 1×10^9 spores/ ml of *M. anisopliae*, *B. bassiana* and *V. lecanii* were used against tomato whitefly under field condition. Among these 3rd concentration (1×10^9) 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 talc (29.62%) and crude formulations (21.63%).

Harshita *et al*. (2019) [4] 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 @ 2ml/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									
		Ist spray			IInd spray			IIIrd spray			
		2 DAS	3 DAS	7 DAS	2 DAS	3 DAS	7 DAS	2 DAS	3 DAS	7 DAS	Overall mean
T_1	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)
T_2	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)
T_3	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)
T_4	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)
T_5	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)
T_6	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)
T_7	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 (m±)	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02
CD at 05%	NS	0.03	0.03	0.06	0.06	0.03	0.06	0.06	0.03	0.06	0.05

*Figures in parenthesis are $\sqrt{X+1}$ values

DAS- Days after Spraying

Conclusion
From the present study, it can be concluded that the treatment *Lecanicillium lecanii* 2×10^8 cfu/ml @ 4ml/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* 2×10^8 cfu/ml @ 5ml/lit (1.55).

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